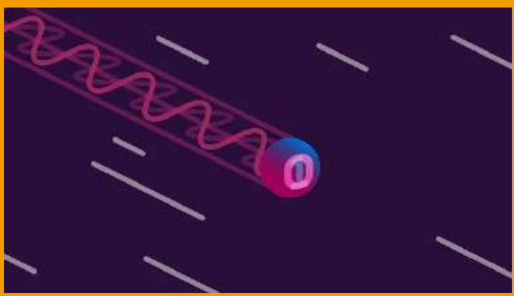
केंद्रीय विद्यालय संगठन

KENDRIYA VIDYALAYA SANGATHAN

मुंबई संभाग Mumbai Region



CLASS XII-SESSION 2023-24

REVISED QUESTION BANK-PHYSICS

प्रश्न बैंक-भौतिकी

केंद्रीय विद्यालय संगठन, मुंबई संभाग

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संकुल वॉर अध्ययन सामग्री निर्माता टीम
CLUSTER WISE TEAM OF PREPARERES

पाठ Ch. No.	पाठ का नाम NAME OF CHAPTER	कोर सदस्य का नाम NAME OF CORE MEMBER	संकुल का नाम NAME OF CLUSTER
1. 2.	ELECTRIC CHARGES AND FIELDS ELECTRIC POTENTIAL AND CAPACITANCE	Mr. VILAS PAWAR PGT PHYSICS K. V. No. 2, AFS Pune	PUNE-2

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पाठ Ch. No.	पाठ का नाम NAME OF CHAPTER	कोर सदस्य का नाम NAME OF CORE MEMBER	संकुल का नाम NAME OF CLUSTER
3.	CURRENT ELECTRICITY	Mr. M.GOPALA REDDY PGT PHYSICS KV RHE PUNE	PUNE-1

क्र. सं S. No.	सदस्य का नाम NAME OF MEMBERS	पद DESIGNATION	केंद्रीय विद्यालय का नाम NAME OF KV
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4. 5.	MOVING CHARGES AND MAGNETISM MAGNETISM AND MATTER	Dr. RAVINDRA KAMBALE PGT PHYSICS K. V. KOLIWADA	MUMBAI -1

क्र. सं S. No.	सदस्य का नाम NAME OF MEMBERS	पद DESIGNATION	केंद्रीय विद्यालय का नाम NAME OF KV
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पाठ Ch. No.	पाठ का नाम NAME OF CHAPTER	कोर सदस्य का नाम NAME OF CORE MEMBER	संकुल का नाम NAME OF CLUSTER
6. 7.	ELECTROMAGNETIC INDUCTION ALTENATING CURRENT	Mr. SANTOSH V. SONTAKKE PGT PHYSICS KV AJNI NAGPUR	NAGPUR

क्र. सं S. No.	सदस्य का नाम NAME OF MEMBERS	पद DESIGNATION	केंद्रीय विद्यालय का नाम NAME OF KV
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CLUSTER WISE TEAM OF PREPARERES

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8. 11.	ELECTROMAGNETIC WAVES DUAL NATURE OF RADIATION AND MATTER	Mrs. NEHA SHARMA PGT PHYSICS KV INS MANDOVI ,GOA	GOA

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पाठ Ch. No.	पाठ का नाम NAME OF CHAPTER	कोर सदस्य का नाम NAME OF CORE MEMBER	संकुल का नाम NAME OF CLUSTER
9. 10.	RAY OPTICS AND OPTICAL INSTRUMENTS WAVE OPTICS	Mr. GANESH AHIRRAO PGT PHYSICS KV ONGC PANVEL	MUMBAI -2

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CLUSTER WISE TEAM OF PREPARERES

पाठ Ch. No.	पाठ का नाम NAME OF CHAPTER	कोर सदस्य का नाम NAME OF CORE MEMBER	संकुल का नाम NAME OF CLUSTER
12. 13.	ATOMS NUCLEI	Mr. SUNIL JADHAV PGT PHYSICS KV Cantt. Aurangabad	AHMEDNAGAR

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2.	Mr. Avinash Ingle	PGT PHYSICS	KV Ahmednagar
3.	Mr. PULGAM RAMESH	PGT PHYSICS	KV SCR NANDED

पाठ Ch. No.	पाठ का नाम NAME OF CHAPTER	कोर सदस्य का नाम NAME OF CORE MEMBER	संकुल का नाम NAME OF CLUSTER
14.	SEMICONDUCTOR MATERIAL: ELECTRONIC DEVICES	Mr. ASHOK KUMAR PGT PHYSICS KV OF VARANGAON BHUSAWAL	NASHIK

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6.	Mrs. PRIYANKA KUWAR	PGT PHYSICS	KV NO. 1 DEOLALI NASHIK

Review of Class XII Physics material prepared in the year 2022-23 (Question Bank, Study Material & Master Card)

Unit No.	Name of the Unit	Question Bank Prepared by Cluster	Name of the cluster core in charge 2022-23	Cluster I/C of Review Committee 2023-24
1	Electrostatics	Pune – 2	Mr. Vilas Pawar (KV No.2 AFS)	Nashik Mr Ashok Kr
2	Current Electricity	Pune – 1	Mr. M G Reddy (KV RHE)	Goa Ms Neha Sharma
3	Magnetic Effects of Current and Magnetism	Mumbai - 1	Mr. Ravindra Kamble (KV Koliwada)	Pune – 2 Mr. Vilas Pawar
4	Electroma gnetic Induction and Alternating Currents	Nagpur	Mr. Santosh V Sontakke (KVAjni Nagpur)	Mumbai –2 Mr. Ganesh Ahirrao
5	Electromagnetic waves	Goa	Ms. Neha Sharma (KV INS Mandovi)	Ahmednagar Mr. Sunil Jadhav
6	Optics	Mumbai - 2	Mr. Ganesh Ahirrao (KV ONGC Panvel)	Nagpur Mr. SantoshV Sontakke
7	Dual Nature of Radiation and Matter	Goa	Ms. Neha Sharma (KV INS Mandovi)	Ahmednagar Mr. Sunil Jadhav
8	Atoms and Nuclei	Ahmednagar	Mr. Sunil Jadhav (KV CANT Aurangabad)	Mumbai – 1 Mr. Ravindra Kamble
9	Electronic Devices	Nashik	Mr. Ashok Kumar (KV OF Varangaon)	Pune – 1 M.G Reddy

विषय सूची
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CLASS XII (2023-24)

PHYSICS (THEORY)

Time: 3 hrs. **Max Marks: 70**

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	Chapter–2: Electrostatic Potential and Capacitance		
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	Chapter–3: Current Electricity		
Unit-III	**Magnetic Effects of Current and Magnetism**	25	17
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	Chapter–5: Magnetism and Matter		
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Unit–IX	**Electronic Devices**	10	7
	Chapter–14: Semiconductor Electronics: Materials, Devices and Simple Circuits		
Total		**160**	**70**

Unit I: Electrostatics 26 Periods

Chapter–1: Electric Charges and Fields

Electric charges, Conservation of charge, Coulomb's law-force between two- point charges, forces between multiple charges; superposition principleand continuous charge distribution.

Electric field, electric field due to a point charge, electric field lines, electric dipole, electric field due to a dipole, torque on a dipole in uniform electric field.

Electric flux, statement of Gauss's theorem and its applications to find field due to infinitely long straight wire, uniformly charged infinite plane sheet and uniformly charged thin spherical shell (field inside and outside).

Chapter–2: Electrostatic Potential and Capacitance

Electric potential, potential difference, electric potential due to a point charge, a dipole and system of charges; equipotential surfaces, electrical potential energy of a system of two-point charges and of electric dipole inan electrostatic field.

Conductors and insulators, free charges and bound charges inside a conductor. Dielectrics and electric polarization, capacitors and capacitance, combination of capacitors in series and in parallel, capacitance of a parallel plate capacitor with and without dielectric medium between the plates, energy stored in a capacitor (no derivation, formulae only).

Unit II: Current Electricity 18 Periods

Chapter–3: Current Electricity

Electric current, flow of electric charges in a metallic conductor, drift velocity, mobility and their relation with electric current; Ohm's law, V-I characteristics (linear and non-linear), electrical energy and power, electrical resistivity and conductivity, temperature dependence of resistance, Internal resistance of a cell, potential difference and emf of a cell, combination of cells in series and in parallel, Kirchhoff's rules, Wheatstone bridge.

Unit III: Magnetic Effects of Current and Magnetism 25 Periods

Chapter–4: Moving Charges and Magnetism

Concept of magnetic field, Oersted's experiment.

Biot - Savart law and its application to current carrying circular loop.

Ampere's law and its applications to infinitely long straight wire. Straight solenoid (only qualitative treatment), force on a moving charge in uniform magnetic and electric fields.

Force on a current-carrying conductor in a uniform magnetic field, force between two parallel current-carrying conductors-definition of ampere, torque experienced by a current loop in uniform magnetic field; Current loop as a magnetic dipole and its magnetic dipole moment, moving coil galvanometer- its current sensitivity and conversion to ammeter and voltmeter.

Chapter–5: Magnetism and Matter

Bar magnet, bar magnet as an equivalent solenoid (qualitative treatment only), magnetic field intensity due to a magnetic dipole (bar magnet) along its axis and perpendicular to its axis (qualitative treatment only), torque on a magnetic dipole (bar magnet) in a uniform magnetic field (qualitative treatment only), magnetic field lines.

Magnetic properties of materials- Para-, dia- and ferro -
magnetic substances with examples, Magnetization of materials,
effect of temperature on magnetic properties.

Unit IV: Electromagnetic Induction and Alternating Currents 24 Periods

Chapter–6: Electromagnetic Induction

Electromagnetic induction; Faraday's laws, induced EMF and current;
Lenz's Law, Self and mutual induction.

Chapter–7: Alternating Current

Alternating currents, peak and RMS value of alternating current/voltage; reactance and impedance; LCR series circuit (phasors only), resonance, power in AC circuits, power factor, wattless current.

AC generator, Transformer.

Unit V: Electromagnetic waves 04 Periods

Chapter–8: Electromagnetic Waves

Basic idea of displacement current, Electromagnetic waves, their characteristics, their transverse nature (qualitative idea only).

Electromagnetic spectrum (radio waves, microwaves, infrared, visible, ultraviolet, X-rays, gamma rays) including elementary facts about their uses.

Unit VI: Optics 30 Periods

Chapter–9: Ray Optics and Optical Instruments

Ray Optics: Reflection of light, spherical mirrors, mirror formula, refraction of light, total internal reflection and optical fibers, refraction at spherical surfaces, lenses, thin lens formula, lens maker's formula, magnification, power of a lens, combination of thin lenses in contact, refraction of light through a prism.

Optical instruments: Microscopes and astronomical telescopes (reflecting and refracting) and their magnifying powers.

Chapter–10: Wave Optics

Wave optics: Wave front and Huygen's principle, reflection and refraction of plane wave at a plane surface using wave fronts. Proof of laws of reflection and refraction using Huygen's principle. Interference, Young's double slit experiment and expression for fringe width (No derivation final expression only), coherent sources and sustained interference of light, diffraction due to a single slit, width of central maxima (qualitative treatment only).

Unit VII: Dual Nature of Radiation and Matter **08 Periods**

Chapter–11: Dual Nature of Radiation and Matter

Dual nature of radiation, Photoelectric effect, Hertz andLenard's observations; Einstein's photoelectric equation-particle nature of light.

Experimental study of photoelectric effect

Matter waves-wave nature of particles, de-Broglie relation.

Unit VIII: Atoms and Nuclei **15 Periods**

Chapter–12: Atoms

Alpha-particle scattering experiment; Rutherford's model of atom; Bohr model of hydrogen atom, Expression for radius of nth possible orbit, velocity and energy of electron in nth orbit, hydrogen line spectra (qualitative treatment only).

Chapter–13: Nuclei

Composition and size of nucleus, nuclear force

Mass-energy relation, mass defect; binding energy per nucleon and its variation with mass number; nuclear fission, nuclear fusion.

Unit IX: Electronic Devices **10 Periods**

Chapter–14: Semiconductor Electronics: Materials, Devices and Simple Circuits

Energy bands in conductors, semiconductors and insulators (qualitative ideas only) Intrinsic and extrinsic semiconductors- p and n type, p-n junction

Semiconductor diode - I-V characteristics in forward and reverse-bias, application of junction diode -diode as a rectifier.

CHAPTER-1

ELECTRIC CHARGES AND FIELDS
SECTION A

(1 MARK QUESTION)

Q1. In an experiment three microscopic latex spheres are sprayed into a chamber and became charged with charges +3e, +5e and -3e respectively. All the spheres came in contact simultaneously for a moment and got separated. Which one of the following possible values for the final charge on spheres?

(a) +5e, -4e, +5e (b) +6e, +6e, -7e (c) -4e, +3.5e, +5.5e (d) +5e, -8e, +7e

Q2. An object has charge of 1 C and gains 5.0 x 10^{18} electrons. The net charge on the object becomes

(a) -0.80 C (b) +0.80 C (c) +1.80 C (d) +0.20 C

Q3. Two equal balls having equal positive charge 'q' coulombs are suspended by two insulating strings of equal length. What would be the effect on the force when a plastic sheet is inserted between the two? (CBSE 2014)

Q4. Sketch the electric field line for +q and –q. [CBSE 2015]

Q5. Why do the electric field lines never cross each other? [CBSE AI 2014]

Q6. Why do the electrostatic field lines not form closed loops? [CBSE 2012,2014]

Q7. Draw the electric field lines of a point charge Q where (i) Q>0 (ii) Q<0 [CBSE 2007]

Q8. A proton is placed in a uniform electric field directed along the positive x-axis. In which direction will it tend to move? [CBSE 2011]

Assertion & Reason

Direction: (FOR ALL THE ASSERTION & REASON QUESTIONS)

Two statements are given. One labelled Assertion (A) and the other labelled reasoning. Select the correct answers to their questions from the codes (a), (b), (c) and (d) are given below.

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R true but R is not the correct explanation of A.
(c) A is true but R is false.

(d) A is false but R is also false.

Q9. Assertion: A point charge is brought in an electric field, then electric field at a nearby point may increase or decrease.

Reason: The electric field is dependent on the nature of charge

Q10. Assertion: Electronic lines of force cross each other.

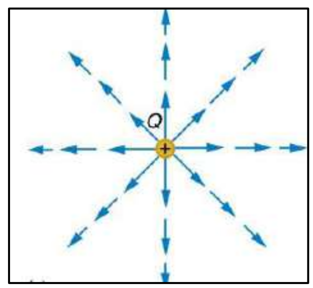
Reason: Electric field at a point does not superimpose to give one resultant electric field.

Q11. Assertion: A way from a charge filed lines gets weaker and density of field lines is less resulting in well separated lines.

Reason: Only a finite number of lines can be drawn from a charge.

Case Based MCQs

Direction: Answer the questions from Q12 to Q14 on the following case.



An electric field lines in general is a curve drawn in such way that the tangent to it at each point is in the direction of the electric field at that point. A field lines is a space curve, i.e. a curve in three dimensions. Electric field lines are then used to pictorially map the electric field around a charge or a configuration of charges:

The density of field lines in more near the charge. Away from the charge, the field is weak, so the density of field lines is less.

Q12. Direction of electric field on field lines is determined by

(a) Field lines moving from –ve to +ve charge.

(b) At the point of intersection of field lines.

(c) By the tangent at that point on the field lines.

(d) None of above.

Q13. The electric field lines of negatively charged particles are

(a) Radial and outwards. (c) Radial and inwards.

(b) Circular and anti-clockwise. (d)Circular and clockwise.

Q14. The spacing between two electric field lines indicate it

(a) Charge (b) Position (c) Strength (d) None of the above

Assertions & Reasons

Q15. The dimensional formula of electric flux is

(a) $[M^1L^2T^{-2}A^{-1}]$ (b) $[M^{-1}L^3T^{-3}A^1]$ (c) $[M^1L^3T^{-3}A^{-1}]$ (d) $[M^1L^{-3}T^{-3}A^{-1}]$

Q16. What is the SI unit of electric flux

(a) $\frac{N}{C}$ x m^2 (b) N x m^2 (c) $\frac{N}{m^2}$ x C (d) $\frac{N^2}{m^2}$ x C^2

Q17. If $\oint_s \vec{E}.\,\vec{dS} = 0$ inside a surface, that means:

(a) There is no net charge present inside the surface

(b) Uniform electric field inside the surface

(c) Discontinuous field lines inside the surface

(d) Charge present inside the surface

Q18. Four charges +8Q -3Q +5Q and -10Q are kept inside a closed surface. What will be the outgoing flux through the surface

(a) 26 V-m (b) 0 V-m (c) 10 V-m (d) 8 V-m

Q19. Electric flux over an area in an electric field represents the ……….. crossing this area.

Q20. A charge Q is enclosed by a Gaussian spherical surface of radius R. If the radius is doubled, then the ………. will remain the same.

Q21. If $\oint_s \vec{E}.\,\vec{dS}$ =0 over a surface, then

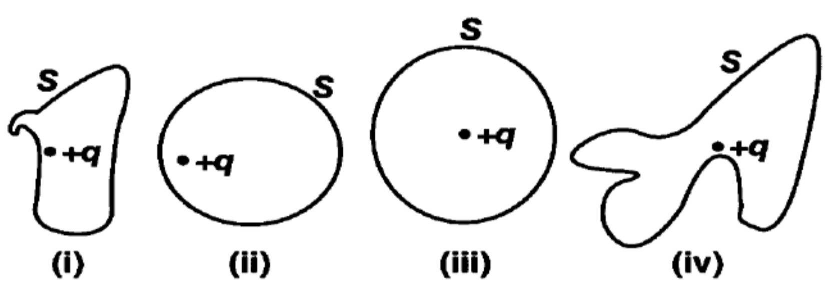
(a) the electric field inside the surface and on it is zero

(b) the electric field inside the surface is necessarily uniform

(c) the number of flux lines entering the surface must be equal to the number of flux lines leaving it

(d) all charges must necessarily be outside the surface

Q22. The electric flux through the surface



(a) In fig (iv) is the largest

(b) fig (iii) is the least

(c) fig (ii) is same as fig (iii) but is smaller than fig (iv)

(d) is the same for all the figures

Q23. **Assertion**- Electric flux is a vector quantity.

Reason- Electric flux is expressed as vector product of electric field vector and area vector.

Q24. **Assertion**- Electric flux through closed spherical surface enclosing an electric dipole is zero.

Reason- Net charge enclosed inside a spherical surface when a dipole is inside it is zero.

Q25. **Assertion**- Gaussian surface is purely imaginary surface.

Reason- Electric field at every point on a Gaussian surface is same.

Q26. **Assertion**- Gaussian surface can be drawn outside the body or within the body.

Reason- It is purely imaginary surface.

Q27. **Assertion**- Electric field at a point inside spherical shell with a charge uniformly spread on its outer surface is zero.

Reason- There is no charge enclosed within the closed shell.

Q28. **Assertion**- Electric field at any point away from linear charge distribution decreases with distance.

Reason- Electric field at any point away from linear charge distribution is expressed as $E= \frac{\lambda}{2\pi\epsilon_o r}$.

Two-mark questions

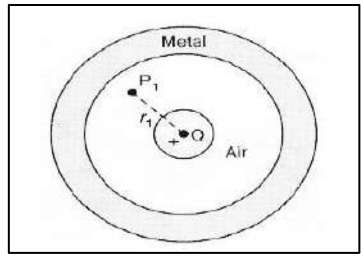
Q29. State the superposition principle for electrostatic force on a charge due to number of charges.

Q30. A force F is acting between two point charges q_1 and q_2. If a third charge q_3 is placed quite close to q_2, what happens to the force between q_1 and q_2? (2011)

Q31. i) The electric field E due to a point charge at any point near it is defined as $E=\lim_{q\to 0} E/q$, where q is the test charge and F is the force acting on it. What is the physical significance of $\lim_{q\to 0}$ in this expression?

(ii) Draw electric field lines of a point charge Q when a. Q>0 b. Q<0 [CBSE 2007]

Q32. A small metal sphere carrying a charge +Q is located at the center of a spherical cavity is a large uncharged metallic spherical shell. Write the charges on the inner and outer surfaces of the shell. Write the expression for the electric field at the point P_1. [CBSE 2014]



Q33. Two point charges q_1 and q_2 are located at point (a,0,0) and (0, b,0) respect. Find the electric field due to both these charges at the point (0,0, e). [CBSE 2013]

Q34. What is Gaussian surface? What is its use?

Q35. S_1 and S_2 are two hollow concentric spheres (S_2 outer sphere and S_1 inner sphere) enclosing charges 9Q and 3Q respectively. What is the ratio of electric flux through S_1 and S_2? What would be electric flux through S_1, if air inside S_1 is replaced by a medium of dielectric constant 3?

Q36. A hollow cube of side 5cm encloses a charge of 6C at its centre. What is the net flux through one of the square face of cube? How would flux through square face change if 6C charge is placed as 4C and 2C inside the cube at two different points?

Three-mark questions

Q37. A particle of charge 2μC and mass 1.6g is moving with a velocity $4\hat{i}\ ms^{-1}$. At t = 0 the particles enters in a region having an electric field E (in N C^{-1}) = $80\hat{i} + 60\hat{j}$. Find the velocity of particle at t = 5s. (CBSE2020)

Q38. A particle of mass 10^{-3} kg and charge 5C enters into a uniform electric field of 2 x 10^5 N/C, moving with a velocity of 20 m/s in a direction opposite to that of the field. Calculate the distance it would travel before coming to rest. [CBSE 2012]

Q39. State and prove Gauss Theorem.

Q40. Using Gauss theorem obtain an expression for electric field intensity at a point due to infinitely long line charge distribution. Sketch graphically variation of E with distance r.

Q41. Using Gauss theorem obtain an expression for electric field intensity at a point due to thin infinite sheet.

Four-mark questions

Q42. Read the following passage and answer questions below it.

A spherical dome in an expo consists of magical fan fixed inside it. The blades of fan have a total charge of 6 C deposited on it. The dome is also surrounded by four such identical fans fixed outside it, each carrying a charge of 6 C on its blade. When a fan inside the dome is switched ON, the charge deposited on the blades of a fan flies off but remains inside the dome. However, when the fans outside the dome are switched ON charge deposited on the blades remain confined to blades. The dome is covered by electrosensitive glittering sheet whose glittering intensity varies directly as the electric flux falling upon its surface varies.

1. What is the net electric flux through the closed surface of dome, when all the fans are switched OFF?

a) $6C/\epsilon o$ b) $1 C/\epsilon o$ c) $30C/\epsilon o$ d) $1 C/12 \epsilon o$

2. What is the net electric flux through the closed surface of dome, when all the fans are switched ON?

a) $30C/\epsilon o$ b) $1 C/\epsilon o$ c) $6C/\epsilon o$ d) $1 C/12 \epsilon o$

3. Which of the following observations is correct for glittering intensity of electrosensitive sheet covering the dome?

a) Glittering intensity is zero when fan inside the dome is switched OFF

b) Glittering intensity is maximum when fan inside the dome is switched ON

c) Glittering intensity is always constant whether the fan inside is switched ON or OFF

d) Glittering intensity varies as outside fans are switched ON

4. Name the principle which explains the observation of glittering intensity of electrosensitive sheet.

a) Coulomb's law in electrostatics b) Gauss theorem in electrostatics

c) Superposition principle of charge d) None of the above

Five-mark questions

Q43. Two point charges of +1 μC and +4 μC are kept 30 cm apart. How far from the +1μC charge on the line joining the two charges will the net electric field be zero? (2020)

Q44. (a) Define electric field intensity. Write its SI unit.

(b) Two point charges 4 μc & 1 μc are separated by a distance of 2m in air. Find the point on the line joining the charges at which the net electric field of the system is zero.

Q45. Obtain the expression for electric field intensity due to a

(a) Point charge and

(b) due to system of charge Plot the graph for the variation for E and r.

SECTION A-ANSWER KEY

(1-MARK QUESTION)

1. (b)

2. (d) Q= ne

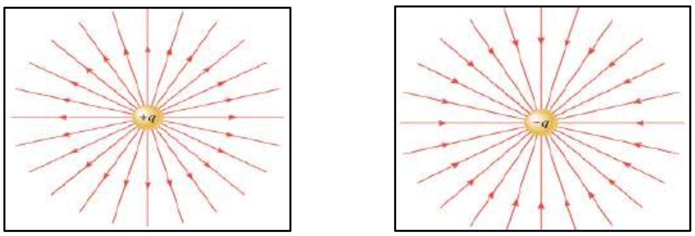
   $Q = 5 \times 10^{18} \times 1.6 \times 10^{-15} = 0.8$ C

   So net charge = q + Q = 1 – 0.8 = 0.2C

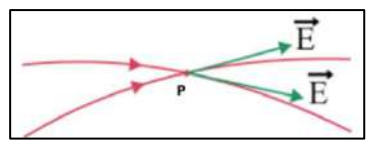
3. F’ = F/K   Where K= dielectric constant

   Hence force is reduced when plastic sheet is inserted

4.

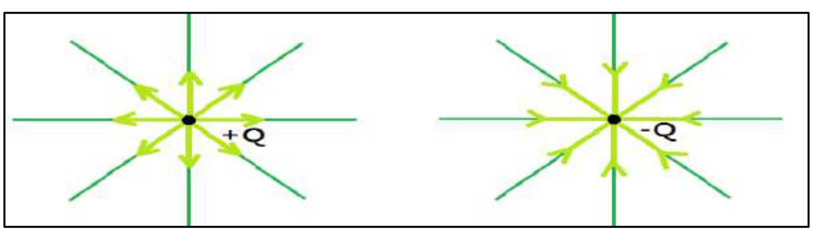


5. If electric field lines cross each other, then at the point of intersection at P, there will be two tangents which is impossible.



6. Since electric field lines emergent from positive charge and terminate at negative charge. If there is a single charge, then emerging field lines terminate at infinity. Therefore, they never form closed loop.

7. (i) Q>0   (ii) Q<0



8. The proton will move in the direction of electric field as it is positively charged. i.e. towards the positive x-axis.

9. (a) 10. (d) 11. (c) 12. (c) 13. (b) 14. (c)

15. (c) $[M^1 L^3 T^{-3} A^{-1}]$

16. (a) $\frac{N}{C} \times m^2$

17. a) There is no net charge present inside the surface.

18. (b) 0 V-m

19.. Total number of electric field lines.

20. Electric Flux.

21. (c) the number of flux lines entering the surface must be equal to the number of flux lines leaving it

22. (d) is the same for all the figures

23. D) 24. A) 25. B) 26. A) 27. A) 28. A)

Answer for Two-mark questions

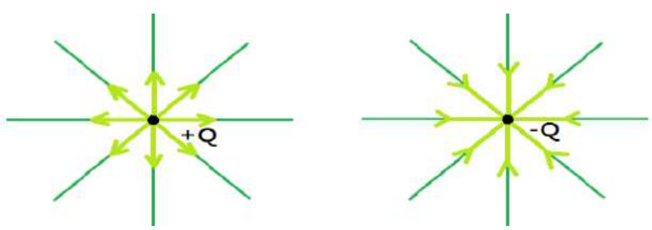
29. The principle of superposition states that the total force on a given charge is the vector sum of the individual forces exerted on it by all other charges, the force between two charges being exerted in such a manner as if all other charges were absent

$F = F_{12} + F_{13} + \ldots\ldots + F_{1N}$

30. The force between q_1 and q_2 remains equal to F.

31. (i) $\lim_{q\to 0}$ tells is that test charge is so small that it does not charge (affect) the source charge.

(ii)



32. Inner surface charge = -Q   Outer surface charge = +Q

$E = Q/4\pi\boldsymbol{\varepsilon}_0 r_1^2$

33.. $\overrightarrow{E_{net}} = \overrightarrow{E_1} + \overrightarrow{E_2}$

$= K\ (\ q_1/r_1^3\ \overrightarrow{r_1} + (\ q_2/r_2^3\ \overrightarrow{r_2})$

Where $\vec{r}_1 = -a\hat{i} + c\hat{k}$ $\overrightarrow{r_2} = -\ b\hat{j} + c\hat{k}$

$\vec{E}\ net = 1/4\pi E_0\ [q_1 (-a\hat{i} + c\hat{k})/(a^2 + c^2)^{3/2} + q_2 (-\ \hat{j} + c\hat{k})/\ (b^2 + c^2)^{3/2}$

34. A Gaussian surface is an imaginary surface at every point of which electric field is same.

By conveniently choosing the Gaussian surface one can evaluate $\oint_s \vec{E}.\vec{dS}$ over it and find out expression for electric field intensity.

35. Electric flux through S_1, Φ_1=9Q/ϵ_o

Electric flux through S_2, Φ_2= 9Q/ ϵ_o +3Q/ϵ_o = 12Q/ϵ_o ∴ Φ_1/ Φ_2=3/4

When air inside S_1 is replaced by a medium of ϵ_r=3

Then electric flux through S_1= Φ_1= 9Q/ϵ= 9Q/ϵ_o ϵ_r = 9Q/3 ϵ_o =3Q/ϵ_o.

36. Electric flux through cube, Φ_E= q/ϵ_o= 6C/ ϵ_o

Electric flux through square face, =1/6 x Φ_E= 1/6 x 6C/ ϵ_o =1/ ϵ_o

Flux through a square face remains same even if 6C charge is distributed ass 4 C and 2 C at two different points since total charge inside the cube remains unchanged.

Answer to Three-mark questions

37. F = ma or qE= ma

a= qE/m = 2 x 10^{-6} x (80î + 60ĵ) / 1.6 x 10^{-3}

= (100x 10^{-3}) î + (75 x 10^{-3}) ĵ

V = u + at

= 4 î +((100x 10^{-3}) î + (75 x 10^{-3}) ĵ)x5

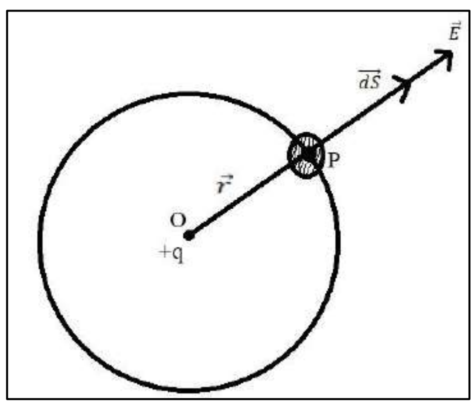
= 4.5î +0.375 ĵ

38. Acceleration, a=qE/m = 5 X $10^{-6}\ X\ 2\ X\ 10^{-5}/\ 10^{-3}$ = 10^3m/s^2

Now $v^2 = u^2 - 2as$

$0 =\ (20)^2$ -2 X 1000 X S

Therefore, S =400/2000 =1/5 =0.2m



39. Let +q be the point charge located at point O. Consider spherically symmetric Gaussian surface around it as shown. Let P be the point on its surrounding elemental area dS and $\vec{r}$ as the position vector of point P. Electric field $\vec{E}$ due to point charge +q and $\vec{dS}$ are in the same direction as shown. Then the total electric flux through closed surface S is

$$\Phi_{E\ Total}=\oint_s \vec{E}.\vec{dS}$$

$$=\oint_S E\, dS \cos\theta = \oint_S E\, dS \cos 0^o$$

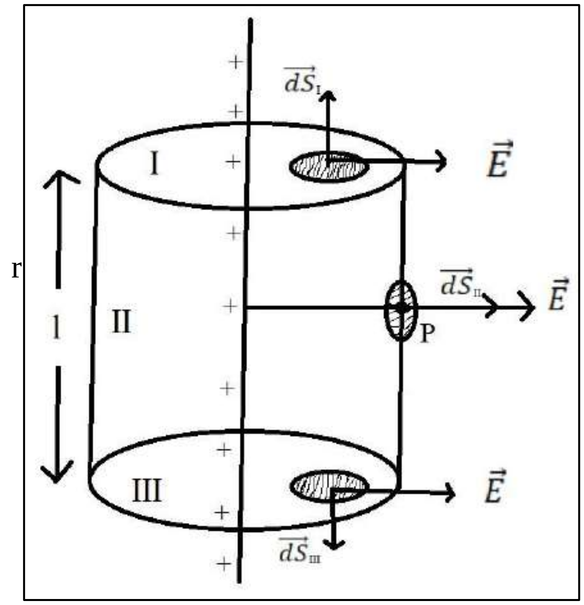
$$\Phi_{E\ Total} = E \oint_S dS = q/4\pi\epsilon_o r^2 \oint dS \quad (\because E = q/4\pi\epsilon_o r^2)$$

$$= q/4\pi\epsilon_o r^2 \times (4\pi r^2)$$

$$\Phi_{E\ Total} = q/\epsilon_o$$

40. Electric field due to infinitely long uniformly charged straight wire

Consider uniformly charged infinitely long straight wire. In order to find electric field intensity at point 'P' distance 'r' from the wire we consider cylindrical Gaussian surface with portion of length'l' of charged wire as axis.



Applying Gauss Theorem to this situation,

$$\oint_S \vec{E}.\overrightarrow{dS} = q/\epsilon_o \text{---------}(1)$$

$$\text{but} \quad \oint_S \vec{E}.\overrightarrow{dS} = \oint_I \vec{E}.\overrightarrow{dS} + \oint_{II} \vec{E}.\overrightarrow{dS} + \oint_{III} \vec{E}.\overrightarrow{dS}$$

$$\text{but} \quad \oint_I \vec{E}.\overrightarrow{dS} = \oint_{III} \vec{E}.\overrightarrow{dS} = 0 \quad (\because \vec{E} \perp \overrightarrow{dS})$$

$$\therefore \oint_S \vec{E}.\overrightarrow{dS} = \oint_{II} \vec{E}.\overrightarrow{dS} = \oint_{II} E\, dS \cos 0^o$$

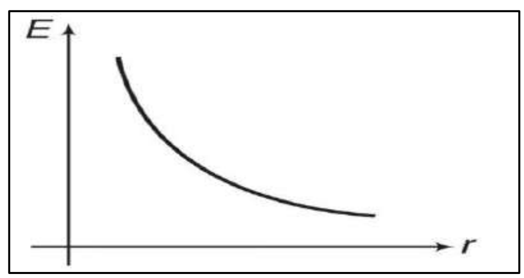
$$= E \oint_{II} dS = E\, 2\pi r l \text{ ---------}(2)$$

From (1) &(2), we get

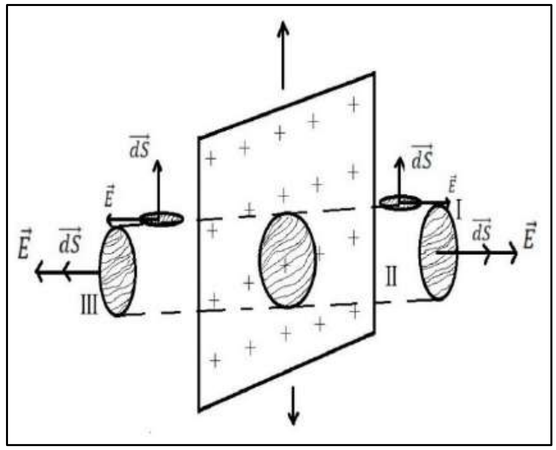
$$E\, 2\pi r l = q/\epsilon_o$$

$E = q/2\pi\epsilon_o r l = \lambda/2\pi\epsilon_o r$ ($\because \lambda = q/l$ is linear charge density)

$E = \lambda/2\pi\epsilon_o r = 2\lambda/4\pi\epsilon_o r$



41. Electric field intensity due to uniformly charged thin infinite plane sheet.



Consider uniformly charged infinitely long thin plane sheet as shown in diagram. Let 'σ' be the surface charge density. In order to find out electric field intensity at point 'P' due plane charged sheet we consider circular elemental area 'A' of the sheet carrying total charge q. Considering cylindrical Gaussian surface enclosing the given charged area A and applying Gauss Theorem to situation

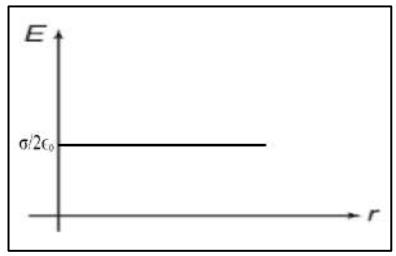
$$\oint_S \vec{E}.\vec{dS} = \oint_I \vec{E}.\vec{dS} + \oint_{II} \vec{E}.\vec{dS} + \oint_{III} \vec{E}.\vec{dS}$$

but $\oint_S \vec{E}.\vec{dS} = \oint_I \vec{E}.\vec{dS} + \oint_{III} \vec{E}.\vec{dS}$ $\quad (\because \oint_{II} \vec{E}.\vec{dS} = 0)$

$= E\oint_I dS + E\oint_{III} dS$

$= E(A)+E(A)=2EA$

but $\oint_S \vec{E}.\vec{dS} = q/\epsilon_o = \sigma A/\epsilon_o$



$\therefore 2EA = \sigma A/\epsilon_o$

$$\boxed{E = \sigma/2\epsilon_o}$$

Answer for Four-mark questions

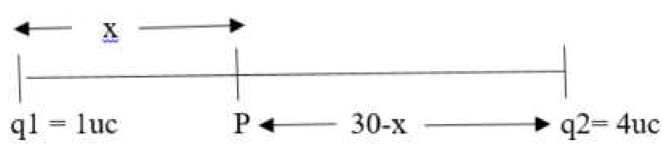
42. 1 a) $6C/\epsilon_o$ 2 c) $6C/\epsilon_o$

3 c) Glittering intensity is always constant whether the fan inside is switched ON or OFF

4 d) Gauss theorem in electrostatics

Answer to Five-mark questions

43. Let at point P, the net electric field is zero, then



$1/x^2 = 4/(30-x)^2$

After solving x = 10cm

44. a. Electric field Intensity – It is defined as the force per unit charge.

$\vec{E}$= F/q , SI unit of $\vec{E}$ = N/C or volt per meter V/m

b. Let the required point is at a distance x from $2\mu c$ charge k 4 μc / x^2= k 1 μc /$(2-x)^2$ = 4/x^2= 1/(4+x^2-2x)

= $(2/x)^2$ = $(1/2-x)^2$ = 2/x = +- 1/(2-x)

x=4/3m or 4m

x= 4 does not satisfy therefore, x=4/3m

45. Expression for intensity of electric field due to a point charge

According to coulomb's law,

F= 1/4π$\boldsymbol{\varepsilon}_0$($q_0$ q/r^2)

E= F/q_0 =1/4π$\boldsymbol{\varepsilon}_0$($q_0$ q/q_0r^2)

E= 1/4π$\boldsymbol{\varepsilon}_0$($q/r^2$) N/C

E=9.0 X 10^9 q/r^2

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

SECTION B

(1 MARK QUESTION)

Q1. Draw a pattern of electric field lines due to two positive charges placed a distance d apart?
(2019) (given in NCERT book)

Q2. Why do the electrostatic field lines not form closed loop? (2012) (given in NCERT book)

Assertions and Reasons

Directions

In the following questions (3-8), a statement of Assertion (A) is followed be a statement of Reason (R). Mark the correct choice as:

(a) If both assertion and reason are true and reason is the correct explanation of the assertion.
(b) If both assertion and reason are true and reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reasons are false.

Q3. **Assertion:** A negative charge in an electric field moves along the direction of the electric field.

Reason: On a negative charge a force acts in the direction of electric field.

Q4. **Assertion:** Acceleration of a charged particle in non-uniform electric field does not depend on velocity of charged particle.

Reason: Charge is an invariant quantity. That is the amount of charge on particle does not depend on frame of reference.

Q5. **Assertion:** Net electric field inside a conductor is zero.

Reason: Total positive charge equals to the total negative charge in a charged conductor.

Q6. **Assertion:** All the charge in a conductor gets distributed on whole of its outer surface.

Reason: In dynamic system charges try to keep their potential energy minimum.

Q7. **Assertion:** The tires of aircrafts are made slightly conducting.

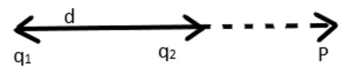
Reason: If a conductor is connected to the ground, the extra charge induced on the conductor will flow to the ground.

Q8. **Assertion:** The Coulomb force is the dominating force in the universe.

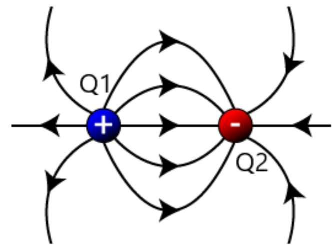
Reason: The Coulomb force is weaker than the gravitational force.

Q9. Draw the pattern of electric field lines when a point charge +Q is kept near an uncharged conducting plate. [CBSE 2019]

Q10. Two point charges q_1 and q_2 are placed at a distance d apart as shown in the fig. The electric filed intensity is zero at the point P on the line joining them as shown. Write two conclusions that you draw from this.

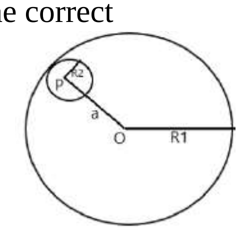


Q11. A few electric field lines for a system of two charges Q_1 and Q_2 are fixed at two different points on the x-axis are shown in the fig. What is the nature of charges? [IIT JEE 2010]



MCQ Types Question

Q12. Consider a uniform spherical distribution of Radius R1 centered at the origin O. In this distribution, a spherical cavity of Radius R2 centered at P with distance OP=a=R1-R2 is made. If the electric field inside the cavity at position $\vec{r}$ is E($\vec{r}$), then the correct statement is



(a) $\vec{E}$ is uniform, its magnitude is independent of R2, but its direction depends on $\vec{r}$

(b) $\vec{E}$ is uniform, its magnitude depends of R2, but its direction depends on $\vec{r}$

(c) $\vec{E}$ is uniform, its magnitude is independent of a, but its direction depends on a

(d) $\vec{E}$ is uniform and both its magnitude and direction depends on $\vec{a}$ [JEE Advanced 2015]

Q13. The surface densities on the surfaces of two charged spherical conductors of radii R1 and R2 are equal. The ratio of electric field intensity on the surface is

(a) $R1^2/R2^2$ (b) $R2^2/R1^2$ (c) R1/R2 (d) 1:1

Assertion/Reasoning Type MCQ

Q14. **Assertion:** Electric lines of force never cross each other.

Reason : Electric field at a point superimpose to give one resultant electric field.

Q15. **Assertion :** Electric lines of field cross each other.

Reason : Electric field at a point superimpose to give one resultant electric field.

Q16. **Assertion :** The electric lines of forces diverges from a positive charge and converge at a negative charge.

Reason : A charged particle free to move in an electric field always move along an electric line of force.

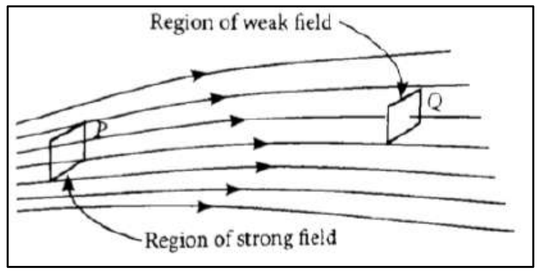
Q17. **Assertion :** A negative charge in an field moves along the direction of electric field.

Reason : On a negative charge a force acts in the direction of electric field.

Q18. **Assertion :** In a non-uniform electric field a dipole will have translator as well as rotatory motion

Reason : In a non-uniform electric field a dipole experience a force as well as torque.

Case Study base type question



Electric field strength is proportional to the density of lines of force i.e., electric field strength at a point is proportional to the number of lines of force cutting a unit area element placed normal to the field at that point. As illustrated in given figure, the electric field at P is stronger than at Q.

Q19. Electric field lines are curved

(a) in the field of a single positive or negative charge

(b) in the field of two equal and opposite charges.

(c) in the field of two like charges.

(d) both (b) and (c)

Q20. **E**lectric lines of force about a positive point charge are

(a) radially outwards (b) circular clockwise

(c) radially inwards (d) parallel straight lines

Q21. Which of the following is false for electric lines of force?

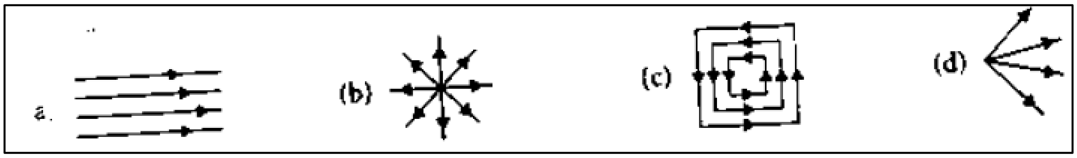
(a) They always start from positive charge and terminate on negative charges.

(b) They are always perpendicular to the surface of a charged conductor.

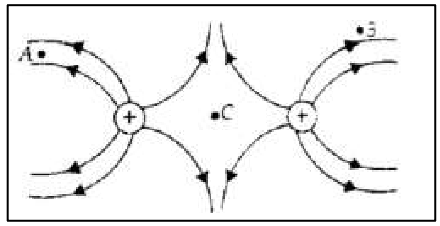
(c) They always form closed loops.

(d) They are parallel and equally spaced in a region of uniform electric field.

Q22. Which one of the following patterns of electric line of force is not possible in field due to stationary charges?



Q23. The figure below shows the electric field lines due to two positive charges. The magnitudes E_A, E_B and E_C of the electric fields at point A, B and C respectively are related as



(a)$E_A>E_B>E_C$ (b) $E_B>E_A>E_C$

(c) $E_A=E_B>E_C$ (d) $E_A>E_B=E_C$

Q24. A closed surface in vacuum encloses charges -q and +3q. Another charge -2q lies outside the surface. Total electric flux over the surface is

(a) Zero (b) $2q/\epsilon o$ (c) $-3q/\epsilon o$ (d) $4q/\epsilon o$

Q25. The number of electric lines of force radiating from a closed surface in vacuum is 1.13×10^{11}. The charge enclosed by the surface is

(a)1 C (b) 1 μC (c) 0.1 C (d) 0.1 μC

Q26. The value of electric field inside a conducting sphere of radius R and charge Q will be:

(a)$\frac{KQ}{R^2}$ (b) $\frac{KQ}{R}$ (c) Zero (d) $\frac{KQ^2}{R^2}$

Q27. Charge Q is kept in a sphere of 5 cm radius first, then it is kept in a cube of side 15 cm, the outgoing flux will be

(a)More in case of sphere (b)More in case of cube

(c)Same in both cases (d)Information incomplete

Q28. Electric flux is a …….. quantity and its units are ……… .

Q29. Net electric flux from a closed surface does not depend upon distribution of ……. inside the surface.

ASSERTION & REASONING

Q30. Assertion- A closed spherical shell has inward electric flux.

Reason- Net charge enclosed inside spherical shell is negative.

Q31. Assertion- Electric field at any point due to infinitely long plain charged sheet is same.

Reason- Electric field at any point due to infinitely long plain charged sheet is expressed as $E=\sigma/\epsilon o$.

Q32. Assertion- A charge Q is placed on a height of h/2 above the centre of a square of height h. The charge is displaced to point h/4 below. The flux through the square remains unchanged.

Reason- The flux associated with the square is independent of position of the charge inside cube but depends only on magnitude of charge.

Q33. Assertion- Number of electric lines of forces emanating from 1 μ C charge in vacuum is 1.13×10^5.

Reason- This follows from Gauss Theorem in Electrostatics.

Q34. Assertion- Electric flux through a given area changes as its orientation with field direction changes.

Reason- $\Phi_E= \oint_s \boldsymbol{E\ dS} \cos \boldsymbol{\theta}$

Q35. Assertion- In case of charged spherical shells, E-r graph is discontinuous while V -r graph is continuous.

Reason- According to Gauss's theorem only the charge inside a closed surface can produce electric field at some point.

Q36. Assertion- Net electric flux through closed spherical surface of radius 5 cm enclosing charge +q is halved when radius is increased to 10 cm.

Reason- Electric flux through closed surface decreases with increase in its volume if charge enclosed is fixed.

Q37. Assertion- Displacing the charges within the closed surface does not affect net electric flux through the closed surface.

Reason- Net electric flux through a closed surface is independent of charge distribution/location within the closed surface.

Two-mark questions

Q38. State the law of conservation of charge. Give two examples to illustrate it. (2009)

Q39. How does the speed of an electrically charged particle affects its mass and charge?

Q40. Write Coulombs law in vector form. What is the importance of expressing it in vector form?

Q41. Two-point charge 4μc and 1μc are separated by a distance of 2m in air. Find the point on the line joining charges at which the net electric field of the system is zero. [OD2017]

Q42. Two identical point charges q each are kept 2m apart in air. A third point charge Q of unknown magnitude and sign is placed on the line joining the charges such that the system remains in equilibrium. Find the position and nature of Q. [CBSE 2019]

Q43. Explain briefly, using proper diagram in difference in behavior of conductor and dielectric in the presence of external electric field.

Q44. Write any two properties of electric field lines.

Q45. Three small spheres each of charge +q are placed on circumference of a circle such that they form an equilateral triangle. What is the electric field intensity at the center of the circle?

Q46. A surface element $\overrightarrow{dS}$ = 25$\hat{\imath}$ is placed in an electric field $\vec{E} = 4\hat{\imath} + 8\hat{\jmath} + 14\hat{k}$. What is the electric flux emanating from the surface?

Q47. An infinite line charge produces a field of 9 x 10^4 N C-1 at a distance of 0.02 m. Calculate the linear charge density.

Three-mark questions

Q48. Give six properties of electric charges? (Given in NCERT book)

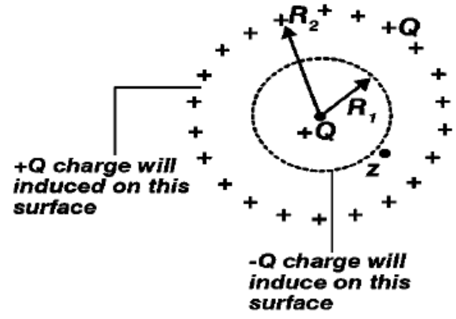
Q49. Two point charges q1 and q2 are located at points (a,0,0) and (0, b, 0) respectively. Find the electric field due to both these charges at the point (0, 0, c).

Q50. The electric field induced in a dielectric when placed in an external field 1/10 times the external field. Calculate relative permittivity of the dielectric.

Q51. S_1 and S_2 concentric spheres such that radius of S_2 is greater than that of S_1 , The spheres enclose charges of Q and 2Q respectively,

1. What is the ratio of electric flux through S_1 and S_2?
2. How will the electric flux through the sphere S_1 change, if a medium of dielectric constant K is introduced in the space inside S_1 in place of air?
3. How will the electric flux through the sphere S_1 change, if a medium of dielectric constant K is introduced in the space inside $S_{2\text{ in}}$ place of air?

Q52. A metallic spherical shell has an inner radius R_1 and outer radius R_2. A charge Q is placed at the centre of the spherical cavity. What will be surface charge density on a) the inner surface b) the outer surface?



Five-mark questions

Q53. (a) Point charge (+Q) is kept in the vicinity of uncharged conducting plate sketch electric field lines between the charge and the plate.

(b) Plot a graph showing the variation of Coulomb force (F) versus $1/r^2$, where r is the distance between two charges of each pair of charges (1μC, 2μC) and (1μC, -3μC). Interpret the graphs.

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SECTION B -ANSWER KEY

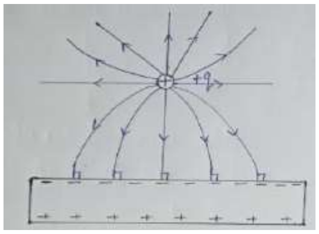
(1 MARK QUESTION)

Q1. Refer from NCERT textbook

Q2. Refer from NCERT textbook

Q3. d Q4. a Q5. c Q6. a Q7. a Q8. d

Q9.



Q10. 1. $q_{1\ and} q_2$ are opposite to each other 2. $q_1 > q_2$

Q11. Since field lines start from Q_1 and end at Q_2 therefore Q_1 is positive and Q_2 is negative

MCQ Types Question

Q12. (d) Explanation : Total field, $\vec{E} = \vec{E}_1 + \vec{E}_2$

$$= \rho/3\boldsymbol{\varepsilon}_0 \overrightarrow{OA} + \rho/3\boldsymbol{\varepsilon}_0 \overrightarrow{AP}$$

$$= \rho/3\boldsymbol{\varepsilon}_0 (\overrightarrow{OA} + \overrightarrow{AP})$$

$$E = \rho/3\boldsymbol{\varepsilon}_0 \overrightarrow{OP} = \rho/3\boldsymbol{\varepsilon}_0 \vec{a}$$

Q13. (d) 1:1

Assertion/Reasoning

Q14. (b) Q15. (d) Q16. (c)

Q17. (d) Both statements are false.

Explanation: A –ve charge moves in opposite direction of electric field and force also acts in opposite direction of electric field.

Q18. (a) Both A and R are true and R is the correct explanation of A.

Case Study Base Type Question

Q19. (d) Q20. (a) Q21. (c) Q22. (c) Q23. (a) Q24. b) $2q/\epsilon o$ Q25. a) 1 C

Q26. c) Zero Q27. c) Same in both cases Q28. Scalar, Nm^2C^{-1}. Q29. Charges. Q30. A

Q31. C Q32. A Q33. B Q34. A Q35. B Q36. D Q37. A

Answer for Two-mark questions

Q38. The total charge of an isolated system remains constant.

Ex: i) NaCl $\rightleftharpoons$ Na+ + Cl—

As the total charge is zero before & after the ionisation, so charge is conserved.

ii) When a glass rod is rubbed with a silk cloth it develops a positive charge. But at the same time silk cloth develop an equal negative charge. Thus, the net charge is zero as it was before rubbing.

Q39. According to special theory of relativity, the mass of body increases with its speed in accordance with the relation :

$m = m_0 /\sqrt{(1- v^2/c^2)}$

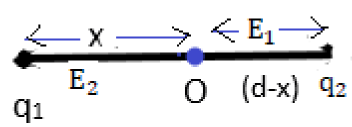
As v is less than c therefore m is greater than m_0.

In contrast to mass, the charge on a body remains constant and does not change as the speed of the body changes.

Q40. As $r_{21} =- r_{12}$, therefore $F_{21}= - F_{12}$

This means that the two charges exert equal and opposite forces on each other. So Coulombian forces obey Newton's third law of motion.

Q41. Therefore, E1=E2



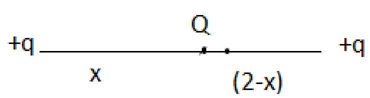
$kq_1 /(x)^2=kq_2 /(d-x)^2$

$1/4\pi\boldsymbol{\varepsilon}_0\ (4x^2) = 1/4\pi\boldsymbol{\varepsilon}_0\ (1/(2-X)^2)$

x/2 = 2-x

therefore, 3x=4 & x=4/3

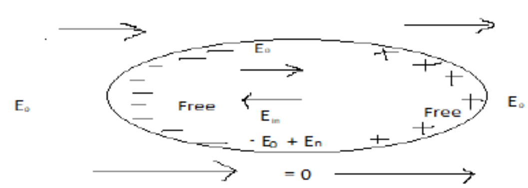
Q42.



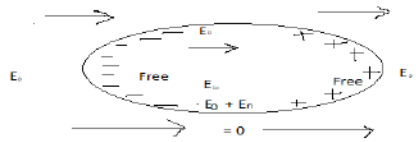
$$\frac{1}{4\pi\in_0}\frac{qQ}{x^2}=\frac{1}{4\pi\in_0}\cdot\frac{qQ}{(2-x)^2}$$

Total force on Q =0 & X=2-x Or 2x =2 or X=1m

Therefore, -Q charge is placed at a midpoint between the two charges of +q each.

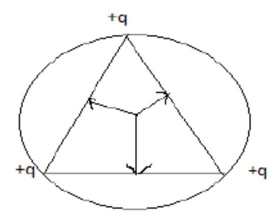


Q43. In conductor, net electric field is zero.



In case of dielectric: Induced electric filed inside is less than external electric field.

Q44. (i) Never intersect (ii) They are perpendicular on surface.



Q45. Resultant force (F=0) $\overrightarrow{E}$ at centre = 0

Three equal force make angle 120^0

Q46. Here, $\overrightarrow{dS} = 5\hat{\imath}$, $\vec{E} = 4\hat{\imath} + 8\hat{\jmath} + 14\hat{k}$

Electric flux, $\Phi = \vec{E}.\overrightarrow{dS} = (4\hat{\imath} + 8\hat{\jmath} + 14\hat{k}).\ 25\hat{\imath}$ or Φ= 100 units.

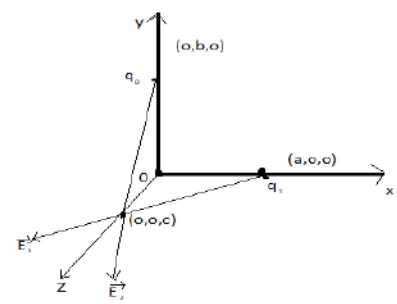
Q47. Here, E= 9 x 104 N C-1, r= 0.02 m, λ=?

As E= λ/2πϵor = 2λ/4πϵor ∴ λ= E (4πϵor)/2 = 9 x 104 x $\frac{1}{9*10^9}$ x $\frac{0.02}{2}$ = 10^{-7} C/m

Answer to Three-mark questions

Q48.- Refer from NCERT textbook

Q49. Net electric filed at the points (o,o,c) due to the charge q_1 & q_2 is



$\vec{E}\ net = \vec{E}_1 + \vec{E}_2 = 1/4\pi E_0\ [q_1/r_1^3\overrightarrow{r_1} + q_2/r_2^3\overrightarrow{r_2})$

But $r_1 = \vec{r} = -a\hat{l} + c\hat{k}$

$\Rightarrow r_1 = (a^2 + c^2)^{1/2}$

$\overrightarrow{r_2} = -\ b\hat{\jmath} + c\hat{k}$

$\Rightarrow r_2 = (b^2 + c^2)^{1/2}$

$\vec{E}\ net = 1/4\pi E_0\ [q(-a\hat{l} + c\hat{k})/(a^2 + c^2)^{3/2} + q_2(-\ b\hat{\jmath} + c\hat{k})/\ (b^2 + c^2)^{3/2}$

Q50. $K = E_0/E_0 = E_0/E_{0/10} = 10$

Q51. 1) From Gauss's theorem electric flux through S_1 is $\Phi_1 = Q/\epsilon_o$

electric flux through S_2 is $\Phi_2 = Q+2Q/\epsilon_o = 3Q/\epsilon_o$

∴ $\Phi_1/\ \Phi_2 = 1/3$

2) When a medium of dielectric constant K is introduced in the space inside S_1, then

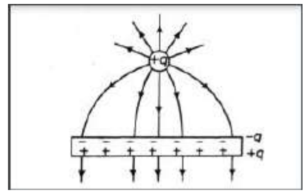
$\Phi_1' = \oint_S \overrightarrow{E}.\ \overrightarrow{dS} = \oint_S \frac{\overrightarrow{E}}{K}.\ \overrightarrow{dS} = Q/\ K\epsilon_o$

3) On introducing dielectric medium inside S_2, electric flux through S_1 will not change.

Q52. +Q is the charge which is kept at the centre of the spherical cavity. –Q is the charge that is induced in the inner surface and +Q on the outer surface.

Answer for Five-mark questions

Q53. a) Equal charge of opposite nature induces in the surface of the conductor nearer to the source charge. Electric lines of forces should fall normally on the conducting plate.



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SECTION C

(1 MARK QUESTION)

1. Consider an uncharged conducting sphere. A positive point charge is placed outside the sphere. The net charge on the sphere is then,

   (a) Negative and uniformly distributed over the surface of sphere.

   (b) Positive and uniformly distributed over the surface of sphere.

   (c) Negative and appears at a point surface of sphere closest to point charge.

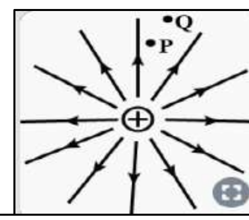
   (d) Zero

2. Why do the electric field lines never cross each other?

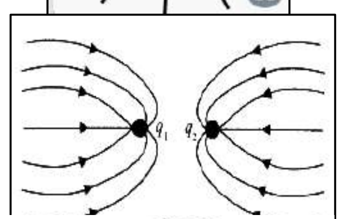
3. Two-point charges +8q and -2q are located at x = 0 and x = L respectively. The point on x-axis at which net electric field is zero due to these charges is (2021)

   (a) 8L (b) 4L (c) 2L (d) L

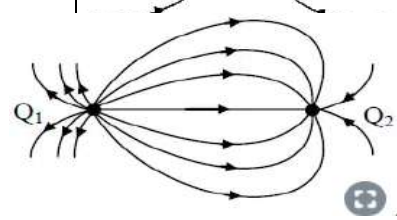
Q4. A point charge +Q is placed in the vicinity of a conducting surface. Draw the electric field lines between the surface and the charge. [CBSE 2014]



Q5. Figure shows the field lines on a positive charge. Is the work done by the field in moving a small positive charge from Q to P positive or negative? Give reason. [CBSE 2014]



Q6. The following fig. shows electric lines of force due to a point charges q_1 and q_2 placed at points A and B respectively. Write the nature of charge on them.



Q7. A few electric field lines for a system of two charges Q_1 and Q_2 fixed at two different points on the x-axis as shown in the fig. Where can be the electric field due to two charges be zero?

Q8. Two-point charges +8q and -2q are located at x=0 and x =L respectively. The location of a point on x-axis at which the net electric field due to these two-point charges is zero in

   a) 2L b) L/4 c) 8L d) 4L [AIEEE 2005]

Assertion Reasoning

Q9. Assertion: Electric force acting on a proton and e^-, moving in a uniform electric field is same, whereas acceleration of e^- is 1836 times is lighter than that of a proton.

Reason – Electron is lighter than proton.

Q10. Assertion- As force is a vector quantity, hence electric field is also a vector quantity.

Reason – The unit of electric field intensity is newton per coulomb.

Q11. Assertion – The electric lines of forces from a point charge and can merge at a negative charge.

Reason – A charge of force to move in electric field moves along an electric line of force.

Q12. Assertion – Three equal charges are situated as a circle of radius r such that they form equilateral triangle, then the electric field intensity at the centre is zero.

Reason – The force on unit positive charge at the centre, due to three equal charges are represented by the three sides of a triangle taken in the same order. Therefore, electric field intensity at centre is zero.

Q13. Assertion –A point charge is brought in an electric field. The filed at a nearby point will increase whatever be the nature of the charge.

Reason – The electric field is independent of the nature of charge.

Q14. The electric field in a certain region is acting radially outwards and is given by E= Ar.

A charge contained in sphere of radius 'a' centred at origin of the field will be given by:

(a) Aϵoa2 (b) 4πϵoAa3 (c) ϵoAa3 (d) 4πϵoAa2

Q15. A charge q is placed at the point of intersection of body diagonals of a cube. The electric flux passing through any one of its faces is

(a) $\frac{q}{6\epsilon_o}$ (b) $\frac{3q}{\epsilon_o}$ (c) $\frac{6q}{\epsilon_o}$ (d) $\frac{q}{3\epsilon_o}$

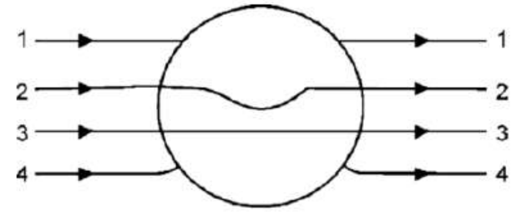
Q16. Name the principle which is mathematical equivalent to Coulomb's law and superposition principle.

Q17. A charge q is placed at the centre of a cube of side 'l' what is the electric flux passing through two opposite faces of the cube?

Two-mark questions

Q18. State Coulomb's law in vector form and prove that F_{21} = - F_{12}, where letters have their usual meaning. (Given in NCERT book)

Q19. Define electric field intensity. What is its S.I unit? What is the relation between electric field and force?



Q20. An infinite number of charges each equal to 4μc are placed along the x-axis at x=1m, x=2m & x=4m as so on. Find electric field at the origin due to given set of charges.

Q21. A metallic solid sphere is placed in a uniform electric field. The lines of force follow the path shown below. Which field lines follow the path?

Q21. If the total charge enclosed by a surface is zero, does it imply that the electric field everywhere on the surface is zero? Conversely, if the electric field everywhere on a surface is zero, does it imply that net charge inside is zero.

Q24. A wire AB of length L has linear charge density λ=Kx, where x is measured from the end A of the wire. This wire is enclosed by a Gaussian hollow surface. Find the expression for electric flux through the surface.

Q25.A uniformly charged conducting sphere of 2.4 m diameter has a surface charge density of 180 $\mu C/m^2$.

(a) Find the charge on the sphere.

(b) What is the total electric flux leaving the surface of the sphere?

Q26. A charge of 17.7 x 10^{-4} C is distributed over a large sheet of area 400 cm^2. Calculate the electric field intensity at a distance of 10 cm from it.

Q27. A large plane sheet of charge having surface charge density 5 x 10^{-16} Cm^{-2} lies in XY plane. Find electric flux through a circular area of radius 1 cm. Given normal to the circular area makes an angle of 60^o with Z-axis.

Three-mark questions

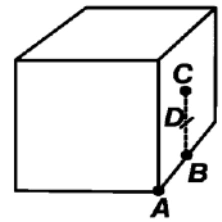
Q28. Derive an expression for electric field intensity at a point due to (a) A point charge (b) A group of charges (c) Continues charge distribution.

Q29. An electron falls through a distance of 1.5 cm in a uniform electric field of value field is reversed, a proton falls through the same distance. Compare the

Fig. a Fig. b

time of fall in each case. Contrast the situation with that of free fall under gravity. [CBSE 2018] [NCERT]

Q30. What will be the total flux through the faces of the cube with side of length a if a charge q is placed at



a) A: a corner of the cube

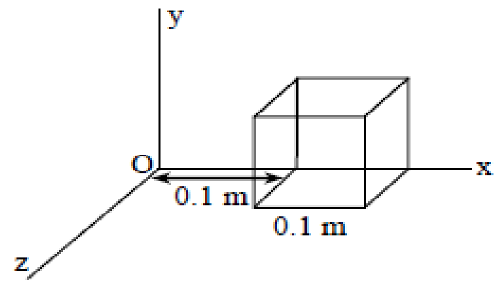
b) B: mid-point of an edge of the cube

c) C: centre of a face of the cube

d) D: mid-point of B and C

Q31. Consider a uniform field $\vec{E} = 30 \times 10^3\ \hat{\imath}\ NC^{-1}$. Calculate the flux of this field through a square surface area of 100 cm^2

(a)When its plane is parallel to Y-Z plane. (b) When the normal to its plane makes an angle of 60^o with X - axis. (c)When parallel to X-Y plane.



Q32.The electric field components due to a charge inside the cube of side 0.1 m are, $E_x = \alpha x$, where $\alpha = 500\ N/Cm^{-1}$, $E_y = 0$, $E_z = 0$. Calculate flux through the cube and charge inside the cube.

Five-mark questions

Q33. State the principle of superposition and use it to obtain the expression for the total force exerted on a point charge due to an assembly of (N -1) discrete point charges. (NCERT)

Case based question

Q34. Paragraph 1: Coulomb's law

This law is a quantitative statement of about the force between two-point charges. When the linear sizes of charged bodies are much smaller than the distance between them, their sizes may be ignored and the charge bodies are called point charges. After retiring from his active services as a military engineer in 1776, Coulomb discovered a torsion balance to measure a small quantity of force and used it for determination of forces of attraction or repulsion between small charged spheres. He thus arrived in 1785 at the inverse square law relation, now known as Coulomb's law. He found that the force between two-point charges varied inversely with the square of the distance between the charges and was directly proportional to the product of the magnitude of the charges and acted along the line joining the two charges. Coulomb's law is an electrical analogue of Newton's law of Universal Gravitation in mechanics.

$$| F_1| = |F_2| = k (q_1 \times q_2) / r^2$$

Q1. Answer the following questions

(I) Identify the wrong statement in the following Coulomb's law correctly describes the electric force that

(a) Blinds the electrons of an atom to its nucleus.

(b) Binds the protons and neutrons in the nucleus of an atom.

(c) Binds atoms together to form molecules.

(d) Binds atoms and molecules to form solids.

(II) Two charges 3×10^{-5}C and 5×10^{4}C are placed at a distance 10cm from each other. The value of electrostatic force acting between them is

(a) 13.5×10^{11} N (b) $40 \text{ X } 10^{11}$ N © 180×10^{9} N (d) 13.5×10^{10} N

2. Each of two point charges is doubles and their distance is halved. Force of interaction becomes n times, where n is

(a) 4 (b) 1 (c) 18 (d) 16

3. The minimum value of force acting between two point charges placed 1 m apart from one another is

(a) ke^2 (b) ke (c) ke/4 (d) $ke^2/2$

4. A and B are two identical spherical charged bodies which repel each other with force F, kept at a finite distance. A third uncharged sphere of same size is brought in contact with sphere B and removed. It is then kept at a mid-point of A and B. Find the magnitude of the force on C.

(a) F/2 (b) F/8 (c) F (d) Zero

<u>Q35. Paragraph 2:</u>

Smallest charge that can exist in nature is the charge of an electron. During friction it is the only transfer of electrons which makes the body charged. Hence net charge on any body is an integral multiple of charge of an electron [1.6×10^{-19}C] i.e. I.e. q=ne

Where n=1, 2, 3……

Hence nobody can have a charge represented as 1.1e, 2.7e…etc.

Recently, it has been discovered that elementary particles such as protons or neutrons are composed of more elemental units called quarks.

Q1. Answer the following questions:

1.Which of the following properties is not satisfied by an electric charge?

(a) Total charge conservation.
(b) Quantization of charge.
(c) Two type of charge.
(d) Circular line of force.

2. Which one of the following charges is possible?

(a) 5.8x 10^{-18}C (b) 3.2x10^{-18}C
© 4.5x10^{-19}C (d) 8.6x10^{-19}C

3. If a charge on a body is 1nC, then how many electrons present on the body?

(a) 6.25x10^{27} (b)1.6x10^{19}
© 6.25x10^{28} (d) 6.25x10^{9}

4. If a body gives out 10^{9} electrons every second, how much time is required to get a total charge of 1C from it?

(a)190.19 years (b)159.12 years
© 198.19 years (d) 188, 21 years

5.A polythene piece rubbed with wool is found to have a negative charge of 3.2x10^{-7}C.

Calculate the number of electrons transferred.

(a) 2x10^{12} (b)3x10^{12}
© 2x10^{14} (d)3x10^{14}

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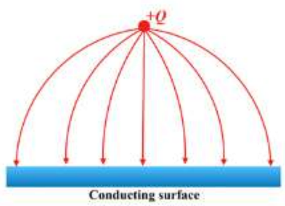
SECTION-C

ANSWER KEY

(1 MARK QUESTION)

1. d
2. If two lines of forces intersect, then there would be two tangents and two directions of electric field at the point of intersection, which is impossible.
3. c
4.



5. Work done by field is negative. Since charge is moved against the force exerted by the field.
6. q_1 and q_2 must be -ve charges. As field lines are pointing towards q_1 and q_2.
7. The electric field due to the system of two charges will be zero at a point to the right of charge.

MCQ Types Question

8. (a) Explanation: Let net electric field due to two given charges be zero at P, where OP = x

E_{AP}= B_{BP} = $K8q/x^2$=$K(2q)/(x – L)^2$ or 2/x = 1/x-L

Or 2x – 2L = x

X = 2L

Assertion/Reasoning

9. (A) 10. (B) 11. (C) 12.(B) 13. (D) 14.b) $4\pi\epsilon_o Aa^3$

15.a) $\frac{q}{6\epsilon_o}$ 16. Gauss' Theorem in electrostatics

17. Flux through each face = $\frac{q}{6\epsilon_o}$

Flux through two opposite faces =$\frac{q}{6\epsilon_o} + \frac{q}{6\epsilon_o} = \frac{q}{3\epsilon_o}$

Answer for Two-mark questions

18. Refer from textbook
19. Electric field intensity at a point defined as the electrostatic force per unit test charge acting on a vanishingly small positive test charge placed at that point .

SI unit of intensity is N/C.

Electrostatic force = charge x electric field.

20. E at origin, $E = 9x10^9 [4x10^{-6}/ (1)^2 + 4x10^{-6}/22] + ----$

$= 36x10^3[1+1/22+1/42 +--]$

(Geometric series)

Therefore, Sum = a/1-r

a= first term = 1

r = common ratio = ¼

$E= 36x10^3 x1/ (1-1/4) = 48x10^3$

21. 4^{th}

Explanation: When metallic solid sphere is placed in uniform electric field the electrons of the sphere move against the direction of electric field. Consequently, the left face acquires negative charge while the right face attains +ve charge. The filed lines will terminate at the left face of sphere and restart from right face. The electric field inside the sphere is zero. On the other surface of the sphere, the filed lines are normal at energy point. i.e., directed towards the centre. Therefore, the correct field is represented.

22. Refer from NCERT textbook

23. The total charge enclosed by a surface is zero, it doesn't imply that the electric field everywhere on the surface is zero. As $\oint_s \vec{E}.\vec{dS} = q/\epsilon_o$, therefore, the field may be normal to the surface. Also, the conversely it does imply that net charge inside is zero if electric field everywhere on the surface is zero.

24. Here, $\lambda=\frac{dq}{dx}= Kx; \phi=?$

dq=Kx dx

Total charge on the wire

$q= \int_0^L Kx\ dx= [\frac{Kx^2}{2}]=KL^2/2$

Total electric flux through the Gaussian hollow surface is

$\Phi= q/\epsilon_o= KL^2/2\epsilon_o$

25. (a) d=2.4m r=1.2m

Surface charge density, $\sigma =180.0\ \mu C/m^2 =180 \times 10^{-6} C/m^2$

Total charge on surface of sphere,

$Q = \sigma \times 4\pi r^2 = 180\times10^{-6}\times4\times3.14\times(1.2)^2$

$= 3.25\times10^{-3}$ C

(b) $\Phi_{\text{Total}} = Q/\epsilon_o$

$\Phi_{\text{Total}} = \frac{3.25*10^{-3}}{8.85*10^{-12}} = 3.67 \text{ X } 10^8 \text{ Nm}^2\text{C}^{-1}$

26. Here, q= 17.7 x 10^{-4} C, A= 400 cm^2, E=?, r =10 cm = 10^{-1}m

In case of a large plane sheet, distance of the point (=r) doesn't matter.

$E = \sigma/2\epsilon_o = q/2\epsilon_o A = \frac{17.7*10^{-4}}{2*(8.85*10^{-12})*400} = 2.5 \text{ x } 10^5$ N/C

27. Here, $\sigma = 5 \text{ x } 10^{-16} \text{ Cm}^{-2}$, ϕ=?

$r = 1$ cm $=10^{-2}$m, $\theta=60^o$

$\phi = E(\Delta S)\cos\theta = (\sigma/2\epsilon_o)\,\pi r^2 \cos 60^o$

$= \frac{5*10^{-16}*3.14*(10^{-4})*1/2}{2*8.85*10^{-12}} = 4.44 \text{ x } 10^{-9}\text{Nm}^2\text{C}^{-1}$.

Answer to Three-mark questions

28. Refer from NCERT textbook

29. For electron

Y_1= 1.5 cm = 1.5 x10^{-2}m

E_1= 2x10^4N/C

q_0 = (-) 1.6x10^{-19} C

m_1 = 9x10^{-3} kg

$Y_1 = u_1 t_1 + ½ a_1 t_1^2$

$= 0 + ½ a_1 t_1^2$

$t_1 = \sqrt{\frac{2y_1}{a_1}} = \sqrt{\frac{2\times1\cdot5\times10^{-2}}{3.55\times10^{15}}} = 2.9 \text{ X } 10^{-9}$sec

therefore,

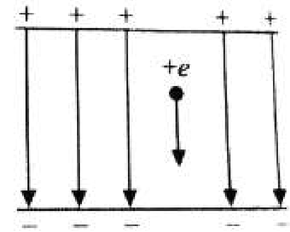
$a_1 = F_1/m_1 = q_0 E_1/m_1$

$a_1 = 1.6 \text{ x } 10^{-19} \text{x } 2 \text{ x } 10^4/ 9 \text{ x } 10^{-37}$

$a_1 = 3.55 \text{ x } 10^{15} \text{ m/s}^2$

For proton

When electric field is reversed



$q_0 = +1.6 \times 10^{-19}$C.

$m_2 = 1.67 \times 10^{-27}$kg.

acceleration $a_2 = F_2/m_2 = q_0E/m_2$

a = 1.6 x 10 -19x 2 x 104/ 1.67 x 10-27 = 1.92 x 1012 m/s2

Similarly, t2 = $\sqrt{\frac{2y_2}{a_2}} = \sqrt{\frac{2\times1\cdot5\times10^{-2}}{1.92\times10^{12}}}$

t1/t2 = 2.9 x 10-9/1.25 x 10-7 = 2.3 x 10-2

Observation:

Acceleration of e^- = 10^{15} m/s^2

Acceleration of p^+ = 10^{12} m/s^2

Acceleration of g = 9.8 m/s^2 = 10 m/s^2 (negligible), Effect of gravity can be ignored.

30. a) When we consider the charged particle to be placed at the centre of the cube whose side is 2a, then the charge is equally distributed among 8 cubes. Therefore, the total flux through the faces of the cube=q/8 ϵ_o.

b) When the charge is placed at B, the charge is equally distributed among the 4 cubes. Therefore, the total flux through the four faces is given as = q/4 ϵ_o.

c) When the charge is placed at C, the charge is shared among 2 cubes equally. Therefore, the total flux through these faces is given as = q/2 ϵ_o.

d) When the charge is place at D, the charge is distributed among two cubes and therefore, the total flux is given as = q/2 ϵ_o.

31. Here, $\vec{E}$= 30 x$10^3\,\hat{\imath}$ NC^{-1}

A= 10^{-2} m^2

(a)As normal to the area is in the direction of electric field, therefore θ=0°

Φ= EA cos θ= 30x10^3x10^{-2} cos 0^0
= 300Nm^{2}C^{-1}

(b)In this case, θ=60°

Φ` = EA cos θ= 30x10^3x10^{-2} cos 60^0
= 150 Nm^{2}C^{-1}.

(c)In this case, $\theta=90^o$

Φ= EA cos θ= $30x10^3x10^{-2}$ cos 90^0

= 0 Nm^2C

32. Through the left face

Φ_1= $E_{x.}$ A cos 180^o

=500 x 0.1 x 10^{-2}(-1) = -0.5

Through the right face

Φ_2= E_x. A cos 0^o

=500 x 0.2 x 10^{-2}= 1.0

∴ Net flux through the cube

$\Phi=\Phi_1+\Phi_2$= 0.5 Nm^2C^{-1}

Charge inside the cube =$\epsilon_o\Phi$

= 8.85 x 10^{-12} x 0.5= 4.425 x 10^{-12} C.

Answer to Five-mark questions

Q33. Refer from NCERT textbook

Q34. Refer from NCERT textbook

1. b 2. a 3. d 4. a 5. c

Q35. 1. d 2. b 3. d 4. c 5. a

****

QUESTION BANK

Chapter:2 Electric Potential and Capacitance

SECTION A

(1 MARK QUESTIONS)

Q1. What is the net charge on a charged capacitor?

Q2. What is an equipotential surface. Give an example. (CBSE 2003)

Q3. What is the geometrical shape of equipotential surfaces due to a single isolated charge? (CBSE 2013)

Q4. Why are electric field lines are perpendicular at a point on an equipotential surface of a conductor? (CBSE 2015)

Q5. Define dielectric constant in terms of the capacitance of a capacitor.

Q6. What may be a possible reason of water having a much greater dielectric constant (=80) than say mica (=6)?

Q7.In what form is the energy stored in a charged capacitor?

MULTIPLE CHOICE QUESTIONS

Q8. If voltage applied on a capacitor is increased from V to 2V, choose the correct conclusion.

(a) Q remains the same, C is doubled

(b) Q is doubled, C doubled

(c) C remains same, Q doubled

(d) Both Q and C remain same

Q9. A parallel plate capacitor is charged. If the plates are pulled apart

(a) the capacitance increases

(b) the potential differences increase

(c) the total charge increases

(d) the charge & potential difference remain the same

Q10.Which of the following is an example of a molecule whose centre of mass of positive and negative charges coincide each other?

(a)CO_2 (b) CO (c) CH_3OH (d) NH_3

Q11.What is the angle between electric field and equipotential surface?

(a) 90^o always (b)0^o always (c)0^o to 90 (d)0^o to 180^o

Q12.If we carry a charge once around an equipotential path, then work done by the charge is:

(a) Infinity (b) Positive (c) Negative (d) Zero

2 MARKS QUESTIONS

Q13.Sketch equipotential surfaces for

(a) A negative point charge (CBSE 2001)

(b) Two equal and positive charges separated by a small distance. (CBSE 2015)

Q14.Deduce the expression for the potential energy of an electric dipole placed with its axis at an angle θ to the external field $\vec{E}$.Hence discuss the conditions of its stable and unstable equilibrium. (CBSE 2008,2019,2021 Compt.)

3 MARKS QUESTIONS

Q15. Obtain the expression for the resultant capacitance when three capacitors C_1 , C_2 and C_3 are connected (i) in series (ii) in parallel.

Q16. Define the capacitance of a capacitor. Obtain the expression for the capacitance of a parallel plate capacitor in vacuum in terms of plate area A and separation d between the plates.

5 MARKS QUESTIONS

Q17. (a) Define the SI unit of capacitance.

(b) Obtain the expression for the capacitance of a parallel plate capacitor.

Q18. (a) Define potential energy of a system of two charges.

(b)Two-point charges q_1 and q_2, separated by a distance r_{12} are kept in an external electric field. Derive an expression for the potential energy of the system of two charges in the field.

****

SECTION-A Answer Key

1. Zero, because the two plates have equal & opposite charges.

2. A surface with a constant value of potential at all points on the surface. Example: Surface of a charged conductor.

3.For the point charge, the equipotential surfaces are concentric spherical shells with their centre at the point charge.

4. If it were not so, the presence of a component of the field along the surface would destroy its equipotential nature

5. The ratio of the capacitance of the capacitor completely filled with dielectric material to the capacitance of the same capacitor with vacuum between the platesis called dielectric constant.

6. Water molecules have permanent dipole moment.

7. Electrostatic potential energy

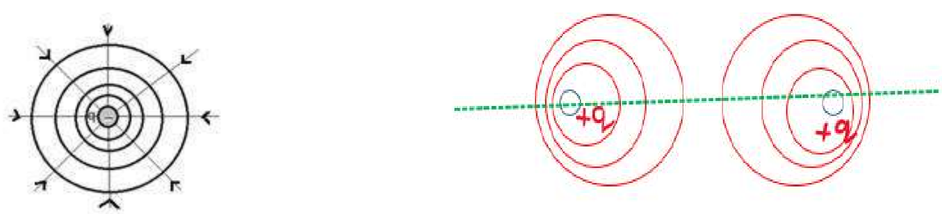
MCQ

8. (c) 9. (b) V = Ed , V increases as distance increases

10. (a) 11. (a) 12. (d)

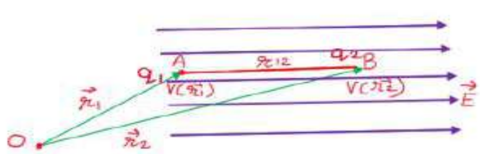
2 MARKS ANSWERS

13.



14. Work done in moving the charge q_1 at the point A,

$W_1 = q_1V\ (\mathbf{r_1})$ Work done in moving the charge q_1 at the point B,



$W_2 = q_2V\ (\mathbf{r_2}) + \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r_{12}}$

Total work done in assembling this configuration,

$W = W_1 + W_2$

$W = q_1V\ (\mathbf{r_1}) + q_2V\ (\mathbf{r_2}) + \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r_{12}}$

3 MARKS ANSWERS

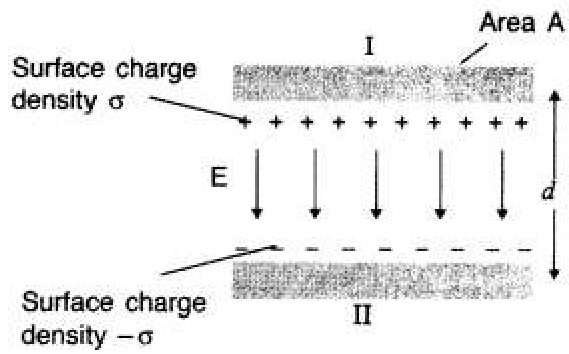
15. Derivation from ncert book

16. Derivation from ncert book

5 MARKS ANSWERS

17.When a charge of one coulomb produces a potential difference of one volt between the plates of capacitor, the capacitance is one farad.

Capacity of a parallel plate capacitor. A parallel plate capacitor consists of two large plane parallel conducting plates separated by a small distance. We first take the intervening medium between the plates to be vaccum. Let A be the area of each plate and d the separation between them. The two plates have charges Q and – Q. Since d is much smaller than the linear dimension of the plates ($d^2 << A$), we can use the result on electric field by an infinite plane sheet of uniform surface charge density. Plate 1 has surface charge density $\sigma = Q/A$ and Plate 2 has a surface charge density $-\sigma$, the electric field in different region is:



Outer region I (region above the plate 1),

$$E = \frac{\sigma}{2\varepsilon_0} - \frac{\sigma}{2\varepsilon_0} = 0$$

Outer region II (region below the plate 2),

$$E = \frac{\sigma}{2\varepsilon_0} - \frac{\sigma}{2\varepsilon_0} = 0$$

In the inner region between the plates 1 and 2, the electric fields due to the two charged plates add up, giving

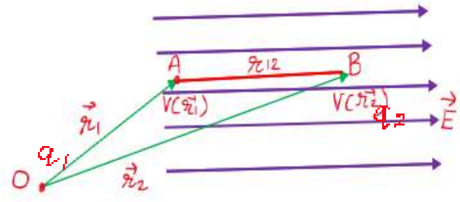
$$E = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0} = \frac{\sigma}{\varepsilon_0} = \frac{Q}{\varepsilon_0 A} \text{ or } V = Ed = \frac{1}{\varepsilon_0}\frac{Qd}{A}$$

The capacitance C of the parallel plate capacitor is then

$$C = \frac{Q}{V} = \frac{\varepsilon_0 A}{d}$$

18. a) The potential energy of a system of two charges is the amount of work done in assembling the charges at their locations by bringing them in, from infinity.

(b) Work done in moving the charge q_1 at the point A,



$W_1 = q_1 V(\mathbf{r_1})$

Work done in moving the charge q_1 at the point B,

$W_2 = q_2 V(\mathbf{r_2}) + \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r_{12}}$

Electric energy of the system,

U = Total work done in assembling this configuration,

$U = W_1 + W_2$

$U = q_1 V(\mathbf{r_1}) + q_2 V(\mathbf{r_2}) + \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r_{12}}$

****

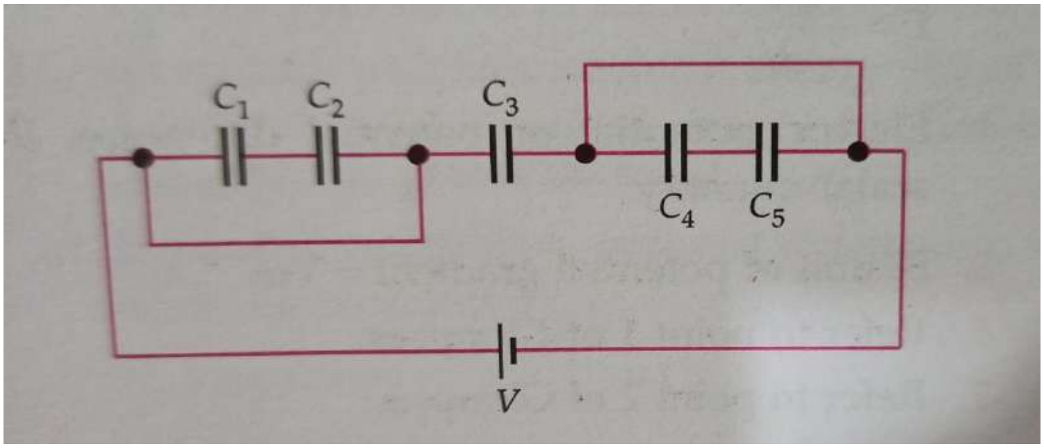
SECTION-B

1 MARK QUESTIONS

Q1. An air capacitor is given a charge of 2μC raising its potential to 200 V. If on inserting a dielectric medium, its potential falls to 50 V. What is the dielectric constant of the medium.

Q2. A parallel plate capacitor with air between the plates has a capacitance of 8pF. What will be the capacitance if the distance between the plates by reduced by half and the space between them is filled with a substance of dielectric constant k =6.

Q3. What is the equivalent capacitance, C, of the five capacitors connected as shown in the figure



ASSERTION – REASON QUESTIONS

Directions: These questions consist of two statements, each printed as Assertion and Reason. While answering these questions, you are required to choose any one of the following four responses.

(a) Both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) Both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

(c) Assertion is correct, Reason is incorrect

(d) Both Assertion and Reason are incorrect.

Q4 **Assertion:** A spherical equipotential surface is not possible for a point charge.

Reason: A spherical equipotential surface is not possible inside a spherical capacitor.

Q5.**Assertion:** The equatorial plane of a dipole is an equipotential surface.

Reason: The electric potential at any point on equatorial plane is zero.

Q6.**Assertion:** Electric potential and electric potential energy are different quantities.

Reason: For a system of positive test charge and point charge electric potential energy = electric potential.

Q7.**Assertion:** Two equipotential surfaces cannot intersect each other.

Reason: Two equipotential surfaces are parallel to each other.

Q8. Assertion : If the distance between parallel plates of a capacitor is halved and dielectric constant is three times, then the capacitance becomes 6 times.

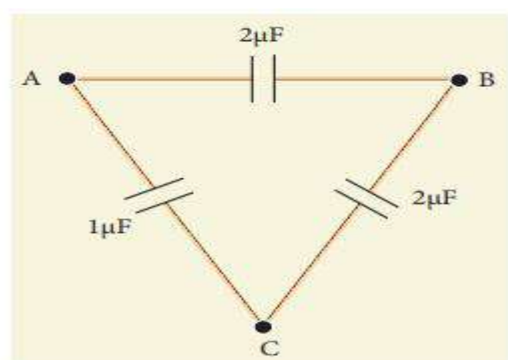
Reason : Capacity of the capacitor does not depend upon the nature of the material.

Q9**. Assertion** : A parallel plate capacitor is connected across battery through a key. A dielectric slab of dielectric constant K is introduced between the plates. The energy which is stored becomes K times.

Reason : The surface density of charge on the plate remains constant or unchanged.

MULTIPLE CHOICE QUESTIONS

Q10. Three capacitors are connected in triangle as shown in the figure. The equivalent capacitance between the points A and C is



(a) 1μF

(b) 2 μF

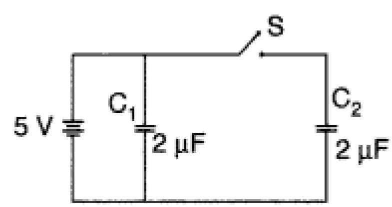
(c) 3 μF

(d)1/4μF

2 MARKS QUESTIONS

Q11.If two charged conductors are touched mutually and then separated, prove that the charges on them will be divided in the ratio of their capacitances.

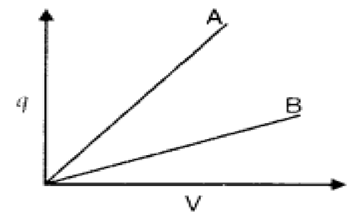
Q12. Figure shows two identical capacitors C_1 and C_2, each of 2 μF capacitance, connected to a battery of 5 V. Initially switch 'S' is left open and dielectric slabs of dielectric constant K = 5 are inserted to fill completely the space between the plates of the two capacitors.



(i) How will the charge and

(ii) potential difference between the plates of the capacitors be affected after the slabs are inserted?

Q13. The given graph shows variation of charge 'q' versus potential difference 'V' for two capacitors C_1 and C_2. Both the capacitors have same plate separation but plate area of C_2 is greater than that of C_1. Which line (A or B) corresponds to C_1 and why?



Q14. A metal plate is introduced between the plates of a charged parallel plate capacitor. What is its effect on the capacitance of the capacitor.

Q15. Two capacitors have a capacitance of 5μF when connected in parallel and 1.2μF when connected in series. Calculate their capacitances.

Q16. Why does current in a steady state not flow in a capacitor connected across a battery? However momentary current does flow during charging or discharging of the capacitor. Explain.

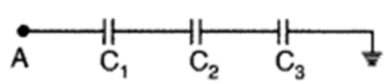
Q17. A capacitor is connected across a battery.

(i) Why does each plate receive a charge of exactly the same magnitude?

(ii) Is this true even if the plates are of different sizes?

3 MARKS QUESTIONS

Q18. Calculate the potential difference and the energy stored in the capacitor C_2 in the circuit shown i the figure. Given potential at A is 90 V, C_1 = 20 μF, C_2 = 30 μF and C_3 = 15 μF.



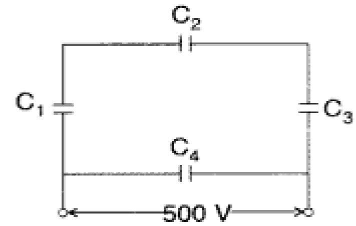
Q19. A capacitor of unknown capacitance is connected across a battery of V volts. The charge stored in it is 300 μC. When potential across the capacitor is reduced by 100 V, the charge stored in it becomes 100 V. Calculate the potential V and the unknown capacitance. What will be the charge stored in the capacitor if the voltage applied had increased by 100 V?

Q20. A parallel plate capacitor, of capacitance 20pF, is connected to a 100 V supply. After sometime the battery is disconnected, and the space, between the plates of the capacitor is filled with a dielectric, of dielectric constant 5. Calculate the energy stored in the capacitor

(i) before

(ii) after the dielectric has been put in between its plates.

Q21. A network of four capacitors each of 12μF capacitance is connected to a 500 V supply as shown in the figure.



Determine

(a) equivalent capacitance of the network and

(b) charge on each capacitor.

Q22. A parallel plate capacitor is charged by a battery to a potential difference V. It is disconnected from battery and then connected to another uncharged capacitor of the same capacitance. Calculate the ratio of the energy stored in the combination to the initial energy on the single capacitor.

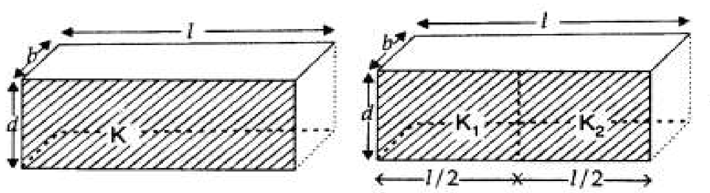
5 MARKS QUESTIONS

Q23. a) Explain, using suitable diagrams, the difference in the behavior of a

(i) conductor and

(ii) dielectric in the presence of external electric field. Define the terms polarization of a dielectric and write its relation with susceptibility.

Q24. Two identical capacitors of plate dimensions l × b and plate separation d have di-electric slabs filled in between the space of the plates as shown in the figure.



Obtain the relation between the dielectric constants K, K_1 and K_2.

Q25. A parallel plate capacitor of capacitance C is charged to a potential V by a battery. Without disconnecting the battery, the distance between the plates is tripled and a dielectric medium of k = 10 is introduced between the plates is tripled and a dielectric medium of k = 10 is introduced between the plates of the capacitor. Explain giving reasons, how will the following be affected:

(i) capacitance of the capacitor

(ii) charge on the capacitance.

****

SECTION B-ANSWER KEY

1. $k = v\_vac/v\_die = 200/30 = 4$

2. With air between the parallel plates,

$C_0 = \frac{\epsilon_0 A}{d} = 8PF$

With dielectric between the parallel plates

$$C = \frac{k\epsilon_0 A}{d / 2} = 96PF$$

3. $C=C_3$ because the combination of C_1 and C_2 as well as C_4 and C_5 have been shorted.

4.(d) 5.(b) 6.(c) 7.(c) 8. (c) 9. (c)

MCQ

10. (b)

2 MARKS ANSWERS

11. Q ∝ C so the charge will be divided in proportion of their capacitances. Explanation: When two charged conductors are touched together then the charge on them will get divided as we know charge can flow. We also know Q= CV.

12. (i) When switch S is open and dielectric is introduced, charge on each capacitor will be $q_1 = C_1 V$, $q_2 = C_2V$

q_1 = 5CV= 5 × 2 × 5 = 50 μC, q_2 = 50 μC

Charge on each capacitor will become 5 times

(ii) P.d. across C_1 is still 5V and across C_2,

q = (5C) V

$$V' = \frac{V}{5} = \frac{5}{5} = \mathbf{1V}$$

13. A represents C_2 and B represents C_1

Reason: From the graph the slope q/v= Capacitance is greater for A. Also according to given conditions the capacitance C∝A

so capacitance is larger for the C_2 because the area of its plates is large and d for the two capacitor is same. Hence, A represents C_2.

Let C be the capacitance of a capacitor

Given : $C_1 = C_2 = C_3 = C$ When connected in series: Cs=C/3=1μF So C=3μF

When connected in parallel: Cp=C+C+C=3+3+3= 9μF

14. By introducing the metal plate between the plates of charged capacitor, the capacitance of capacitor increases. As C=Aε_O /d-t(1-$\frac{1}{K}$). For metal plate K is infinite so Obviously, effective separation between plates is decreased from d to (d – t)

15. 5 = C1 + C2 ....(1st equation)

1.2 = C1C2/(C1 + C2) ....(2nd equation)

On solving we get C1 = 2mF and 3mF.

16. In the steady state, the displacement current and hence the conduction current, is zero as | |E→| | between the plates, is constant.

During charging and discharging, the displacement current and hence the conduction current is non zero as | |E→| | between the plates, is changing with time.

Current is non zero as | |E→| | between the plates, is changing with time.

17.a. The charge from one plate gets transferred to another plate through battery. The battery pumps the charge from one plate to another.

b. Yes size of plates does not matter.

3 MARKS ANSWERS

18. Given V_A= 90V, C_1 = 20μF, C_2 = 30μF and C_3= 15μF

Since these capacitors are connected in series, net capacitance will be

$$\frac{1}{c} = \frac{1}{20} + \frac{1}{30} + \frac{1}{15} = \frac{3}{20}$$

$$c = \frac{20}{3}\,\mu F$$

Carge on each capacitor q = CV =600μC

Potential difference across the capacitor C_2

$V_2 = \frac{q}{C_2} = \frac{600}{30} = 20v$

Energy stored in capacitor across C_2

E_2= 6000J

19. (i) Charge stored, Q = CV

300 μC = C × V ,

When potential is reduced by 100 V

100 μC = C(V – 100) = CV – 100 C

100 μC = 300 μC – 100 C

⇒ 100 C = 300 μC – 100 μC

⇒ 100 C = 200 μC

Therefore, capacitance C = 2μF

(ii) Charge stored when voltage applied is increased by 100 V

Q' = 2μF × (150 + 100) = 500μC

20. C = 20μF = 20 X 10^{-6} F, V= 100 V , K= 5

Charge stored Q= CV = 2000μC

New value of capacitance C' = 100μF

Energy stored in a capacitor (E) =$\frac{Q^2}{2C}$

(i) Energy stored before dielectric is introduced

E_1= 0.1 J

(ii) Energy stored after dielectric is introduced (no change in the value of Q)

E_2 = 0.02J

21. C_{123} = 4μF (being in series)

$C_{eq} = C_{123} + C_4$ =16μF

(i) $Q_1 = C_4V$= 6 X 10^{-3}

(ii) $Q_2 = C_{123}$ V= 2 X 10^{-3} C

Charge on each of the capacitors C_1 ,C_2 ,C_3 = 2 X 10^{-3} C

22.Charge stored on the capacitor q=CV

When it is connected to the uncharged capacitor of same capacitance, sharing of charge takes place between the two capacitor till the potential of both the capacitor becomes $V/2$

Energy stored on the combination (U_2) =$\frac{1}{2}c\left(\frac{v}{2}\right)^2 + \frac{1}{z}c\left(\frac{v}{2}\right)^2 = \frac{cv^2}{4}$

Energy stored on single capacitor before connecting

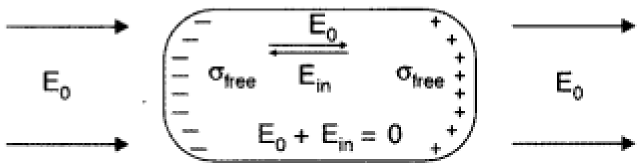
U_1=$\frac{1}{2}Cv^2$

Ratio of energy stored in the combination to that in the single capacitor

$$\frac{U_z}{v_1} = \frac{cv^{2}/_{4}}{cv^2\ /\ 2} = 1:2$$

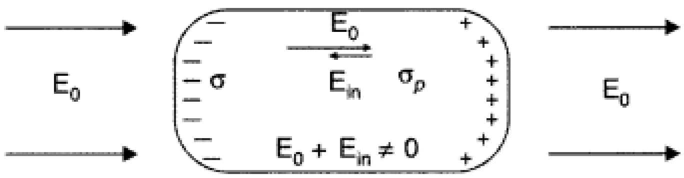
5 MARKS ANSWERS

22. (i) Behaviour of conductor in an external electric field :



Conductor

(ii) Behaviour of a dielectric in an external electrical field :



Dielectric

Explanation: In the presence of electric field, the free charge carriers in a conductor move the charge distribution and the conductor readjusts itself so that the net Electric field within the conductor becomes zero.

In a dielectric, the external electric field induces a net dipole moment, by stretching / reorienting the molecules. The electric field, due to this induced dipole moment, opposes, but does not exactly cancel the external electric field.

Polarisation: Induced Dipole moment, per unit volume, is called the polarisation. For Linear isotropic dielectrics having a susceptibility x_c, we have polarisation (p) as: $p = X_c E$

23. In first case $C_1 = \varepsilon o K x (l x b)/d$……….(i)

In second case, these two apartments are in parallel, their net capacity would be the sum of two individual capacitances

$C_2 = C'_2 + C''_2$

$$= \frac{\varepsilon_0 K_1 \left(\frac{l}{2} \times b\right)}{d} + \frac{\varepsilon_0 K_2 \left(\frac{l}{2} \times b\right)}{d}$$

$$\Rightarrow C_2 = 2\varepsilon_0 \frac{(l \times b)}{d} (K_1 + K_2) \qquad \ldots(ii)$$

Since these are identical capacitors, comparing (i) and (ii), We have $C_1 = C_2$

$$\frac{\varepsilon_0 K(l \times b)}{d} = \varepsilon_0 \frac{(l \times b)}{d}\left(\frac{K_1 + K_2}{2}\right)$$

$$\therefore \quad \mathbf{K = \frac{K_1 + K_2}{2}}$$

24.Given : d' = 3d, K = 10, C = ?, Q' = ?, U'_d= ?

(i) For parallel plate capacitor

$$C = \frac{\epsilon_0 A}{d}$$

Let the new capacity be C'

$$C' = \frac{K \epsilon_0 A}{d'} = \frac{10 \times (\epsilon_0 A)}{3d}$$

$$[\because K = 10,\ d' = 3d]$$

$$\Rightarrow \quad \left(\frac{10}{3}\right)\left(\frac{\epsilon_0 A}{d}\right) = \frac{10}{3}C$$

$$\Rightarrow \quad \mathbf{C' = \frac{10}{3}C}$$

(*ii*) Since V remains the same as the battery is not disconnected,

$Q' = C'V$

$$Q' = \left(\frac{10}{3}C\right)V = \frac{10}{3}CV = \frac{10}{3}Q$$

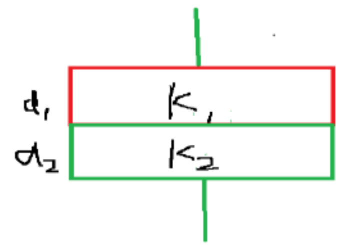
$$\Rightarrow \quad \mathbf{Q' = \frac{10}{3}Q}$$

****

SECTION- C

1 MARK QUESTIONS

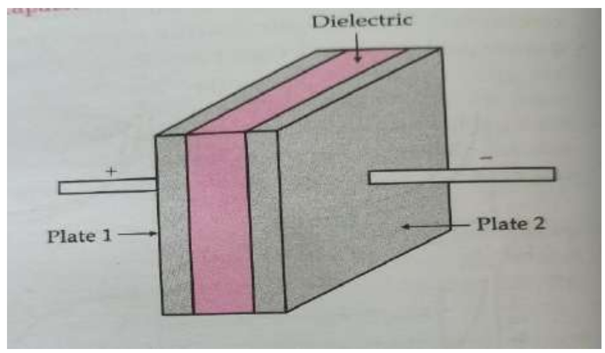
Q1. A parallel plate capacitor is made of two dielectric blocks in series. One of the blocks has thickness d_1 and dielectric constant K_1 and the other has thickness d_2 and dielectric constant K_2 as shown in figure. This arrangement can be thought as a dielectric slab of thickness d (= $d_1 + d_2$) and effective dielectric constant K. Then K is



(a) $\frac{k_1 d_1+k_2 d_2}{d_1+d_2}$ **(b)** $\frac{k,d,+k_2 d_2}{k_1+k_2}$

(c) $\frac{k_2k_1+(d_1+d_2)}{(k_1a,+k_2d_2)}$ **(d)** $\frac{2k_1k_2}{k_1^{+}k_2}$

Q2. **CASE BASED STUDY QUESTION**



An arrangement of two conductors separated by an insulating medium can be used to store electric charge and electric energy. Such a system is called a capacitor. The more charge a capacitor can store, the greater is its capacitance. Usually, a capacitor consists of two conductors having equal and opposite charge +Q and -Q. Hence, there is a potential difference V between them. By the capacitance of a capacitor, we mean the ratio of the charge Q to the potential difference V. By the charge on a capacitor we mean only the charge Q on the positive plate. Total charge of the capacitor is zero. The capacitance of a capacitor is a constant and depends on geometric factors, such as the shapes, sizes and relative positions of the two conductors, and the nature of the medium between them. The unit of capacitance is farad (F), but the more convenient units are μF and pF. A commonly used capacitor consists of two long strips or metal foils, separated by two long strips of dielectrics, rolled up into a small cylinder. Common dielectric materials are plastics (such as polyestors and polycarbonates) and aluminium oxide. Capacitors are widely used in radio, television, computer, and other electric circuits.

1.A parallel plate capacitor C has a charge Q . The actual charge on its plates are

(a) Q,Q (b) Q/2, Q/2 (c) Q ,-Q (d) Q/2, -Q/2

2.A parallel plate capacitor is charged. If the plates are pulled apart .

(a) the capacitance increases (b) the potential difference increases

(c) the total charge increases (d) the charge & potential difference remains the same

3.Three capacitors of 2 , 3 & 6 μF are connected in series to a 10 V source. The charge on the 3 μF capacitor is

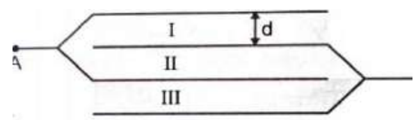
(a) 5μC (b) 10μC (c) 12μC (d) 15μC

4.If n capacitors each of capacitance C are connected in series, then the equivalent capacitance of the combination is

(a) NC (b) n^2C (c) C/n (d) C/n^2

2 MARKS QUESTIONS

Q3. A capacitor has some dielectric between its plates and the capacitor is connected to a DC source. The battery is now disconnected and then the dielectric is removed. State whether the capacitance, electric field, charge stored and the voltage will increase, decrease or remain constant.

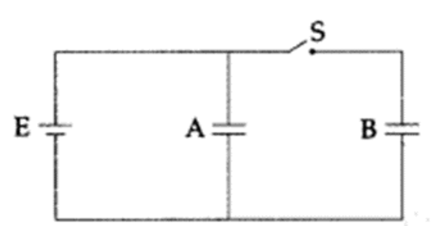


Q4.What is the capacitance of arrangement of 4 plates of area A at distance d in air in fig.

Q5. A parallel plate capacitor has square plates of side 5 cm and separated by a distance of 1 mm. (a) Calculate the capacitance of this capacitor. (b) If a 10 V battery is connected to the capacitor, what is the charge stored in any one of the plates? (The value of $\varepsilon_o = 8.85 \times 10^{-12}$ $Nm^2 C^{-2}$)

3 MARKS QUESTIONS

Q6. A 200 μF parallel plate capacitor having plate separation of 5 mm is charged by a 100 V dc source. It remains connected to the source. Using an insulated handle, the distance between the plates is doubled and a dielectric slab of thickness 5 mm and dielectric constant 10 is introduced between the plates. Explain with reason, how the (i) capacitance, (ii) electric field between the plates, (iii) energy density of the capacitor will change ?



Q7.Two identical parallel plate capacitors A and B are connected to a battery of V volts with the switch S closed. The switch is now opened and the free space between the plates of the capacitors is filled with a dielectric of dielectric constant K.

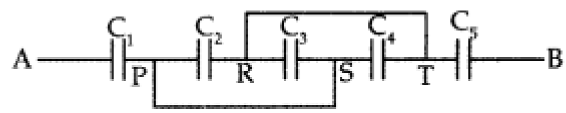
Find the ratio of the total electrostatic energy stored in both capacitors before and after the introduction of the dielectric.

5 MARKS QUESTIONS

Q8. A capacitor of unknown capacitance is connected across a battery of V volt. A charge of 120 μC is stored in it. When the potential across the capacitor is reduced by 40 V, the charge stored in the capacitor becomes 40 μC. Calculate V and the unknown capacitance. What would have been the charge in the capacitor if the voltage were increased by 40 V?

Q9. A capacitor of unknown capacitance is connected across a battery of V volt. A charge of 240 pC is stored in it. When the potential across the capacitor is reduced by 80 V, the charge stored in the capacitor becomes 80 pC. Calculate V and the unknown capacitance. What would have been the charge in the capacitor if the voltage were increased by 80 V?

Q10. Find equivalent capacitance between A and B in the combination given below. Each capacitor is of 2 μF capacitance.



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SECTION-C ANSWER KEY

1. (c) Here the system can be considered as two capacitors C_1 and C_2 connected in series.

CASE BASED STUDY QUESTION

2. 1.(c) 2. (b) 3. (b) 4.(c)

2 MARKS ANSWERS

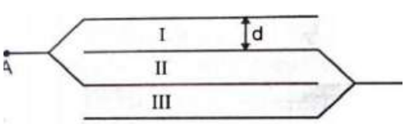
3. The capacitance of the parallel plate capacitor, filled with dielectric medium of dielectric constant K is given by $C=K\epsilon_0 A/d$

The capacitance of the parallel plate capacitor decreases with the removal of dielectric medium as for air or vacuum K = 1 and for dielectric K > 1.

If we disconnect the battery from capacitor, then the charge stored will remain the same due to conservation of charge.

The potential difference across the plates of the capacitor is given by $V = q/C$ Since q is constant and C decreases which in turn increases V and therefore E increases as $E = V/d$.

4.



$C_p=3C=3A\varepsilon_O/d$

5. The capacitance of this capacitor is 221.2×10^{-13} F. The charge stored in any one of the plates 221.2 pC.

3 MARKS ANSWERS

6. Dielectric slab of thickness 5mm is equivalent to an air capacitor of thickness = $\frac{5}{10}$mm

Effective separation between the plates with air in between is = 5.5 mm

Effective new capacitance = 200 μF X $\frac{5}{5\cdot5}$ = 182 μF

(ii)Effective new electric field = $\frac{100}{5\cdot5\times10^{-3}}$ =18182 V/m

New energy stored / original energy stored = 10/11

7.Given : $C_A = C_B = C$, Dielectric costant = K

Energy stored = $\frac{1}{2}Cv^2$ (i)

Net capacitance with switch S closed = C+C= 2C

E_1= Energy stored = CV^2 (ii)

After switch S is opened, capacitance of each capacitor = KC

Energy stored in capacitor A = $\frac{1}{2}kcv^2$ (iii)

For capacitor B,

Energy stored = $\frac{Cv^2}{2k}$ (iv)

From equations (iii) & (iv)

E_2 = Total energy stored = $\frac{1}{2}cv^2\left(\frac{k^2+1}{k}\right)$

Required Ratio = $\frac{E_1}{E_2} = \frac{2k}{k^2+1}$

5-MARKS ANSWERS

8. Answer:

Given : $q_1 = 360\ \mu C = 360 \times 10^{-6}\ \mu C$, $q_2 = 120\ \mu C$
$= 120 \times 10^{-6}$ C

$C = \frac{q_1}{V_1}$. Also $C = \frac{q_2}{V_2}$ and $C = \frac{q_3}{V_3}$

[∵ Capacitor is the same

$$\because \quad \frac{q_1}{V_1} = \frac{q_2}{V_2}$$

$$\Rightarrow \quad \frac{(360 \times 10^{-6})}{V} = \frac{(120 \times 10^{-6})}{(V - 120)}$$

On solving, **V = 180 V**

$$C = \frac{360 \times 10^{-6}}{180}$$

= **2μF** is the unknown capacitance.

Now the voltage has been increased by 120 V, then V = 180 + 120 = 300 V

$$C = \frac{q_3}{300} = 2\mu F$$

$$q_3 = 300 \times \mu C$$

>

q_3 = 600 μC would be charge on the capacitor if voltage were incresed by 120 V.
[Ans : V = 60 V, c = 2 pF, Q3 = 200 μC].

9.

Given : $q_1 = 360\ \mu C = 360 \times 10^{-6}\ \mu C$, $q_2 = 120\ \mu C$
$= 120 \times 10^{-6}$ C

$C = \frac{q_1}{V_1}$. Also $C = \frac{q_2}{V_2}$ and $C = \frac{q_3}{V_3}$

[$\because$ Capacitor is the same

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$=$ **2μF** is the unknown capacitance.

Now the voltage has been increased by 120 V, then V = 180 + 120 = 300 V

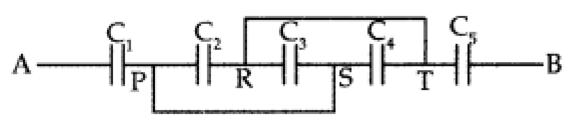
$$C = \frac{q_3}{300} = 2\mu F$$

$$q_3 = 300 \times \mu C$$

$q_3 = 600\ \mu C$ would be charge on the capacitor if voltage were incresed by 120 V.
[Answer : V = 120 V, c = 2 μF, Q = 400 μC]

10.

Given : $C_1 = C_2 = C_3 = C_4 = C_5 = 2\mu F$
$= 2 \times 10^{-6}$ F



(*i*) Capacitors C_2, C_3 and C_4 are in parallel

$\therefore \quad C_{234} = C_2 + C_3 + C_4 = 2 + 2 + 2$

$\therefore \quad C_{234} = 6\mu F$

Capacitors C_1, C_{234} and C_5 are in series

$$\therefore \ \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_{234}} + \frac{1}{C_5} = \frac{1}{2} + \frac{1}{6} + \frac{1}{2} = \frac{7}{6}\mu F$$

$$C_{equivalent} = \frac{\mathbf{6}}{\mathbf{7}}\mu F = \frac{6}{7} 10^{-6}\ F$$

(*ii*) Charge drawn from the source

$$Q = C_{eq}\ V = \frac{6}{7} \times 7\ \mu C = 6\ \mu C$$

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QUESTION BANK

CHAPTER 3- CURRENT ELECTRICITY

SECTION-A

1-MARK QUESTIONS

Q1.What is meant by current and conventional current?

Q2.Define SI unit of current.

Q3. 1 Ω=1V/1A From this what do you mean by 1 ohm?

Q4.How does drift velocity of electrons change with temperature?

Q5.What is the effect of temperature on the relaxation time of electrons in a metal?

Q6. A wire or resistivity ρ is stretched to double its length. What will be its new resistivity?

Q7.Which physical quantity does the voltage versus current graph for a metallic conductor depict? Give its SI unit.

Q8.Draw the graph showing the variation of resistance of a cylindrical conductor with its radius

Q9.Draw the graph showing the variation of resistance of a conductor with rise in temperature.

Q10.Answer the following questions:

(a) Alloys of metals usually have ___________ resistivity than that of their constituent metals.

(b) Alloys usually have much ___________ temperature coefficients of resistance than pure metals.

(c) The resistivity of the alloy manganin is _______________ rapidly with increase of temperature.

(d) The resistivity of a typical insulator (e.g., amber) is greater than that of a metal by a factor of the order of _______________

Q11. If 2.25×10^{20} electrons pass through a wire in one minute, find the magnitude of the current flowing through the wire.

Q12. Define EMF of a cell.

Q13. What happens to the conductivity of electrolytes as temperature is increased?

Q14. What are ohmic conductors? Give two examples.

Q15. What are non ohmic devices. Give two examples.

Q16. Draw V-I graph for GaAs.

Q17. How is temperature coefficient of resistivity for metals is different from temperature coefficient of resistivity for semiconductor.

Q18. Name two substances for which temperature coefficient of resistivity is positive.

Q19. Name two materials for which temperature coefficient of resistivity is negative.

Q20. How is temperature coefficient of resistivity different for metals and alloys.

Q21.What happens to resistivity of metals with increase in temperature?

Q22. What happens to resistivity of semiconductors or insulators with increase in temperature?

Q23.Define terminal potential difference of a cell.

Multiple Choice Questions (Each 1M)

Choose the correct option(s) in the following questions.

Q24**.** The resistance of a metal wire increases with increasing temperature on account of

(a) decrease in free electron density.

(b) decrease in relaxation time.

(c) increase in mean free path.

(d) increase in the mass of electron.

Q25. $m^2 V^{-1} s^{-1}$ is the SI unit of which of the following?

(a) Drift velocity (b) Mobility (c) Resistivity (d) Potential gradient

Q26. Resistivity of a given conductor depends upon

(a) temperature. (b) length of conductor. (c) area of cross-section. (d) shape of the conductor.

Q27. The carriers of electricity in a metallic conductor are

(a) holes (b) negative ions (c) positive ions (d) electrons

Q28. The time rate of flow of charge through any cross section of a conductor is ______

(a) electric potential (b) electric current(c) electric intensity (d) electric charge

Q29. When no current is passed through a conductor:

(a) the free electrons do not move

(b) the average speed of a free electron over a large period of time is not zero

(c)the average velocity of a free electron over a large period of time is zero

(d) the average of the velocities of all the free electrons at an instant is non-zero

Q30. A steady current is flowing through a conductor of non-uniform cross-section. The charge passing through any cross-section of it per unit time is:

(a) directly proportional to the area of cross-section

(b) inversely proportional to the area of cross-section

(c) proportional to square of the area of cross-section

(d) independent of the area of cross-section

Q31. Drift velocity of electrons is due to:

(a) motion of conduction electrons due to random collisions.

(b) motion of conduction electrons due to electric field *E*.

(c) repulsion to the conduction electrons due to inner electrons of ions.

(d) collision of conduction electrons with each other.

Q32.Identify the set in which all the three materials are good conductors of electricity:

(a)Cu, Ag and Au (b) Cu, Si and diamond (c) Cu, Hg and NaCl (d) Cu, Ge and Hg

Q33.The I-V characteristics shown in figure represents:

(a)ohmic conductors (b)non-ohmic conductors (c)insulators (d)superconductors

Q34. In the equation AB = C, A is the current density, C is the electric field, Then B is:

(a)resistivity (b) conductivity (c) potential difference (d) resistance

Q35.If a current of 0.5 A flows in a 60 W lamp, then the total charge passing through it in two hours will be:

(a)1800 C (b) 2400 C (c) 3000 C (d) 3600 C

Q36.The relaxation time in conductors:

(a)increases with the increases of temperature (b)decreases with the increases of temperature

(c)it does not depend on temperature (d)all of sudden changes at 400 K

Q37. A steady current of 1 A is flowing through the conductor. The number of electrons flowing through the cross-section of the conductor in 1 sec is:

(a)6.25×10^{15} (b) 6.25×10^{17} (c) 6.25×10^{19} (d) 6.25×10^{18}

Q38. Drift speed of electrons, when 1.5 A of current flows in a copper wire of cross-sectional area 5 mm^2 is v. If the electron density of copper is $9 \times 10^{28}/m^3$ the value of v in mm/s is close to (Take charge of electron to be = 1.6×10^{-19} C)

(a) 3 (b) 0.2 (c) 2 (d) 0.02

Q39. A current of 2 mA was passed through an unknown resistor which dissipated a power of 4.4 W. Dissipated power when an ideal power supply of 11 V is connected across it is

(a) 11×10^{-4} W (b) 11×10^{-5} W (c) 11×10^{5} W (d) 11×10^{-3} W

Q40. Nichrome and copper wires of same length and area of cross section are connected in series, current is passed through them, which wire gets heated first?

(a) Nichrome (b) copper (c) both equally (d) none of them

Q41. The specific resistance of a conductor increases with

(a) increase in temperature (b)increase in cross-sectional area

(c) decrease in length (d)decrease in cross-sectional area

Q42. Nichrome or Manganin is widely used in wire bound resistors because of their

(a)temperature independent resistivity (b)very weak temperature dependent resistivity

(c)strong dependence of resistivity with temperature (d)mechanical strength

Q43.EMF is electromotive force, what is its SI unit:

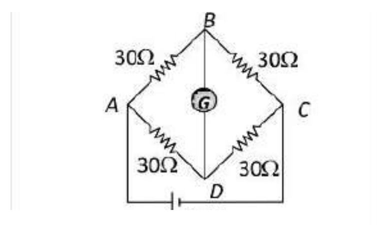
a) Newton b) Newton sec c) Joule / coulomb d) Newton meter

Q44. Kirchhoff's laws are based upon

a) Law of conservation of energy b) law of conservation of charge

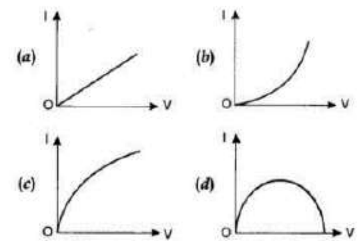
c) both of these d) none of these

Q45. In the following figure current flowing through BD is



(a) 0 (b)0.033 A (c) 0.066 A
(d) None of these

Q46. Which of the following I-V graph represents ohmic conductors?



Q47.The specific resistance of a rod of Aluminium as compared to that of thin wire of Aluminium is:

(a) less (b) more (c) same (d) depends upon the length and area of cross-section

Q48. A current passes through a wire of non-uniform cross section. Which of the following quantities are independent of cross section

(a) the charge crossing (b)Drift velocity (c)current density
(d)number density of free electrons

Q49. When a battery of internal resistance 0.5 ohm is connected to a thick copper slab, a current of 12A passes through it. The emf of the cell is

(a) 6V (b) 24V (c) 12V (d) 4V

ASSERTION AND REASONS (Each 1M)

Directions: In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as:

(a) If both assertion and reason are true and reason is the correct explanation of assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of assertion.

(c) If assertion is true but reason is false.

(d) If both assertion and reason are false.

Q50.**Assertion:** The current density j at any point in ohmic resistor is in direction of electric field E at that point.

Reason: A point charge when released from rest in a region having only electrostatic field always moves along electric lines of force.

Q51.**Assertion:** The 200 W bulbs glows with more brightness then 100 W bulbs.

Reason: A 100 W bulb has more resistance than a 200 W bulb.

Q52. **Assertion:** Bending a wire does not affect electrical resistance.

Reason: Resistance of wire is proportional or resistivity of material.

Q53. **Assertion:** Fuse wire must have high resistance and low melting point.

Reason: Fuse is used for small current flow only.

Q54. **Assertion**: Two electric bulbs of 50 W and 100 W are given. When connected in series 50 W bulb glows more but when connected parallel 100 W bulb glows more.

Reason: In series combination, power is directly proportional to the resistance of circuit. But in parallel combination, power is inversely proportional to the resistance of the circuit.

Q55.**Assertion**: When current through a bulb decreases by 0.5%, the glow of bulb decreases by1%.

Reason: Glow (Power) which is directly proportional to square of current.

Q56. **Assertion**: Two bulbs of same wattage, one having a carbon filament and the other having a metallic filament are connected in series. Metallic bulbs will glow more brightly than carbon filament bulb.

Reason: Carbon is a semiconductor.

Q57. **Assertion**: A current flows in a conductor only when there is an electric field within the conductor.

Reason: The drift velocity of electron in presence of electric field decreases.

Q58. **Assertion**: In practical application, power rating of resistance is not important.

Reason: Property of resistance remain same even at high temperature

2 MARK QUESTIONS

Q59. A potential difference of 10 V is applied across a conductor of resistance 1 kΩ. Find the number of electrons flowing through the conductor in 5 minutes.

Q60. Whatis drift velocity of electrons? How do you explain the flow of current in a conductor based on this?

Q61. Establish the relation between drift velocity and electric current.

Q62.What is non-Ohmic device? Give one example.

Q63. Define relaxation time of electrons in a conductor. Give its SI units. Explain, how it varies with increase in temperature of conductor?

Q64. State Ohm's law. Discuss three situations which describe the failures of Ohm's law.

Q65. A negligibly small current is passed through a wire of length 15 m and uniform cross-section 6.0×10^{-7} m^2 , and its resistance is measured to be 5.0 Ω. What is the resistivity of the material at the temperature of the experiment?

Q66. What are the factors on which the resistance of a conductor depends? Give the corresponding relation.

Q67. A potential difference of 6 V is applied across a conductor of length 0.12 m. Calculate the drift velocity of electrons, if the electron mobility is 5.6×10^{-6} m^2 V^{-1} s^{-1} conductor.

Q68. A current of 1 A flows through a wire of length 0.24 m and area of cross-section 1.2 mm^2, when it is connected to a battery of 3 V. Find the number density of free electrons in the wire, if the electron mobility is 4.8 x 10^{-6} m^2 V^{-1} s^{-1}.

Given that charge on electron = 1.6 x 10^{-19} C.

Q69. An electron moves in a circle of radius 0.15 m with a constant speed of 3.6×10^6 m s^{-1}. What electric current does this correspond to?

Q70.A silver wire has a resistance of 2.1 Ω at 27.5 °C, and a resistance of 2.7 Ω at 100 °C. Determine the temperature coefficient of resistivity of silver.

Q71. Define electric power and electric energy. Give their SI units.

Q72. Define conductivity of a conductor. State its SI unit. Explain the variation of conductivity with temperature of a metallic conductor.

Q73. Derive an expression for electric energy consumed in a device in terms of V,I and t, where V is the potential difference applied to it, I is the current drawn by it and t is the time for which current flows?

Q74.Is electric current a scalar or vector quantity? Give reason.

Q75. Why is a Wheatstone Bridge so called?

Q76. What do you mean by sensitivity of Wheatstone Bridge? when is wheat stone Bridge most sensitive?

Q77. What are the advantages of a Wheatstone Bridge method of measuring resistances over other methods?

Q78. Draw a circuit of balanced Wheatstone Bridge and label it.

Q79. Why is EMF of a cell always greater than terminal potential difference? Is there a case when terminal potential difference is greater than emf?

3 MARK QUESTIONS

Q80. What are the factors on which internal resistance of a cell depend?

Q81. Show the variation of resistivity of

i) copper with temperature ii) Nichrome with temperature. iii)silicon with temperature

Q82. Two cells of different emfs and internal resistance are connected in series with one another find the expressions for equivalent EMF and equivalent internal resistance of the combination.

Q83. A resistance R is connected across a cell of emf 8V and internal resistance r. A Voltmeter now measures the potential difference between the terminals of the cell as V. Obtain the expression for r in terms of E, V and R. Draw related circuit diagram also.

5 MARK QUESTIONS

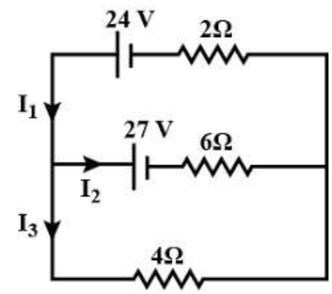
Q84.Define resistivity of a conductor and give its SI unit. Plot a graph showing the variation of resistivity with temperature for (i). Copper (ii).Nichrome (iii).Semiconductor.

How does one explain such a behavior, using the mathematical expression of the resistivity of a conductor?

Q85. Explain the variation of resistivity, of metals, semiconductors, insulators with graphs and hence define temperature coefficient of resistivity, write its si unit.

Q86. State Kirchhoff's laws and explain them using appropriate circuit diagrams. Write about the fundamental principles on which they are based.

Q87. Applying the Kirchhoff's laws in following circuit diagram, Write all relations between I_1,I_2, and I_3



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SECTION- A- ANSWER KEY

1. Rate of flow of charge is called as current. The current that flows from positive pole to negative pole of a cell in the external circuit is called conventional current.

2. One ampere is that current when one Coulomb of charge flows through the conductor in one second

3.If the potential difference between the ends of conductor is 1 V and if a current of 1 A flow through it, then the resistance of the conductor is 1Ω.

4. Inversely proportional to temperature

5.The relaxation time of electrons decreases with the rise in temperature of the metal.

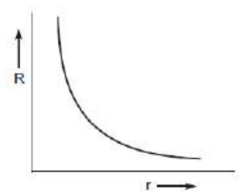
6.The resistivity remains the same as it does not depend upon the length of the wire.

7.It represents resistance. It is measured in ohm.

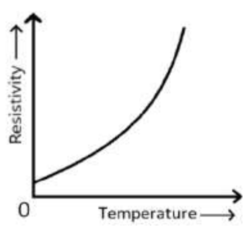
8.

Resistance of a conductor of length l, and radius r is given by

$$R = \rho \frac{\ell}{\pi r^2}$$



9.



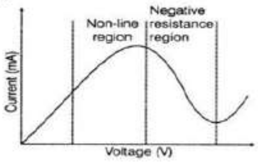
10.(a) greater (b) lower (c) nearly independent of (d) 10^{22}

11.0.6A

$$I = ne/t = \frac{2.25 \times 10^{20} \times 1.6 \times 10^{-19}}{60} = 0.6 \text{ A}$$

12.

Variation of current *versus* voltage for the material GaAs.



13. Conductivity increases due to increase in movement of ions with temperature.

14. (a) A metallic conductor for small amounts of current.

(b) Electrolytes such as $CUSO_4$ solution with copper electrodes.

15.Non-ohmic devices are those that do not obey Ohm's law. Vacuum tubes and thermistors are two examples.

16.The maximum potential difference which is present between two electrodes of a cell is defined as the electromotive force of a cell or EMF of a cell.

17.The temperature coefficient of resistivity is positive for metals and negative for semiconductor.

18.Gold, silver

19.silicon, germanium

20.The value of temperature co-efficient of resistance *(alpha) is more for metals than for alloys.*

21. It increases with rise in temperature.

22. Increases

23. Terminal potential difference of a cell is defined as the potential difference between the two electrodes of a cell in a closed circuit

Multiple Choice Questions –answers

24.(b) 25.(b) 26. (a) 27. (d) 28. (b) 29. (d) 30. (d) 31. (b) 32. (a) 33. (b) 34. (a) 35. (d) 36. (b)

37. (d)

38.As $I = neAv_d$

$v_d = I/neA = 1.5/(9 \times 10^{28} \times 1.6 \times 10^{-19} \times 5 \times 10^{-6})$

$v = 0.02 \times 10^{-3}$ m/s = 0.02 mm/s

Answer: (d) 0.02

39. Case (1)As $I^2R = P$

$R = P/I^2$

$R = (4.4)/(2 \times 10^{-3})^2 = 1.1 \times 10^6\ \Omega$

Case (2)$P = V^2/R = (11)^2/(1.1 \times 10^6) = 11 \times 10^{-5}$ W

Answer: (b) 11 × 10^{-5} W

40. (a) Nichrome

41. (a) Increase in temperature

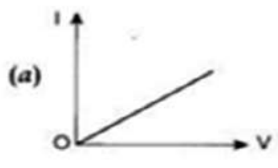
42. (b) very weak temperature dependent resistivity

43. (c) Joule / coulomb

44. (c) both of these

45. (a) 0

46. (a)



47. (c) same

48. (d) number density of free electrons

49. (a) 6V

Assuming copper slab to be ideal conductor i.e. R = 0
$\Rightarrow E = I \times r$
$E = 12 \times 0.5$
$E = 6V$

ASSERTION AND REASONS (Each 1M)

50. (C) 51. (A) 52. (A) 53. (C) 54. (A) 55. (A) 56. (D) 57. (C) 58. (D)

2 MARK QUESTIONS

59. 1.875 x 10^{19}

I = V/R = 10^{-2}A = q/t

q = It = ne

n = 1.875 x 10^{19}

60**.** When electrons are subjected to an electric field they do move randomly, but they slowly drift in one direction, in the direction of the electric field applied. The net velocity at which these electrons drift is known as drift velocity.

61.Let l is the length of the conductor and A uniforms area of cross-section.

Therefore, the volume of the conductor = Al

If n is the number of free electrons per unit volume of the conductor, then the total number of free electrons in the conductor=Aln.

If e is the charge on each electron, then total charge on all the free electrons in the conductor q=Alne

Let a constant potential differences V is applied across the ends of the conductor with the help of a battery

The electric field set up across the conductor is given by

E=V/l

$t=l/v_d$

As current I=q/t

$I=neAv_d$.

62.A device that does not obey Ohm's law is non ohmic device. Ex. Semiconductor diode

63. Relaxation time is the time interval between two successive collisions of electrons in a conductor, when current flows

Second Inversely proportional to temperature

64. It states that the current through any two points of the conductor is directly proportional to the potential difference applied across the conductor provided that the physical conditions remains constant.

(a) V ceases to be proportional to I.

(b) The relation between V and I depends on the sign of V. In other words, if I is the current for a certain V, then reversing the direction of V keeping its magnitude fixed, does not produce a current of the same magnitude as I in the opposite direction. This happens, for example, in a diode.

(c) The relation between V and I is not unique, i.e., there is more than one value of V for the same current I. A material exhibiting such behavior is GaAs.

65.Length = 15 m

Area of cross section 6×10^{-7} m^2

R= 5 Ohms

Resistivity $=p=\frac{RA}{l}=2.0 \times 10^{-7}\Omega m$

66. The resistance of a wire depends on its length (l), cross-sectional area (A), number of electrons per m^3 (n) and the relaxation time $R=\frac{m\ \ l}{ne^2\tau A}$

67.Ans. 2.8 x $10^{-4}ms^{-1}$

$E = V/l = 50$ V/m

$v_d = \mu E = 2.8 \times 10^{-4} ms^{-1}$

68. $E = V/l = 12.5$ V/m

$v_d = \mu E = 6 \times 10^{-5} ms^{-1}$

$n = \frac{I}{Aev_d} = 8.68 \times 10^{28} m^{-3}$

69. The electron crosses a point on the circle once in every revolution. If v is number of revolutions made by the electron in 1 s, then its motion along circle corresponds to a current,

$I = ef = e/T = \frac{ev}{2\pi r} = 6.1 \times 10^{-13}$ A

70. Temperature coefficient of resistivity of silver = α

$$\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)}$$

$$\alpha = \frac{2.7 - 2.1}{2.1(100 - 27.5)} = 0.0039^\circ C^{-1}$$

71. **Electric energy**: The total work done by the source of emf in maintaining an electric current in a circuit for a given time is called electric energy consumed in the circuit. Its SI unit is joule.

Electric power: The rate at which work is done by a source of emf in maintaining an electric current through a circuit is called electric power of the circuit. Its SI unit is Watt.

72. Conductivity (or specific conductance) of a conductor is a measure of its ability to conduct electricity. It is also reciprocal of resistivity of the conductor. The SI unit of conductivity is Siemen per meter (S/m). The electrical conductivity of a metallic conductor will decrease with an increase in temperature.

73. Electric energy consumed = W=Q×V

$I = \frac{Q}{t}$

W=I×t×V

$\therefore W = I \times t \times V$

Is also = I^2Rt and $\frac{V^2 t}{R}$

74. Electric current is a scalar quantity the reason is that laws of ordinary algebra are used to add electric currents and laws of vector additions do not apply to the addition of electric currents.

75.It is so called because this method was first suggested by a British physicist Charles Wheatstone in 1843.It is called a bridge because galvanometer circuit forms a kind of bridge by connecting two points having the same potential.

76. Wheatstone bridge is said to be sensitive if it produces more deflection in the galvanometer for a small change of resistance in resistance arm. It is most sensitive when all four resistors P, Q, R, S are nearly of same magnitude and null point is obtained in the middle of alloy wire.

77. a) It is a null point method hence the result is free from the effect of extra resistances of the circuit.

b) As it is null point method so it is easier to detect a small change in deflection.

78.Diagram of Wheatstone bridge.

79. The EMF of a cell is greater than its terminal voltage because there is some potential drop across the cell due to its small internal resistance. During charging of a cell, terminal potential difference is greater than emf

3 MARK QUESTIONS

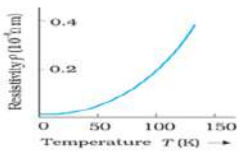
80.i. The surface area of electrodes- Larger the surface area of electrodes, less is the internal resistance.

ii. Distance between electrodes- More the distance between the electrodes, the greater is the internal resistance.

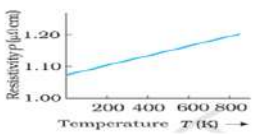
iii. Concentration of electrolyte - less ionic the electrolyte or higher the concentration of electrolyte, greater is the internal resistance.

iv. Temperature of electrolyte - higher the temperature, less is the internal resistance.

81.



Resistivity ρ_T of copper as a function of temperature T.



Resistivity of nichrome wire as a function of temperature

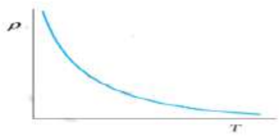


FIGURE 3.11 Temperature dependence of resistivity for a typical semiconductor.

82. $E_{eq} = E_1 + E_2 + E_3$ ———- $E_n = nE$

$r_{eq} = r_1 + r_2 + r_3$ ———- $r_n = nr$

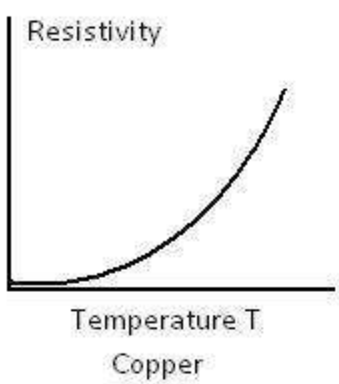
83. Obtain following all the steps $r = \frac{(E-V)R}{V}$

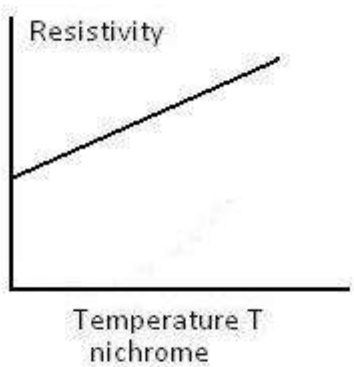
5 MARK QUESTIONS

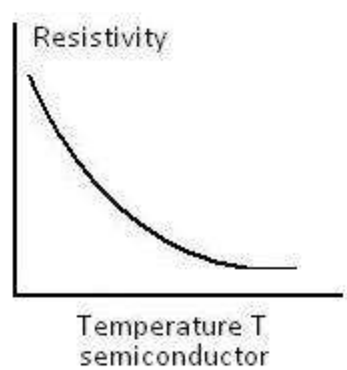
84. We know that, $R=\frac{pl}{A}$

$l=1m$, $A=1m^2 \Rightarrow p=R$

Thus, resistivity of a material is numerically equal to the resistance of the conductor having unit length and unit cross-sectional area and its SI unit is Ohm-m







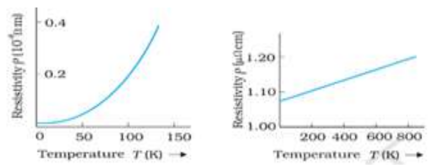
The resistivity of a material is found to be dependent on the temperature. The resistivity of a metallic conductor is given by

$p_T=p_o[1+\alpha (T-T_0)]$ ....(i)

Where p_T is the resistivity at a temperature T and p_0 is the same at a reference temperature T_0, α is called the temperature co-efficient of resistivity. This expression shows that resistivity increases with increase in temperature of the conductor

85.Explanation using

$$\rho = \frac{1}{n\tau}$$



Resistivity ρ_T of copper as a function of temperature T.

Resistivity of nichrome wire as a function of temperature

temperature coefficient of resistivity

$$\alpha = \frac{\Delta\rho}{\rho_0 \Delta T}$$

SI unit – K^{-1}

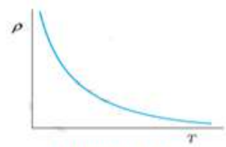


FIGURE 3.11 Temperature dependence of resistivity for a typical semiconductor.

86. Kirchhoff's laws explanations from book.

1st law is based upon law of conservation of charge and 2nd law is based upon law of conservation of energy.

87.$I_1 = I_2 + I_3$ ………………….. (1) (Using KCL)

$4 I_3 + 2 I_1 - 24 = 0$ ……………………(2) (Using KVL)

$4 I_3 - 6 I_2 - 27 = 0$ ………………….. (3) (Using KVL)

****

SECTION – B

1-Mark Questions

Q1. Is current density scalar or vector quantity?

Q2. Steady current is flowing in cylindrical conductor. Does electric field exist within the conductor?

Q3. When a straight wire of resistance R bent into U-shape, does its resistance change?

Q4. If the radius of copper wire is doubled, will its specific resistance increase, decrease or remain same?

Q5. What is the effect of heating of conductor on the drift velocity of free electrons?

Q6. A uniform wire resistance 50 ohms is into equal parts. These parts are now connected parallel. What the value equivalent resistance of combination?

Q7. What happens to the power dissipation if the value of electric current passing through conductor of constant resistance doubled?

Q8. Define the resistivity and write the SI unit.

Q9. A wire resistivity p stretched double length. What will be new resistivity?

Q10.What is the Significance of positive value of temperature coefficient of resistivity?

Q11. What is the significance of negative value of temperature coefficient of resistivity?

Q12. What happens to internal resistance of a cell after long use?

Q13. Write the relation between internal resistance, EMF, and terminal potential difference of a cell

Q14. Under what condition EMF of a cell is less than terminal potential difference**.**

Q15. How does the relaxation time of electron in the conductor change when temperature of the conductor decreases.

Q16. Resistors of high value are made up of carbon. Why?

Multiple Choice Questions (Each 1M)

Q17. In a current carrying conductor, the ratio of the electric field and the current density at a point is called

(a) Resistivity (b) Conductivity (c) Resistance (d) Mobility

Q18. Consider a current carrying wire (current I) in the shape of a circle. Note that as the current progresses along the wire, the direction of j (current density) changes in an exact manner, while the current I remain unaffected. The agent that is essentially responsible for is ________

(a) source of emf.

(b) electric field produced by charges accumulated on the surface of wire.

(c) the charges just behind the given segment of wire which push them just the right way by repulsion

(d) the charges ahead

Q19. Calculate the conductance and conductivity of a wire of resistance 0.01 Ω and area of cross section 10^{-4} m^2 and length 0.1 m.

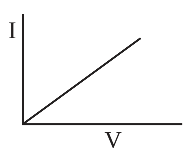
(a) 10 S and 10^5 S m^{-1}

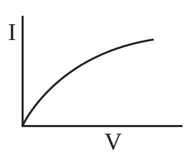
(b) 100 S and 10^4S m^{-1}

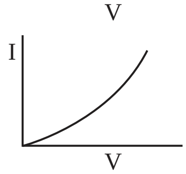
(c) 100 S and 10^6S m^{-1}

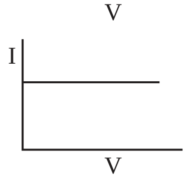
(d)100 S and 10^5 S m^{-1}

Q20. The *V*-*I* characteristics of four circuit elements are shown. Which of these is ohmic?

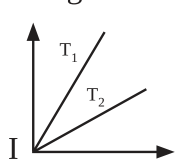
(a)


(b)


(c)


(d)


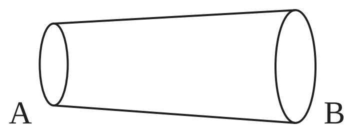
Q21. The current-voltage (*I*-*V*) graph for a given metallic wire at two different temperatures T_1 and T_2 are shown in figure. It follows from the graph that:



V

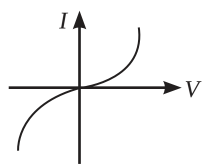
(a) $T_1 > T_2$
(b) $T_1 < T_2$
(c) $T_1 = T_2$
(d) T_1 is greater or less than T_2 depending on whether the resistance R of the wire is greater or less than the ratio V/I.

Q22. A wire has a non-uniform cross-section as shown in the figure. If a steady current is flowing through it, then the drift speed of the electrons:



(a)is constant throughout the wire
(b) decreases from A to B
(c) increases from A to B
(d) varies randomly

Q23. The I-V characteristics shown in figure represents:



(a) ohmic conductors (b) non-ohmic conductors
(c) Insulators (d) superconductors

Q24.A metal wire is subjected to a constant potential difference. When the temperature of the metal wire increases, the drift velocity of the electron in it:

(a) increases, thermal velocity of electron increases

(b) decreases, thermal velocity of electron increases

(c) increases, thermal velocity of electron decreases

(d) decreases, thermal velocity of electron decreases

Q25.Current of 4.8 amperes is flowing through a conductor. The number of electrons crossing any cross-section per second will be:

(a) 3×10^{19} (b) 7.68×10^{21} (c) 7.68×10^{20} (d) 3×10^{20}

Q26.Ohm's law deals with the relation between:

(a) current and potential difference

(b) capacity and charge

(c) capacity and potential

(d) charge and potential difference

Q27. Ohm’s law is valid when the temperature of the conductor is _____:

(a) constant (b) very high (c) very low (d) varying

Q28.Ohm’s law is valid for:

(a)metallic conductors at low temperature

(b)metallic conductors at high temperature

(c)electrolytes when current passes through them

(d)diode when current flows

Q29.In gallium-arsenide material, Ohm’s law does not hold good because:

(a)current remains constant for any value of voltage

(b)resistance is infinite

(c)negative resistance exists in the voltage-current variation

(d)current goes to infinite at very low voltages

Q30.When the length and area of cross-section both are doubled, then its resistance:

(a) will become half

(b)will be doubled

(c)will remain the same

(d)will become four times

Q31.For a metallic wire, the ratio V/I (V = the applied potential difference, I = current flowing):

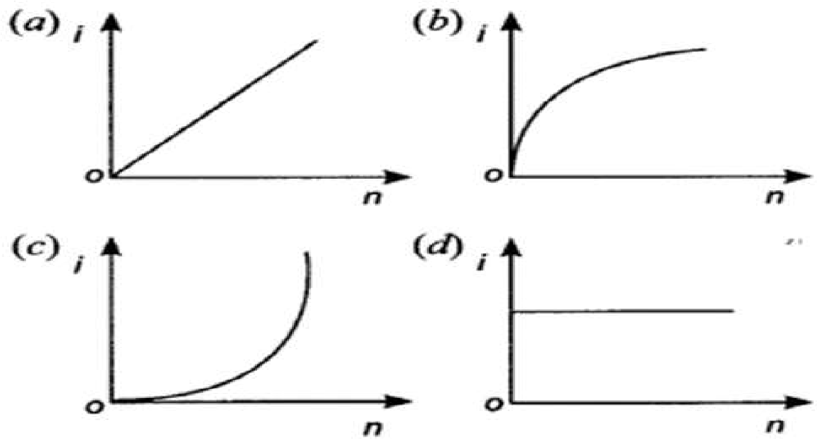
(a)is independent of temperature.

(b)increases as the temperature rises.

(c)decreases as the temperature rises.

(d)increases or decreases as temperature rises, depending upon the metal.

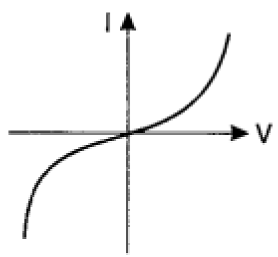
Q32. A battery consists of a variable number ′n′ of identical cells (having internal resistance ′r′ each) which are connected in series. The terminals of the battery are short-circuited and the current I is measured. Which of the graphs shows the correct relationship between I and n?



Q33.Drift velocity v_d varies with the intensity of electric field as per the relation

(a) $v_d \propto E$ (b) $v_d \propto \frac{1}{E}$ (c) v_d = constant (d) $v_d \propto E^2$

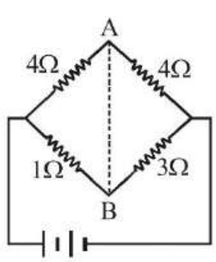
Q34. The I-V characteristics shown in figure represents



(a) ohmic conductors (b) non-ohmic conductors

(c) insulators (d) superconductors

Q35. In the circuit shown, if a conducting wire is connected between points A and B, the current



in this wire will

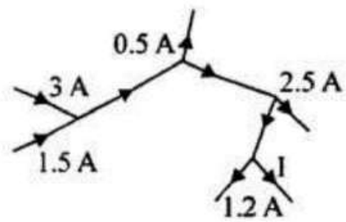
(a) flow in the direction which will be decided by the value of V

(b) be zero

(c) flow from B to A

(d) flow from A to B

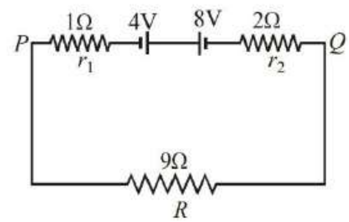
Q36.In following figure shows currents in a part of electrical circuit, then the value of I (in ampere) is given by :



(a) 0.3 A (b) 0.5 A

(c) 1.3 A (d) None of these

Q37. Two batteries of emf 4 V and 8V with internal resistance 1 ohm and 2 ohm are connected in a circuit with a resistance of 9 W as shown in figure.



The current and potential difference between the points P and Q are

a) 1 /3 A and 3 V (b) 1 /6 A and 4 V

(c) 1 /9 A and 9 V (d) 1 /12 A and 12 V

Q38. In a Wheatstone bridge all the four arms have equal resistance 2R. If the resistance of the galvanometer arm A B is also R, the equivalent resistance of the combination as seen by the battery is

(a) 2 R (b) R (c)2R (d) 4 R

Assertion-Reasoning Questions

Directions: These questions consist of two statements, each printed as Assertion and Reason. While answering these questions, you are required to choose any one of the following four responses.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

(c) If the Assertion is correct but Reason is incorrect.

(d) If both the Assertion and Reason are incorrect.

Q39.**Assertion**: There is no current in the metals in absence of electric field.

Reason: Motion of free electrons is randomly.

Q40. **Assertion**: A wire carrying an electric current has no electric field around it.

Reason: Rate of flow of electrons in One direction is equal to rate of flow of protons in opposite direction

Q41. **Assertion**: In a simple battery circuit, the point of the lowest potential is positive terminal of the battery.

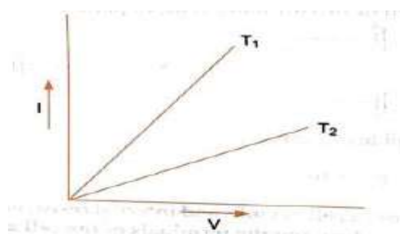
Reason: The current flows towards the point of the higher potential, as it does in such a circuit from the negative to the positive terminal

2 MARKS QUESTIONS

Q42. The metallic conductor is at temperature θ_1. The temperature of metallic conductor is increased to θ_2. How will the product of resistivity and conductivity change? Why?

Q43. Specific resistance copper, silver constantan are 1.18 x 10^{-6}, 1 x 10^{-6}, and 45 x 10^{6} ohm cm respectively. Which is the best electrical conductor and why?

Q44. Nichrome and copper wires of same length and same radius are connected in series. Current I is passed through them. Which wire gets heated up more? Justify your answer.



Q45. I - V graph for a metallic wire at two different temperatures, T1 and T2 is as shown in the figure. Which of the two temperatures is lower and why?

Q46. What conclusion can you draw from the following observations on a resistor made of an alloy manganin?

Current A	Voltage V	Current A	Voltage V
0.2	3.94	3.0	59.2
0.4	7.87	4.0	78.8
0.6	11.8	5.0	98.6
0.8	15.7	6.0	118.5
1.0	19.7	7.0	138.2
2.0	39.4	8.0	158.0

Q47. An electric bulb rated for 500W at 100V is used in circuit having a 200V supply. Calculate the resistance R that must be put in series with the bulb, so that the bulb delivers 500W.

Q48. Why is Wheatstone Bridge method considered unsuitable for measurement of very low resistances?

Q49. Why is the Wheatstone method considered Unsuitable for measurement of very high resistances?

Q50.A Battery of emf 3 volt and internal resistance r is connected in series with 55 ohms through an ammeter of resistance 1 ohm. The ammeter reads 50 mA. Draw the circuit diagram and calculate value of r.

Q51. Derive the conditions for obtaining maximum current through external resistance connected across a series combination of n identical cells.

Q52. Derive condition for obtaining maximum current through an external resistance connected to a parallel combination of n identical cells.

Q53. Two identical cells, whether joined in series or in parallel give the same current, when connected to an external resistance of 1 ohm. Find the internal resistance of each cell.

Q54. Two wire one of copper and other of manganin have same resistance and equal length. Which wire is thicker?

Q55. When does the terminal voltage of a cell become (i) greater than its emf (ii) less than its emf?

Q56.A car battery is of 12V. Eight dry cells of 1.5 V connected in series also give 12V, but such a combination is not used to start a car. Why?

Q57. The current flowing through a conductor is 2mA at 50V and 3mA at 60V. Is it an ohmic or non-ohmic conductor? Give reason.

3MARKS QUESTIONS

Q58. On what factors resistivity of the material depend? Write the corresponding equation. Why copper wires are used as connecting wires?

Q59. A heating element using nichrome connected to a 230 V supply draws an initial current of 3.2 A which settles after a few seconds to a steady value of 2.8 A. What is the steady temperature of the heating element if the room temperature is 27.0 °C? Temperature coefficient of resistance of nichrome averaged over the temperature range involved is $1.70 \times 10^{-4}\ °C^{-1}$?

Q60.Answer the following questions:

(a) A steady current flows in a metallic conductor of the non-uniform cross-section. Which of these quantities is constant along the conductor: current, current density, electric field, drift speed?

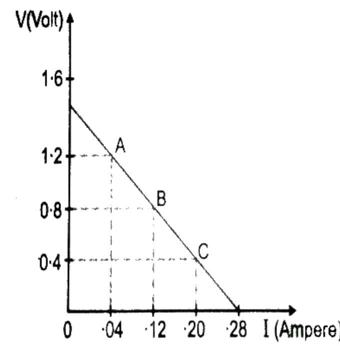
(b) Is Ohm's law universally applicable for all conducting elements? If not, give examples of elements that do not obey Ohm's law.

(c) A low voltage supply from which one needs high currents must have very low internal resistance. Why?

Q61 **.** Two cells of different emfs and internal resistance are connected in parallel with one another find the expressions for equivalent EMF and equivalent internal resistance of the combination.

Q62.A battery of emf 12.0 V and internal resistance 0.5Ω is to be charged by a battery charger which supplies 110 V dc. How much resistance must be connected in series with the battery to limit the charging current to 5.0 A? What will be the potential difference across the terminals of the battery during charging?

Q63. Potential differences across the terminals of a cell were measured (in volt) against different currents (in ampere) flowing through the cell. A graph was drawn which was a straight-line ABC as shown in figure

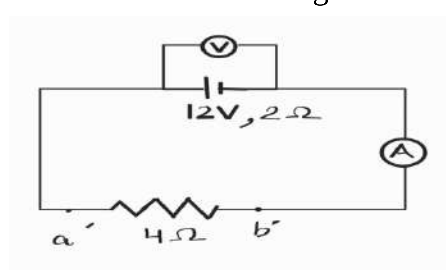


Determine from graph (i) emf of the cell (ii) maximum current obtained from the cell and (iii) internal resistance of the cell.

Q64. Four identical cells each of emf 2V, are joined in parallel providing supply of current to external circuit consisting of two 15Ω resistors joined in parallel. The terminal voltage of the cells ae read by an ideal voltmeter is 1.6V. Calculate the internal resistance of each cell.

Q65. Give three differences between e.m.f. and terminal potential difference of a cell.

Q66. In the figure, an ammeter A, and a resistor of resistance R = 4Ω have been connected to the terminals of the source to form a complete circuit. The emf of the source is 12V having an internal resistance of 2Ω. Calculate voltmeter and ammeter reading.



5 MARKS QUESTIONS

Q67. (a) On the basis of electron drift, derive an expression for resistivity of a conductor in terms of number density of free electrons and relaxation time. On what factors does resistance and resistivity of a conductor depend?

(b) Why alloys like constantan and manganin are used for making standard resistors?

Q68.(a) The electron drift arises due to the force experienced by electrons in the electric field inside the conductor. But force should cause acceleration. Why then do the electrons acquire a steady average drift speed?

(b) If the electron drift speed is so small, and the electron's charge is small, how can we still obtain large amounts of current in a conductor?

(c) When electrons drift in a metal from lower to higher potential, does it mean that all the 'free' electrons of the metal are moving in the same direction?

(d) Are the paths of electrons straight lines between successive collisions (with the positive ions of the metal) in the (i) absence of electric field, (ii) presence of electric field?

Q69.Define current density. Give its SI unit. Whether it is vector or scalar?

How does it vary when (i) potential difference across wire increases (ii) length of wire increases (iii) temperature of wire increases (iv) Area of cross-section of wire increases justify your answer.

Q70. State Kirchhoff's rules for electrical networks. Use them to explain the principle of Wheatstone bridge for determining an unknown resistance. How is it realized in actual practice in the laboratory? Write the formula used.

Q71. Deduce the condition for balance in a Wheatstone bridge. Write any two important precautions you would observe while performing the experiment. When is Wheatstone bridge most sensitive?

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SECTION-B- Answers

1.Current density is vector quantity.

2.Yes, electric field exists within the conductor because it is the electric field which imparts acceleration to electrons for the flow of current.

3.No, the resistance remains same, because length and cross-sectional area of the wire remain unchanged.

4. The specific resistance of wire depends only on the material (at given temperature). Therefore by changing the radius, the specific resistance of copper remains unchanged.

5.$V_d = eE\frac{\tau}{m}$

By heating conductor, the collisions electrons occur more frequently; relaxation time decreases and hence drift velocity decreases.

6. 2 ohms

7. Power $P=I^2Rt \infty I^2$

Clearly current doubled, power dissipated becomes times.

8. The resistivity of material of conductor defined the resistance offered by conductor length 1m and area cross-section 1 m^2. Its unit ohm metre

9. New resistivity will be (unchanged) because resistivity independent of dimensions

10.Resitivity increases with increase in temperature.

11. Resistivity decreases with increase in temperature.

12. As the battery or cell is in continuous use, consuming electrolyte and the chemical reaction keeps occurring in the cell, due to which the concentration of ions in the cell decreases and this resists the flow of charge through it. Hence, the internal resistance increases with time.

13.$E = V + Ir$.

14.During charging.

15.When temperature of the conductor decreases, ionic vibration in the conductor decreases so relaxation time increases.

16. High resistivity and low temperature Coefficient of resistance.

Multiple Choice Questions (Each 1M) -solution

17.(a)

18.(b)

19. (d) 100 S and 10^5 S m^{-1}

R $=\frac{pl}{A}$

G = 1/R = 100 S

Conductivity = 1/Resistivity = 10^5 S m^{-1}

20.(a)

21.(b)

22. (b)

23. (b)

24.(b)

25. (a)

26. (a)

27. (a)

28. (a)

29. (c)

30. (c)

31. (b)

32. (d)

Here, i=nE/ n, r= E/ r Because I is totally independent of n, hence it will remain constant.

33. (a) $v_d \propto E$

34. (b)

35. (c) flow from B to A

36. (a) 0.3 A

37. (a)

$I = \frac{8-4}{1+2+9} = \frac{4}{12}$ = 1/3 A

$V_P - V_Q = \left(4 - \frac{1}{3} X\ 3\right) = \ 3\ V$

38. (a) 2 R

39

40.

41.

2 MARKS QUESTIONS -ANSWERS

42. Product of resistivity and conductivity is constant = 1

Product independent temperature.

43. Smaller the resistivity of substance, larger is conductivity. The resistivity of silver is least so silver is the best conductor

44. Nichrome wire gets heated up more. Heat dissipated in a wire is given by

H = I^2Rt = $I^2 \frac{pl}{A} t$

H ∞ p

p of nichrome>p of copper

H of nichrome>H of copper

45. Answer

$R_1 = V_1/I$ and $R_2 = V_2/I$

$V_2 > V_1$ So $R_2 > R_1$ and $T_1 < T_2$

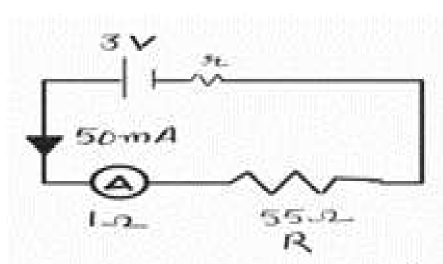
46.Ohm's law is valid to high accuracy. This means that the resistivity of the alloy manganin is nearly independent of temperature.

47. Resistance of bulb=V^2/P = 20 Ω, I = 5A, for the same power dissipation, current should be 5A when the bulb is connected to a 200V supply. The safe resistance R' = V'/I= 40Ω. Therefore, 20Ω resistors should be connected in series.

48.For measuring lower resistance all other resistances should have low value so that bridge is sensitive, this requires galvanometer of very low resistance, also the end resistance and resistance of connecting wires becomes comparable to the resistance measured hence error may be introduced.

49. For measuring higher resistance all other resistances forming the wheat stone bridge should be high but this reduces the current through the galvanometer and hence it becomes insensitive.

50.Emf = 3 V

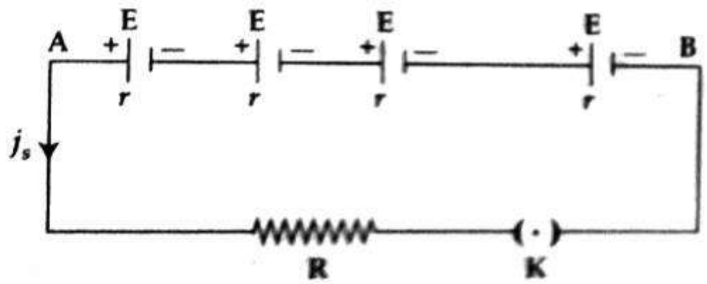


R_{net} = 55 +1+r = 56+r

I= 50 x 10^{-3}A

I= E/R_{net}

R = 4 ohm



51.I = $\frac{nE}{R+nr}$

If R>> nr

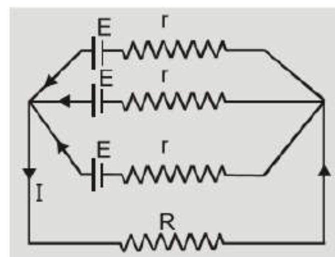
I = $\frac{nE}{R}$= n x current from a single cell

When external resistance is much higher than the total internal resistance then the cells should be connected in series to get maximum current.

52.

$$I = \frac{\varepsilon}{R+\frac{r}{n}}$$

$$I = \frac{n\varepsilon}{nR+r}$$



IF $\frac{r}{n}$>> R

r>> Nr

I =$\frac{nE}{r}$ = n X current from a single cell

When external resistance is much smaller than the total internal resistance then the cells should be connected in parallel to get maximum current.

53. E_{Series}= 2 E　　　　$E_{Parallel}$= E

I =$\frac{2E}{2r+1}$　　　　I =$\frac{E}{\frac{r}{2}+1}$

$\frac{2E}{2r+1} = \frac{E}{\frac{r}{2}+1}$

$\frac{2}{2r+1} = \frac{1}{\frac{r}{2}+1}$　　　　r = 1 ohm

54.where ρ= specific resistance of wire

for copper wire　R=ρ_cL/A_c,

for manganin wire R=ρ_mL/A_m

or　$\rho_c/A_c=\rho_m/A_m$

or　$A_c/A_m=\rho_c/\rho_m$

we know $\rho_m>\rho_c$ (as manganin is an alloy)

therefore　$A_c<A_m$Hence manganin wire is thicker

55. (i) When the cell is being charged terminal potential difference (V) becomes greater than emf (E), $V = E + Ir$

(ii) When the cell is discharged, then $V < E$, $V = E – I r$

56. Dry cell used in series will have high resistance (= 10Ω) and hence provide low current, while a car battery has low internal resistance (0.1Ω) and hence gives high current for the same emf, needed to start the car.

57.The resistance of first case, $R_1 = V_1 / I_1 = 50 / 2 \times 10^{-3} = 25,000\ \Omega$ the resistance of second case, $R_2 = V_2 / I_2 = 60 / 3 \times 10^{-3} = 20,000\ \Omega$

As resistance changes with current, so the given conductor is non-ohmic.

3 MARKS QUESTIONS

58. The resistivity of a conductor depends on two factors i.e., nature of the material of the conductor and temperature.

$p = \frac{m}{ne^2\tau}$

Copper wires are used as connecting wires because the electrical resistivity of copper is low. It prevents any wastage of electric current.

59.The supply voltage is V = 230 V

The initial current drawn is $I_1 = 3.2$ A

Consider the initial resistance to be R 1, which can be found by the following relation:

$R = V/I = 71.87\ \Omega$

Value of current at steady state, I 2 = 2.8 A

Value of resistance at steady state = R_2

R_2 can be calculated by the following equation :

$R_2 = 82.14\Omega$

The temperature coefficient of nichrome averaged over the temperature range involved is

$1.70 \times 10^{-4}\ °C^{-1}$

Value of initial temperature of nichrome , T 1 = 27.0 ° C

Value of steady state temperature reached by nichrome = T 2

This temperature T 2 can be obtained by the following formula

$$\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)}$$

$$T_2 - 27 = \frac{82.14 - 71.87}{71.87 \times (1.7 \times 10^{-4})}$$

$$T_2 - 27 = 840.5$$

T_2 = 840.5 + 27 = 867.5 ° C

60. (a) Current is given to be steady. Therefore, it is a constant. The current density, electric field, drift speed depends on the area of cross-section inversely.

(b) No, examples of non-ohmic elements are vacuum diode, semiconductor diode etc.

(c) Because the maximum current drawn from a source = ε/r.

61.$E_{eq} = (\varepsilon_2 r_1 + \varepsilon_1 r_2)/(r_1 + r_2)$

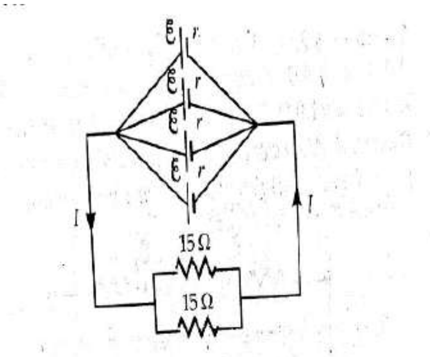
$(1/R_{eq}) = (1/R_1) + (1/R_2) + (1/R_3) \ldots\ldots (1/R_n)$

62. E= 110- 12= 98 V

$I = \frac{98}{R+0.5}$, R= 19.1 ohm , V= E + ir = 12 + 5x0.5 = 14.5 Volt

63. (i) 1.4 V (ii) I_{max} = 0.28 A (iii) r = E/I_{max} = 1.4/.28 = 5 ohm

64. E = 2 V



$r_{eq} = r/4$

$R_{ex} = R/2 = 7.5$

V= 1.6 V

$E = V + I\, r_{eq}$

$E - V = I\, r_{eq}$ $I = V/R_{ex}$

$r_{eq} = \frac{(E-V)Rex}{V} = \frac{(2-1.6)5}{1.6} = 15/8$ ohm

$\frac{r}{4} = \frac{15}{8}$

r = 7.5 ohm

65.

E.M.F. OF A CELL	TERMINAL VOLTAGE OF A CELL
1.It is measured by the amount of work done in moving a unit positive charge in the complete circuit inside and outside the cell.	1.It is measured by the amount of work done in moving a unit positive charge in the circuit outside the cell.
2.It is the characteristic of the cell i.e.; it does not depend on the amount of current drawn from the cell	2.It depends on the amount of current drawn from the cell. More the current is drawn from the cell, less is the terminal voltage
3.It is equal to the terminal voltage when cell is not in use while greater than the terminal voltage when cell is in use.	3.It is equal to the emf of cell when cell is not in use, while less than the emf when cell is in use.

66. E = 12 V $\quad$ $R_{net} = 2 + 4 = 6$ ohm

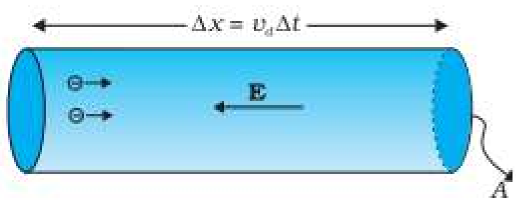
I = 12 /6 = 2 A

VOLTMETER READING = I R = 2 x 4 = 8 V,

Ammeter reading=2A

5 MARKS QUESTIONS

67.



Relaxation time of free electrons drifting in a conductor is the average time elapsed between two successive collisions.
Consider a conductor of length 1 and cross-sectional area A. When a potential difference V is applied across its ends, the current produced is I.

If n is the number of electrons per unit volume in the conductor and v_d the drift velocity electrons, then the relation between current and drift velocity is $\quad I = -neAv_d$

Where -e is the charge on electron

Electric field produced at each point of wire, $E = \frac{V}{l}$

If τ is relaxation time and E is electric field strength, then drift velocity $v_d = -\frac{e\tau E}{m}$

$I = -neA(-\frac{e\tau E}{m})$ or $I = -\frac{ne^2\tau}{m}AE$

As $E = \frac{V}{l}$

$I = \frac{ne^2}{m}\tau A\frac{V}{l}$ or $\frac{V}{l} = \frac{m}{ne^2\tau}\frac{l}{A}$

Current density $J = \frac{I}{A} = \frac{ne^2\tau}{ml}V$

This is relation between current density J and applied potential difference V.

Under give physical conditions (temperature, pressure) for a given conductor

$\frac{m \quad l}{ne^2\tau A}$ = Constant ∴ This constant is called the resistance of the conductor (i.e. R)

i.e. $R = \frac{m \quad l}{ne^2\tau A}$------------------ 1

$\frac{V}{I} = R$

This is Ohm's law from equation it is clear that the resistance of a wire depends on its length (l), cross-sectional area (A), number of electrons per m3 (n) and the relaxation time

Expression for resistivity

As $R = \frac{pl}{A}$ ---------------------2

Comparing 1 and 2, we get

Resistivity of a conductor $p = \frac{m}{ne^2\tau}$

clearly, resistivity of a conductor is inversely proportional to number density of free electrons and relaxation time.

Resistivity of the material of a conductor depends upon the relaxation time - i.e. temperature and the number density of free electrons. This is because constantan and manganin show very weak dependence of resistivity on temperature.

68. (a) Each 'free' electron does accelerate, increasing its drift speed until it collides with a positive ion of the metal. It loses its drift speed after collision but starts to accelerate and increases its drift speed again only to suffer a collision again and so on. On the average, therefore, electrons acquire only a drift speed.

(b) Simple, because the electron number density is enormous, $\sim 10^{29}\ m^{-3}$.

(c) By no means. The drift velocity is superposed over the large random velocities of electrons.

(d) In the absence of electric field, the paths are straight lines; in the presence of electric field, the paths are, in general, curved

69. Definition, SI unit is A / m^2

Current density is a vector quantity. Its direction is same as that of motion of positive charge.

$$J = \frac{I}{A} \qquad = \frac{neAv}{A} \qquad = \frac{neeE\tau}{m} = nee\frac{V\tau}{ml} = ne^2\frac{V\tau}{ml}$$

(a) With increase in potential gradient, J increase.

(b) With increase in temperature, τ decreases, so J decreases.

(c) With increase in length J decreases.

(d) With increase in area, J remains unchanged as J is independent of A.

70. DERIVATION, CIRCUIT DIAGRAM

71.The current should not flow in the Set up for a long time, otherwise the wire will become hot and its resistance will be changed.

The null point should be between 45cm and 55cm.

It is most sensitive When all four registers P,Q,R,S are nearly of same magnitude and null point is obtained in the middle of alloy wire.

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<u>SECTION-C</u>

<u>Multiple Choice Questions (Each 1M)</u>

1.Consider a current carrying wire (current *I*) in the shape of a circle. Note that as the current progresses along the wire, the direction of *j* (current density) changes in an exact manner, while the current *I* remain unaffected. The agent that is essentially responsible for is:

(a) source of emf

(b) electric field produced by charges accumulated on the surface of wire.

(c) the charges just behind a given segment of wire which push them just the right way by repulsion.

(d)the charges ahead

2.A metal rod of length 10 cm and a rectangular cross section of 1cm × 1/2 cm is connected to a battery across opposite faces. The resistance will be:

(a) maximum when the battery is connected across 1 cm × 1/2 cm faces

(b) maximum when the battery is connected across 10 cm x 1 cm faces

(c) maximum when the battery is connected across 10 cm x 1/2 cm faces

(d) same irrespective of the three faces

3.Which of the following characteristics of electrons determines the current in a conductor?

(a) Drift velocity alone

(b) Thermal velocity alone

(c) Both drift velocity and thermal velocity

4.A constant voltage is applied between two ends of a metallic wire. If the length is halved and the radius of the wire is doubled, the rate of heat developed in the wire will be

(a) Increased 8 times (b) Unchanged (c) Doubled (d) Halved

5. A heating element has a resistance of 100 Ω at room temperature. When it is connected to a supply of 220 V, a steady current of 2 A passes in it and the temperature is 500°C more than room temperature. What is the temperature coefficient of resistance of the heating element?

(a) 1×10^{-4} °C^{-1} (b) 2×10^{-4} °C^{-1} (c) 0.5×10^{-4} °C^{-1} (d) 5×10^{-4} °C^{-1}

6. A uniform wire of length l and radius r has a resistance of 100 Ω. It is recast into a wire of radius r/2.The resistance of new wire will be

(a) 400 Ω (b)100 Ω (c) 200 Ω (d)1600 Ω

7. In a large building, there are 15 bulbs of 40 W, 5 bulbs of 100 W, 5 fans of 80 W and 1 heater of 1 kW. The voltage of the electric mains is 220 V. The minimum capacity of the main fuse of the building will be

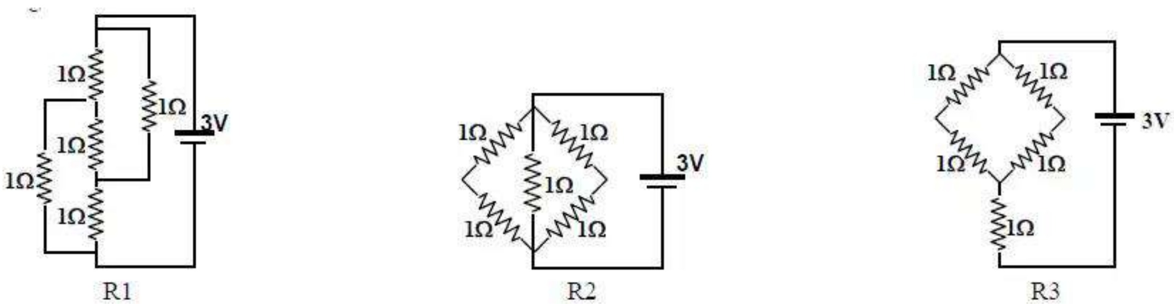
(a) 14 A (b) 8 A (c) 10 A (d) 12 A

8. If a wire is stretched to make it 0.1% longer, its resistance will

(a) increase by 0.05% (b) increase by 0.2%

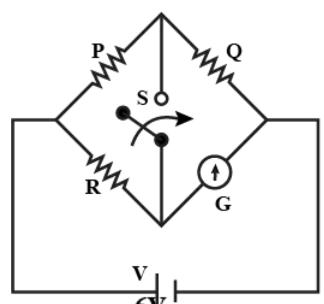
(c) decrease by 0.2% (d) decrease by 0.05%

9. Figure shows three resistor configurations R1, R2 and R3 connected to 3 V battery.



If the power dissipated by the configuration R_1, R_2 and R_3 is P_1, P_2 and P_3, respectively, then

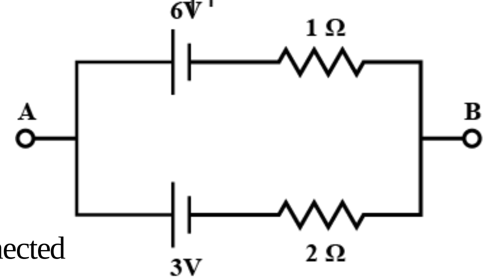
(a) $P_1 > P_2 > P_3$ (b) $P_1 > P_3 > P_2$ (c) $P_2 > P_1 > P_3$ (d) $P_3 > P_2 > P_1$



10. In the circuit shown, P is not equal to R, the reading of the galvanometer is same with switch S open or closed. Then,

(a) $I_R = I_G$ (b) $I_P = I_G$ (c) $I_Q = I_G$ (d) $I_Q = I_R$

11. Two batteries of different emfs and different internal resistances are connected as shown. The voltage across AB in volts is



(a) 4 (b) 5 (c) 6 (d) 7

12. Ten identical cells each of potential E and internal resistance r are connected in seriesto form a closed circuit. An ideal voltmeter connected across 3cells will read

(a) 10E (b) 13E (c) 3E (d) 5E

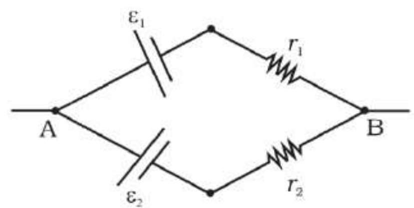
13.The resistance of a wire at a temperature t and 0 degree are related as

(a) $R = R_0(1 + BT)$ (b) $R = R_0(1 - BT)$ (c) $R = R_0(1 + B^2T)$ (d) $R = R_0(1 - B^2T)$

14.Temperature dependence of resistivity $\rho(T)$ of semiconductors, insulators and metals is significantly based on the following factors:

(a) number of charge carriers can change with temperature T.
(b) time interval between two successive collisions can depend on T.
(c) length of material can be a function of T.
(d) mass of carriers is a function of T.

15.Two batteries of emf ε_1 and ε_2 ($\varepsilon_2 > \varepsilon_1$) and internal resistances r1 and r2 respectively are connected in parallel as shown



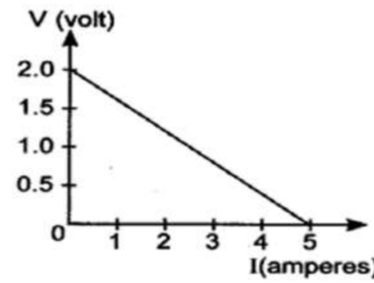
(a) The equivalent emf ε_{eq} of the two cells is between ε_1 and ε_2, i.e., $\varepsilon_1 < \varepsilon_{eq} < \varepsilon_2$

(b) The equivalent emf ε_{eq} is smaller than ε_1.

(c) The ε_{eq} is given by $\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2$ always.

(d) ε_{eq} is independent of internal resistances r_1 and r_2.

16. For a cell, the graph between the potential difference (V) across the terminals of the cell and the current (I) drawn from the cell is shown in the figure

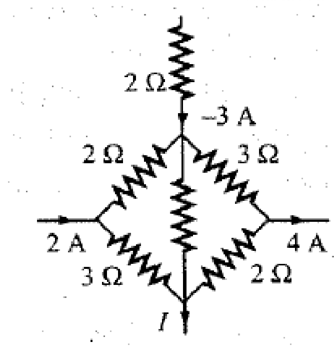


The e.m.f and the internal resistance of the cell are

(a) 2V, 0.5 Ω (b) 2V, 0.4 Ω

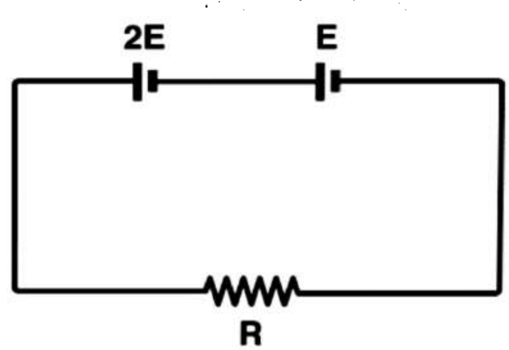
(c) > 2V, 0.5 Ω (d) > 2V, 0.4 Ω

17. What is the current I for the circuit shown in the figure?



(a) 3A (b) 1A (c) -5A (d) 5A

18.Two cells of emf 2E and E with internal resistance r_1 and r_2 respectively are connected in series to an external resistor R (see figure). The value of R, at which the potential difference across the terminals of the first cell becomes zero is



(a) $r_1 - r_2$ (b) $r_1 + r_2$

(c) $(r_1/2) + r_2$ (d) $(r_1/2) - r$

V.S.A(1 MARK)

Q19. How the internal resistance of a cell changes when area of the anode is decreased?

Q20. Why are alloys used for making standard resistances?

Q21. Write the dimensional formula of emf of a cell.

Q22. Alloys of metal have greater resistivity than that of their constituent metals, why?

DIRECTIONS:(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

(c) If the Assertion is correct but Reason is incorrect.

(d) If both the Assertion and Reason are incorrect.

Q23.**Assertion**: The current density J at a point in ohmic resistor is in direction of electric field E at that point

Reason: A point charge when released from rest in a region having only electrostatic field always moves along electric lines of force

DIRECTIONS: (a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

(c) If the Assertion is correct but Reason is incorrect.

(d) If the Assertion is correct but Reason is incorrect.

Q24. **Assertion**: The temperature dependence of resistance is usually given as $R=R_0(1+\alpha\Delta t)$.

The resistance of wire changes from 100 ohm to 150 ohm when its temperature is increased from 27 degree Celsius to 227 degrees Celsius. This implies that a =2.5 x 10^{-3} /degree Celsius.

Reason: $R=R_0(1+ \alpha\Delta t)$ is valid only when the change in temperature is small and $\delta R <<R0$

DIRECTIONS: (a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

(c) If the Assertion is correct but Reason is incorrect.

(d) If the Assertion is correct but Reason is incorrect.

Q 25. **Assertion**: EMF is potential difference between two terminals of the cells when no current is drawn from it.

Reason: It is an effect of terminal potential difference.

DIRECTIONS: (a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

(c) If the Assertion is correct but Reason is incorrect.

(d) If the Assertion is correct but Reason is incorrect.

Q26. **Assertion**: The number density of free electrons in metals is very high.

Reason: Number density of metals increases with increase in temperature hence it is the cause of increase in conductivity of metals with temperature.

DIRECTIONS: (a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

(c) If the Assertion is correct but Reason is incorrect.

(d) If the Assertion is correct but Reason is incorrect.

Q27. **Assertion**: Internal resistance of a cell decreases when immersed area of electrons in the electrolyte increases

Reason: Internal resistance of a cell in is its characteristic property.

DIRECTIONS: (a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

(c) If the Assertion is correct but Reason is incorrect.

(d) If the Assertion is correct but Reason is incorrect.

Q28. **Assertion**: Which of Junction rule reveals that at a junction sum of current is zero.

Reason: Kirchhoff's Junction rule is based upon law of conservation of charge.

2 MARK QUESTIONS

Q29. A current of 2.4 A flows through a wire of cross-sectional area 1.5 mm². Find the current density in the wire. If the wire contains 8 x 10^{28} free electrons calculate the drift velocity of electrons per cubic meter, calculate the drift velocity of electrons.

Q30. An aluminum wire of diameter 0.24 cm is connected in series to a copper wire of diameter 0.16 cm. The wires carry an electric current of 10 A. Find (a) current density of free electrons in the aluminum wire and (b) drift velocity of electrons in the copper wire. Given that number of densities of free electrons in copper = 8.4×10^{28} m^{-3}.

Q31. Given that resistivity of copper is 1.68 x 10^{-8} Ω m.

Calculate the amount of copper required to draw a wire 10 km long having resistance 10 ohm. The density of copper is 8.9 x 10^3 kg m^{-3}.

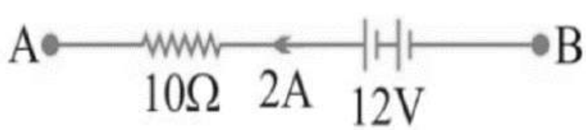
Q32. Which lamp has greater resistance (i) 60W and (ii) 100W when connected to the same supply? Why?

Q33. Nichrome and Cu wires of the same length and same diameter are connected in series in an electric circuit. In which wire will the heat be produced at a higher rate? Give reason.

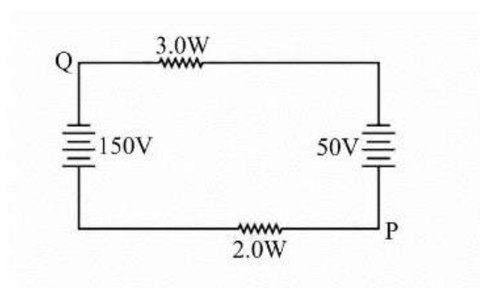
Q34. The resistance of the platinum wire of a platinum resistance thermometer at the ice point is 5 Ω and at steam point is 5.23 Ω. When the thermometer is inserted in a hot bath, the resistance of the platinum wire is 5.795 Ω. Calculate the temperature of the bath.

Q35. A rheostat has 100 turns of a wire of radius 0.4 mm having resistivity 4.2×10^{-7} Ω m. The diameter of each turn is 3 cm. What is the maximum value of resistance it can introduce?

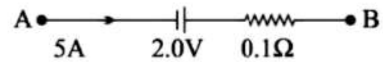
Q36. In the figure, what is the potential difference between A and B?



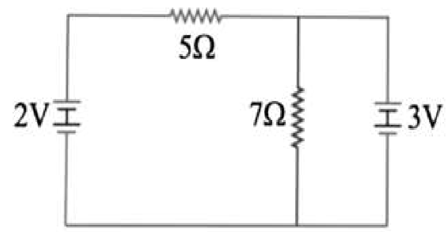
Q37. In the figure, if the potential at point P is 100V, what is the potential at point Q?



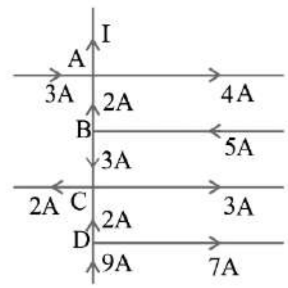
Q38.A battery of emf 2.0 V and internal resistance 0.1Ω is being charged with a current of 5.0 A. What is the potential difference between the terminals of the battery?



Q39. Two resistance 5Ω and 7Ω are joined as shown to two batteries of emf 2V and 3V. If the 3Vbattery is short circuited. What will be the current through 5Ω?



Q40. Find the value of I in the given circuit:



Q41. Is the momentum conserved when charge crosses a junction in an electric circuit? Why or why not?

3 MARK QUESTIONS

Q42. (a) Estimate the average drift speed of conduction electrons in a copper wire of cross-sectional area 1.0×10^{-7} m^2 carrying a current of 1.5 A. Assume that each copper atom contributes roughly one conduction electron. The density of copper is 9.0×10^3 kg/m^3, and its atomic mass is 63.5 u.

(b) Compare the drift speed obtained above with, (i) thermal speeds of copper atoms at ordinary temperatures, (ii) speed of propagation of electric field along the conductor which causes the drift motion.

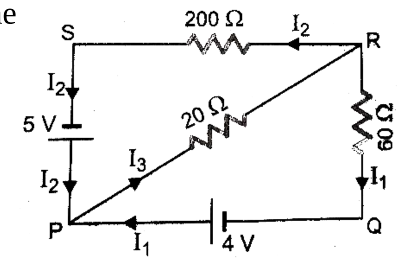
Q43. Two wires of equal length, one of aluminium and the other of copper have the same resistance. Which of the two wires is lighter? Hence explain why aluminium wires are preferred for overhead power cables.

($\rho_{Al} = 2.63 \times 10_{-8}$ Ω m, $\rho_{Cu} = 1.72 \times 10^{-8}$ Ω m, Relative density of Al = 2.7, of Cu = 8.9.)

Q44. An electric toaster uses nichrome for its heating element. When a negligibly small current passes through it, its resistance at room temperature (27.0 °C) is found to be 75.3 Ω. When the toaster is connected to a 230 V supply, the current settles, after a few seconds, to a steady value of 2.68 A. What is the steady temperature of the nichrome element? The temperature coefficient of resistance of nichrome averaged over the temperature range involved, is 1.70×10^{-4} °C^{-1}.

Q45. The amount of charge passing through the cross-section of a wire in time t is given by $q=at^2+bt+c$ (a) What are the dimensional formulae of constants a, b and c? (b) If the values of constants a, b, c are 3, 5 and 2 in SI units, find the value of current at t=3s.

Q46. Apply Kirchhoff's rules to the length PRSP and PRQP to find the current I_1, I_2 and I_3 in the circuit.

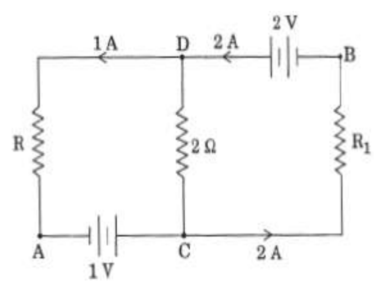


Q47. A cell of e.m.f. 'E' and internal resistance 'r' is connected across a variable resistor 'R'. Plot a graph showing the variation of terminal potential 'V' with resistance 'R'. Predict from the graph the condition under which 'V' becomes equal to 'E'. What is significance of this graph?

Q48. Four cells each of internal resistance 0.8Ω and emf 1.4V, are connected (i) in series (ii) in parallel. The terminals of the battery are joined to the lamp of resistance 10Ω. Find the current through the lamp and each cell in both the cases.

Q49. When resistance of 2Ω is connected across the terminals of a battery, the current is 0.5A. When the resistance across the terminal is 5Ω, the current is 0.25A. (i) Determine the emf of the battery (ii) What will be current drawn from the cell when it is short circuited.

Q50. In the given circuit, assuming point A to be at zero potential, use Kirchhoff's rules to determine the potential at point B and value of R.



5 MARK QUESTIONS

Q51. (a) The electron drift arises due to the force experienced by electrons in the electric field inside the conductor. But force should cause acceleration. Why then do the electrons acquire a steady average drift speed?

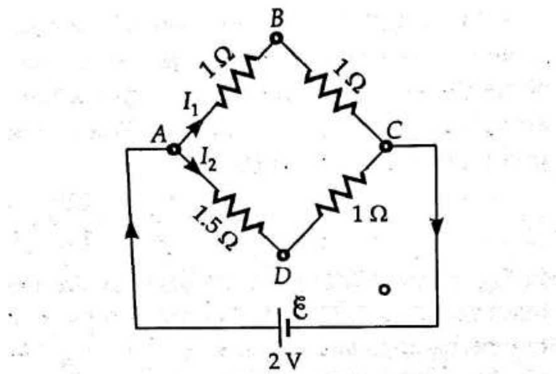
(b) If the electron drift speed is so small, and the electron's charge is small, how can we still obtain large amounts of current in a conductor?

(c) When electrons drift in a metal from lower to higher potential, does it mean that all the 'free' electrons of the metal are moving in the same direction?

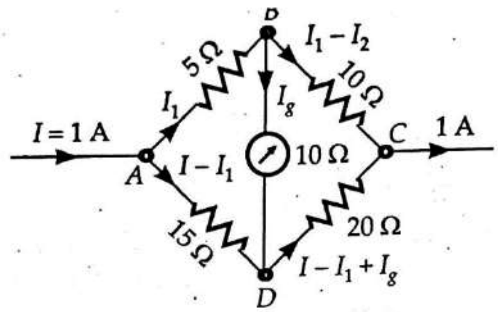
(d) Are the paths of electrons straight lines between successive collisions (with the positive ions of the metal) in the (i) absence of electric field, (ii) presence of electric field?

Q52. Two cells of EMF 3V and 4V and internal resistances 1 ohm and 2 ohms respectively are connected in parallel so as to send current in same direction through an external resistance of 5 ohm. Draw the circuit diagram using Kirchhoff's laws. Calculate the current through each branch of the circuit and potential difference across 5-ohm resistance.

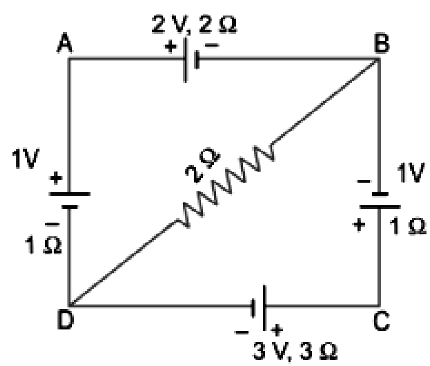
Q53. Calculate the potential difference between the junctions B and D in the Whetstone Bridge shown in figure



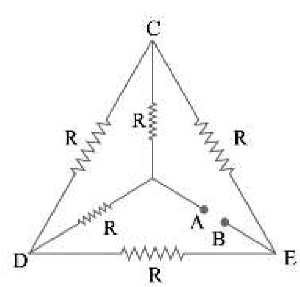
Q54. Determine the current flowing through the galvanometer G of Wheatstone Bridge shown in figure.



Q55. For the circuit given below, find the potential difference b/w points B and D.

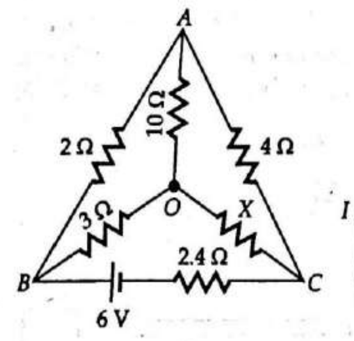


Q56. Calculate Equivalent Resistance of the given electrical network b/w points A and B. Also calculate the current through CD& ACB if a 10V dc source is connected b/w points A and B and the value of R = 2Ω. If battery of V volt is connected find current in circuit and current through DC.



Q57. P, Q, R and S are four resistance wires of 2,2,2 and 3 ohms respectively. Find out the resistance with which S must be shunted in order that bridge may be balanced.

Q58. Find the value of unknown resistance X, in the following circuit, if no current flows through the section AO. Also calculate the current drawn by the circuit from the battery of emf 6V and negligible internal resistance.



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SECTION-C-Answer Key

Multiple Choice Questions -solutions

1.(b)

2. (a)

3. (a)

4.Rate of heat developed, $P = V^2/R$

For given V, $P \propto 1/R = A/\rho l = \pi r^2/\rho l$

Now, $P_1/P_2 = (r_1^2/r_2^2)(l_2/l_1)$

As per question, $l_2 = l_1/2$ and $r_2 = 2r_1$

$P_1/P_2 = (\frac{1}{4}) \times (\frac{1}{2}) = \frac{1}{8}$

$P_2 = 8P_1$ Answer: (a) Increased 8 times

5. Resistance after temperature increases by 500°C,

R_T = Voltage applied/Current = 220/2 = 110

Also, $R_T = R_0 (1 + \alpha\Delta T)$

$110 = 100 (1 + (\alpha \times 500))$

$\alpha = 10/(100 \times 500) = 2 \times 10^{-4}\ {}^0C^{-1}$

Answer: (b) $2 \times 10^{-4}\ °C^{-1}$

6. Resistance of a wire of length l and radius r is given by

$R = \rho l/A = (\rho l/A) \times (A/A)$

$R = (\rho V/A^2) = (\rho V/\pi^2 r^4)$ ($\because V = Al$)

i.e., $R \propto 1/r^4$

$R_1/R_2 = (r_2/r_1)^4$

Here, $R_1 = 100\ \Omega$, $r_1 = r$, $r_2 = r/2$

$R_2 = R_1(r_1/r_2)^4 = 16R_1 = 1600\ \Omega$

Answer: (d) 1600 Ω

7. Power of 15 bulbs of 40 W = 15 × 40 = 600 W

Power of 5 bulbs of 100 W = 5 × 100 = 500 W

Power of 5 fan of 80 W = 5 × 80 = 400 W

Power of 1 heater of 1 kW = 1000

Total power, P = 600 + 500 + 400 + 1000 = 2500 W

When these combination of bulbs, fans and heater are connected to 220 V mains, current in the main fuse of building is given by

$I= P/V = 2500/220 = 11.36\ A \approx 12\ A$

Answer: (d) 12 A

8. (b) increase by 0.2%

Resistance of wire $R = \rho l/A$……..(1)

On stretching, volume (V) remains constant.

So $V = Al$ or $A=V/l$

Therefore, $R = \rho l^2/V$ (Using (1))

Taking logarithm on both sides and differentiating we get,

$\Delta R/R = 2\Delta l/l$ (Since V and ρ are constants)

$(\Delta R/R)\% = (2\Delta l/l)\%$

Hence, when the wire is stretched by 0.1% its resistance will increase by 0.2%

Answer: (b) increase by 0.2%

9.(c) $P_2 > P_1 > P_3$

For $R_1 = 1$ ohm For $R_2 = 0.5\Omega$ $R_3 = 2\Omega$

As $P=V^2 / R$ and $V=3$ for each so $P \propto 1/R$

Thus, $P_2>P_1>P_3$.

10. (a) $I_R=I_G$

The reading of Galvanometer G is the same with switch S open or closed. This implies that closing or opening the switch does not affect the circuit. It means that no current flows through switch S. Hence, the given arrangement of resistors is a Balanced Wheatstone bridge. Hence we can remove switch S.

R and G will be in series. Hence current flows through resistor R is equal to the current flows through the galvanometer G. $\Rightarrow I_R=I_G$. Hence option (a) is correct.

11. (b)

$I = 6-3/3 = 3/3 = 1\ A$

$V_A - 6 + 1 - V_B = 0$

therefore $V_A - V_B = 5$

12 (c) 3E

$I = 10\,E / 10\,r = E/r$

Current through three cells $I \times 3r = 3E$

13 (b) $R = R_0(1 - BT)$

14. (a) number of charge carriers can change with temperature T.

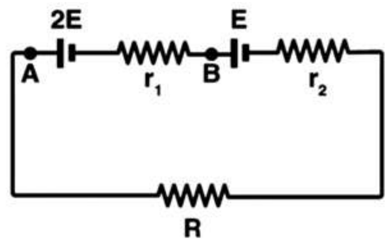
(b) time interval between two successive collisions can depend on T

15. (a) The equivalent emf ε_{eq} of the two cells is between ε1 and ε2, i.e., $\varepsilon 1 < \varepsilon eq < \varepsilon 2$

16. (a) 2V, 0.5 Ω

17. c) -5A

18. (d) $(r_1/2) - r_2$



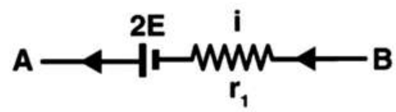
Solution

$I = \frac{3E}{R+r1+r2}$

If potential difference across terminals of first cell is zero

$V_A = V_B$

$2\,E = i\,r_1 2E = \frac{3E}{R+r1+r2} r1$



$2R + 2r_1 + 2r_2 = 3r_1$

$R = (r_1/2) - r_2$

V.S.A

19. When area of the anode is decreased, the internal resistance of the cell increases. Lesser area of the anode decreases its tendency to attract oppositely charged ions

20. High resistivity and low temperature Coefficient of resistance

21. $ML^2A^{-1}T^{-3}$

22. In an alloy like nichrome (made of nickel and chromium), the free electron finds a disordered arrangement of nickel ions and chromium ions. Due to it, the electron is scattered by them randomly and very frequently. As a result of it, the value of relaxation time of electron decreases and hence resistivity increases because $\rho \propto 1/\tau$.

23.(c) $J = \sigma E$

The current density at any point in ohmic resistor is in the direction of electric field at that point in space having non-uniform electric field. Charges released from rest may not move along electric line of force hence statement 1 is true while statement 2 is false

24. (d)R=R0(1+ $\alpha\Delta t$) is valid only when the change in temperature is small and DR <<R0

Statement 1 is false and 2 is true

25. (c) statement 1 is true 2 is false

26. (c) statement 1 is true 2 is false

27. (c) statement 1 is true 2 is false

SOL Internal resistance is not characteristic property but depends upon the quantity and concentration of electrolyte and distance between the electrodes

28. (a) Both true 2 is explanation of 1

2 MARKS QUESTIONS SOLUTION

29.Ans. 1.6×10^6 A m^2; 1.25×10^4

j = I/A = 1.6×10^6 Am^{-2}

v_d= j/ne = 1.25×10^{-4} ms^{-1}

30.a. $A = \frac{\pi D^2}{4}$ = 4.524×10^{-6} m^2

j = I/A = 2.21×10^6 Am^{-2}

b. $A = \frac{\pi D^2}{4}$ = $2.01 \times 10^{-6} m^2$

v_d = I/neA = 3.7×10^4 ms^{-1}

31.Ans. 1495.2 kg

R =$\frac{pl}{A}$

From which A = $1.68 \times 10^{-5} m^2$

m = volume x density = A x l x density = 1495.2 kg

32. Ans: Nichrome Wire

P = I^2 R

P α R Heat produced is higher in Nichrome wire.

33. Solution R_0 = 5 Ω, R_{100} = 5.23 Ω and R_t = 5.795 Ω

$$t = \frac{R_t - R_0}{R_{100} - R_0} \times 100, \qquad R_t = R_0 (1 + \alpha t)$$

$$= \frac{5.795 - 5}{5.23 - 5} \times 100$$

$$= \frac{0.795}{0.23} \times 100 = 345.65\ °C$$

34.Ans. 7.875 Ω

n = 100

D = 0.03 m

l = $n\pi D$ = 100 x π x 0.03m

$A = \pi r^2$

R=$\frac{pl}{A}$ = 7.875 Ω

35.v_d = (I/neA) Now, e = 1.6 × 10^{-19} C, A = 1.0 × $10^{-7}$$m^2$, I = 1.5 A. The density of conduction electrons, n is equal to the number of atoms per cubic metre (assuming one conduction electron per Cu atom as is reasonable from its valence electron count of one). A

cubic metre of copper has a massof 9.0 × 10^3 kg. Since 6.0 × 10^{23} copper atoms have a mass of 63.5 g,

which gives

$$n = \frac{6.0 \times 10^{23}}{63.5} \times 9.0 \times 10^6$$
$$= 8.5 \times 10^{28}\ m^{-3}$$

$$v_d = \frac{1.5}{8.5 \times 10^{28} \times 1.6 \times 10^{-19} \times 1.0 \times 10^{-7}}$$
$$= 1.1 \times 10^{-3}\ m\ s^{-1} = 1.1\ mm\ s^{-1}$$

(b) (i) At a temperature T, the thermal speed* of a copper atom of mass M is obtained from [< (mv^2/2) >3 kT/2] and is thus typically of the order of $\sqrt{kT/M}$, where k is the Boltzmann constant. For copper at 300 K, this is about 2 × 10^2 m/s. This figure indicates the random vibrational speeds of copper atoms in a conductor. Note that the drift speed of electrons is much smaller, about 10^{-5} times the typical thermal speed at ordinary temperatures. (ii) An electric field travelling along the conductor has a speed of an electromagnetic wave, namely equal to 3.0 × 10^8 m s^{-1}

The drift speed is, in comparison, extremely small; smaller by a factor of 10^{-11}

36. Ans. $V_A - V_B$ = – 8 volt.

37. Using KVL, ANS = -10 V.

38.
$$\begin{aligned} V &= E + ir \\ &= 2 + 0.15 \\ &= 2.15V \end{aligned}$$

39. 2 / 5 Ampere

40.On applying Kirchhoff's current law on junction A, at junction A 2 + 3 = I + 4 so,

I = + 1A

41. In the circuit when an electron approaches a junction, in addition to the uniform E that faces it normally (which keep the drift velocity fixed), as drift velocity (vd) is directly proportional to Electric field (E). That's why there is accumulation of charges on the surface of wires at the junction.

These produce additional electric fields. These fields alter the direction of momentum. Thus, the motion of a charge across junction is not momentum conserving.

3 MARKS QUESTIONS SOLUTION

42.v_d = (I/neA) Now, e = 1.6×10^{-19} C, A = $1.0 \times 10^{-7} m^2$, I = 1.5 A.

The density of conduction electrons, n is equal to the number of atoms per cubic metre (assuming one conduction electron per Cu atom as is reasonable from its valence electron count of one). A cubic metre of copper has a mass of 9.0×10^3 kg. Since 6.0×10^{23} copper atoms have a mass of 63.5g,

$$n = \frac{6.0\times10^{23}}{63.5} \times 9.0\times10^6$$
$$= 8.5 \times 10^{28}\ m^{-3}$$

which gives
$$v_d = \frac{1.5}{8.5\times10^{28}\times1.6\times10^{-19}\times1.0\times10^{-7}}$$
$$= 1.1 \times 10^{-3}\ m\ s^{-1} = 1.1\ mm\ s^{-1}$$

(b) (i) At a temperature T, the thermal speed* of a copper atom of mass M is obtained from [< $(mv^2/2)$ >3 kT/2] and is thus typically of the order of $\sqrt{kT/M}$, where k is the Boltzmann constant. For copper at 300 K, this is about 2×10^2 m/s. This figure indicates the random vibrational speeds of copper atoms in a conductor. Note that the drift speed of electrons is much smaller, about 10^{-5} times the typical thermal speed at ordinary temperatures. (ii) An electric field travelling along the conductor has a speed of an electromagnetic wave, namely equal to 3.0×10^8 m s^{-1}

The drift speed is, in comparison, extremely small; smaller by a factor of 10^{-11}

43.Length of aluminium = l_1

Resistance of aluminium = R

Resistivity of aluminium, $\rho_{AI} = \rho_1 = 2.63\times10^{-8}\ \Omega m$

Relative density of aluminium, $d_1 = 2.7$

Area of cross-section of the aluminium wire $= A_1$

Length of copper = l_2

Resistance of copper = R_2

Resistivity of copper, $\rho_{cu} = \rho_2 = 1.72 \times 10^{-8}\ \Omega$ m

Relative density of copper, $d_2 = 8.9$

Area of cross-section of the copper wire $= A_2$

Therefore,

$R_1 = \rho_1 l_1 / A_1$ and $R_2 = \rho_2 l_2 / A_2$

$\rho_1 l_1 / A_1 = \rho_2 l_2 / A_2$

Given $l_1 = l_2$ $\quad A_1/A_2 = \rho_1/\rho_2 = 1.52$

Mass of aluminium, m_1 = Volume x density= $A_1 l_1 \times d_1$

Mass of copper = m_2 = Volume x density= $A_2 l_2 \times d_2$

$m_1/m_2 = (A_1 d_1 / A_2 d_2)$

$m_1/m_2 = (1.52) \times (2.7/8.9) = (1.52) \times (0.303)$, $m_1/m_2 = 0.46$

44.When the current through the element is very small, heating effects can be ignored and the temperature T1 of the element is the same as room temperature. When the toaster is connected to the supply, its initial current will be slightly higher than its steady value of 2.68 A. But due to heating effect of the current, the temperature will rise. This will cause an increase in resistance and a slight decrease in current. In a few seconds, a steady state will be reached when temperature will rise no further, and both the resistance of the element and the current drawn will achieve steady values. The resistance R2 at the steady temperature T2 is

$R_2 = 230\text{ V} / 2.68\text{ A} = 85.8\ \Omega$

Using the relation $R_2 = R_1 [1 + \alpha (T_2 - T_1)]$ with $\alpha = 1.70 \times 10^{-4}\ °C^{-1}$,

we get $T_2 - T_1 = 820\ °C$

that is, $T_2 = (820 + 27.0)\ °C = 847\ °C$

Thus, the steady temperature of the heating element (when heating effect due to the current equals heat loss to the surroundings) is 847 °C.

45.Ans.(a) $[I T^{-1}]$, $[I]$ and $[I T]$

(b) 23 A

Here, $q = a t^2+bt+c$

(a) Dimensions of each factor on R.H.S. of the above relation are that of charge i.e. current x time or [IT].

$[a]=\frac{q}{t^2} = [IT^{-1}]$

$[b]= \frac{q}{t} = [I]$

$[c] = [q] = [IT]$

(b) Here, a = 3, b = 5 and c = 2

Now, I = dq/dt = 2at+b

I (at t = 3 s) =2x3x3+5= 23 A

46.From Kirchhoff's I law $I_3 = I_1 + I_2$ …(i)

Applying Kirchhoff's II law to loop PRSP

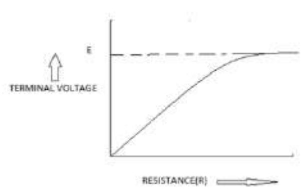
$- 20I_3 -200I_2 + 5 = 0$

$=> 40I_2 + 4I_3 =$ …(ii)

Applying Kirchhoff's II law to loop PRQP

$- 20I_3 - 60I_2 + 4 = 0$

$=> 15I_1 + 5I_3 = 1$



47. $V = I R \ = \frac{E}{r/R+1}$ V= EMF, when no current is drawn from the cell.

48. Ans. I) SERIES

$E_{eq} = E_1 + E_2 +E_3$ ——$+E_n = nE$

$r_{eq} = r_1 + r_2 + r_3$ ——-$+r_n = nr$

$E_{net} = 4 X 1.4 = 5.6$ V

$r_{eq}= 4X.8 = 3.2$-ohm R =10-ohm $R_{net} = 13.2$ ohm

I = 5.6 /13.2 = $I_{series} = 0.424$A

FOR PARALLEL

$E_{eq} = E$

$(1/r_{eq}) = (1/r_1) + (1/r_2) + (1/r_3)$ ……..$(1/r_n)$

$E_{parallel} = 1.4$ V

r_{eq}= .8 /4=.2 ohm R =10 ohm Rnet = 10.2 ohm

I = 1.4 /10.2 =$I_{parallel}$ = 0.137A

current through each cell is 0.03A

49. EMF = E $R_{net} = r + 2$

I = E / r + 2 = 0.5

0.5 X2 + 0.5 r = E ………… 1)

Similarly

0.25 X5 + 0.25 r = E ………………….2)

Solving

r = 1 ohm, E = 1.5 V

when short circuited, current = 1.5

50. In 1st loop

$-R+1+2=0$

$\Rightarrow R=3\Omega$

In 2nd loop

$-2R_1+2-2=0 \quad \Rightarrow R_1=0$

Now going from point, A to B via C.

$V_A+1-0=V_B \quad \Rightarrow V_B=1V$

5 MARKS QUESTIONS SOLUTION

51.(a) Each 'free' electron does accelerate, increasing its drift speed until it collides with a positive ion of the metal. It loses its drift speed after collision but starts to accelerate and increases its drift speed again only to suffer a collision again and so on. On the average, therefore, electrons acquire only a drift speed.

(b) Simple, because the electron number density is enormous, ~1029 m^{-3}.

(c) By no means. The drift velocity is superposed over the large random velocities of electrons.

(d) In the absence of electric field, the paths are straight lines; in the presence of electric field, the paths are, in general, curved

52.(a)1/17 A, 9/17 A, 8/17 A

(b)2.35 V

53. In loop ABCEA

$I_1+I_1=2$

$I_1=1A$

From loop ADCEA

$1.5I_2+ I_2=2$

$I_2=0.8A$

$V_A-V_B=1x1=1V$

$V_A-V_D=0.8x1.5=1.2V$

$V_B-V_D=1.2-1.0=0.2V$

54. From loop ABDA

$5I_1+10I_g-(I-I_1)15=0$

Put I=1A

$4I_1+2I_g=3$

For Loop BCDB

$10(I_1-I_g)-20(I-I_1+I_g)-10I_g=0$

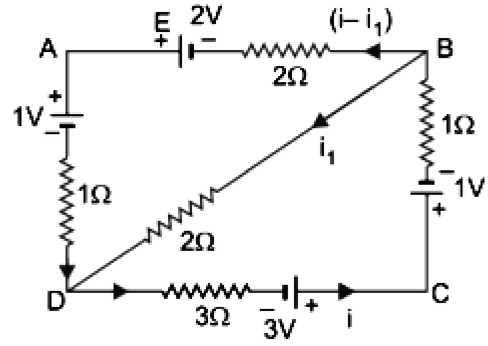
Put I-1A

$3I_1-4I_g=2$

On solving

$I_g=1/22=0.0454A$

55.Applying Kirchhoff's second law to mesh BADB,



$-2(i - i_1) + 2 - 1 - 1. (i - i_1) + 2i_1 = 0$

$\Rightarrow 3i - 5i_1 = 1$ …(i)

Applying Kirchhoff's law to mesh DCBD,

$-3i + 3 - 1 - 1\times i - 2i_1 = 0$

$\Rightarrow 4i + 2i_1 = 2$

Or $2i + i_1 = 1$ …(ii)

Multiplying equation (ii) with 5, we get

$10i + 5i_1 = 5$ …(iii)

Adding (i) and (iii), we get

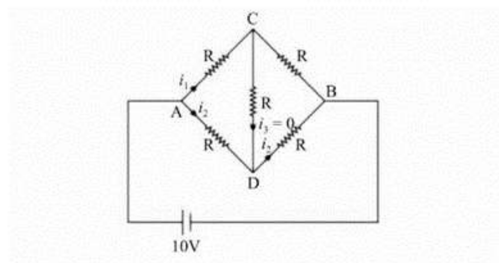
$13i = 6 \Rightarrow i = 6/13$ A

From (ii), $i_1 = 1 - 2i = 1 - 12/13 = 1/13$ A

Potential difference between B and D is

$V_B - V_D = i_1 \times 2 = 2/13$ V

56.R_{AB}= 2 Ohm



$I_{CD} = 0$

$I_{ACB} = V/2R = 10/4 = 2.5$ A

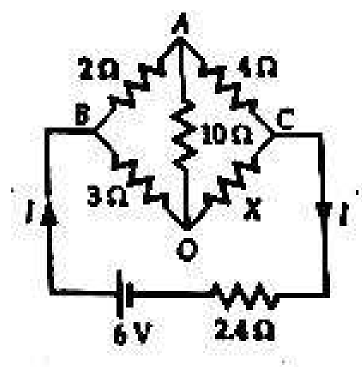
57. Using $\frac{P}{Q} = \frac{R}{X}$

$X=\frac{SU}{S+U}$

Put X=2, S=3, Find U = unknown

U=3 ohm

I = V /3



58.No current flows through section AO, So Wheatstone Bridge is balanced

2/4 =3/X

X= 6 ohm

R_{BAC} = 6 Ohm

R_{BOC} = 9 ohm

R $=\frac{6*9}{6+9}=$ 3.6

Total resistance = 3.6+2.4= 6

I=6/6=1A

Case Based/Passage based integrated questions

59. When a conductor does not have a current through it, its conduction electrons move randomly, with no net motion in any direction. When the conductor does have a current through it, these electrons actually still move randomly, but now they tend to drift with a drift speed Vd in the direction opposite to the applied electric field that causes current. The drift speed is very small as compared to the speeds in the random motion. For example, in the copper conductors of household wiring, electron drift speeds are perhaps 10^5 m/s to 10^3 m/s, where as the random speed is around 10 ms^{-1}.

(i) The electron drift speed is estimated to be only a few mm s^{-1} for currents in the range of a few amperes? How is current established almost the instant a circuit is closed?

(ii) The electron drift arises due to the force experienced by electrons in the electric field inside the conductor. But force should cause acceleration. Why do the electrons acquire a steady average drift speed?

(iii) If the electron drift speed is so small, and the electron's charge is small, how can we still obtain large amounts of current in a conductor?

(iv) When electrons drift in a metal from lower to higher potential, does it mean that all the 'free' electrons of the metal are moving in the same direction?

(v) Are the paths of electrons straight lines between successive collisions (with the positive ions of the metal) in the (a) absence of electric field, (b) presence of electric field?

Case Based/Passage based integrated questions-answers

59. (i) As soon as a circuit is closed, everywhere in conductor, electric field is set up (with the speed of light), and the conduction of electron at every point experience a drift.

(ii) Each conduction electron does accelerate, and gain speed until it collides with a positive ion of a conductor, thereby losing its drift speed after collision again it gains kinetic energy but suffers a collision again and so on. Therefore, on the average, electron acquire only a drift speed.

(iii) As number of the density of electrons ($\approx 10^{29}$ m^{-3}) is very large, therefore current flowing is large.

(iv) No. When electric field is applied, the net drift of the electrons is from lower to higher potential. But locally electrons collide with ions and may change its direction during the course of their motion.

(v) Yes. In the (a) absence of electric field, the paths are straight lines.

Reason: As electrons were not acted upon by any kind of forces.

(b) No. In the presence of electric field paths were curved. Reason: As direction of random velocities and acceleration are not always same.

Case-Based MCQ

60. Read the following text and answer the following questions on the basis of the same:

Electric Toaster: Small Industries Service Institute Takyelpat Industrial Estate Imphal has designed an Electric toaster which is operated at 220 volts A.C., single phase and available in four different rated capacity such as 600 W, 750 W, 1000 W and 1250 W. The heating element is made of nichrome 80/20 (80% nickel, 20% chromium), since Nichrome does not get oxidize readily at high temperature and have higher resistivity, so it produces more heat.

The element is wound separately on Mica sheets and fitted with body of toaster with the help of ceramic terminals.

Q. 1. Heating element of the toaster is made of:

(A) copper (B) nichrome (C) chromium (D) nickel

Q. 2. What is meant by 80/20 Nichrome?

(A) 80% Chromium and 20% Nickel

(B) 80% Nickel and 20% Chromium

(C) Purity 80%, Impurity 20%

(D) It is a mixture of Chromium and Nickel

Q.3. Which one will consume more electricity?

(A) 600 W (B) 1000 W (C) 750 W (D) 1200 W

Q.4. Operating voltage of the device is: (A) 220 V AC, single phase

(A) 220 V AC, single phase (B) 220 V AC, three phase (C) 220 V DC (D) 220 V AC/DC

Q. 5. Insulating materials used in the device are:

(A) Mica (B) Ceramic (C) Mica, ceramic, Nichrome (D) Mica, ceramic

Case Based/Passage based integrated questions-answers

60.

1.Ans. Option (B) is correct.

Explanation: The heating element is made of nichrome 80/20 (80% nickel, 20% chromium).

2.Ans. Option (B) is correct.

Explanation: Nichrome 80/20 means an alloy of 80% nickel, 20% chromium.

3.Ans. Option (D) is correct.

Explanation: Electricity consumption is measured by kWH. So, 1200W toaster will consume more electricity

4.Ans. Option (A) is correct.

Explanation: The designed electric toaster is IN operated at 220 volts A.C., single phase.

5.Ans. Option (D) is correct.

Explanation: The element is wound separately on Mica sheets and fitted with body of toaster with the help of ceramic terminals.

Case-Based MCQ

61.Whenever an electric current is passed through a conductor, it becomes hot after some time. The phenomenon of the production of heat in a resistor by the flow of an electric current through it is called heating effect of current or Joule heating. Thus, the electrical energy supplied by the source of emf is converted into heat. In purely resistive circuit, the energy expended by the source entirely appears as heat. But if the circuit has an active element like a motor, then a part of energy supplied by the source goes to do useful work and the rest appears as heat. Joule's law of heating forms the basis of various electrical appliances such as electric bulb, electric furnace, electric press etc.

(i) Which of the following is correct statement?

(a) Heat produced in a conductor is independent of the current flowing.

(b) Heat produced in a conductor varies inversely as the current flowing.

(c) Heat produced in a conductor varies directly as the square of the current flowing.

(d) Heat produced in a conductor varies inversely as the square of the current flowing.

(ii) If the coil of a heater is cut to half, what would happen to heat produced?

(a) Doubled (b) Halved (c) Remains same (d) Becomes four times.

(iii) A 25 W and 100 W are joined in series and connected to the mains. Which bulb will glow brighter?

(a) 100 W (b) 25 W (c) Both bulbs will glow brighter (d) None will glow brighter

(iv) A rigid container with thermally insulated wall contains a coil of resistance 100 Ω, carrying 1A. Change in its internal energy after 5 min will be

(a) 0 KJ (b) 10 KJ (c)20 KJ (d) 30 KJ

(v) The heat emitted by a bulb of 100 W in 1 min is

(a) 100 J (b) 1000 J (c) 600 J (d) 6000 J

Case Based/Passage based integrated questions-answers

61. (i) (c) Heat produced in a conductor varies directly as the square of the current flowing

(ii) (a) Doubled

(iii)(a) 100 W

(iv)(d) 30 kJ

(v) (d) 6000 J

Case Based/Passage based integrated questions

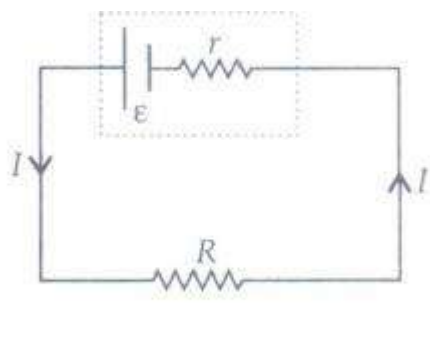
62.Emf of a cell is the maximum potential difference between two electrodes of the cell when no current is drawn from the cell. Internal resistance is the resistance offered by the electrolyte of a cell when the electric current flows through it. The internal resistance of a cell depends upon the following factors;

(i) distance between the electrodes

(ii) nature and temperature of the electrolyte

(iii) nature of electrodes

(iv) area of electrodes.



For a freshly prepared cell, the value of internal resistance is generally low and goes on increasing as the cell is put to more and more use. The potential difference between the two electrodes of a cell in a closed circuit is called terminal potential difference and its value is always less than the emf of the cell in a closed circuit. It can be written as V = E - Ir.

(i) The terminal potential difference of two electrodes of a cell is equal to emf of the cell when

a) during charging b) during discharging c) both a and b d) I= 0

(ii) A cell of emf ε and internal resistance r gives a current of 0.5 A with an external resistance of 12Ω and a current of 0.25 A with an external resistance of 25Ω. internal resistance of the cell and emf of the cell are

a)1Ω, 6.5 V b) 5Ω, 6.5 V c) 1Ω, 7.5 V d) 5Ω, 7.5 V

(iii) Choose the wrong statement.

(a) Potential difference across the terminals of a cell in a closed circuit is always less than its emf.

(b) Internal resistance of a cell decreases with the decrease in temperature of the electrolyte.

(c) Potential difference versus current graph for a cell is a straight line with a -ve slope

(d) Terminal potential difference of the cell when it is being charged is given as V = E + Ir.

(iv) An external resistance R is connected to a cell of internal resistance r, the maximum current flows in the external resistance, when

(a) R = r (b) R < r (c) R> r (d) R=0

(v) IF external resistance connected to a cell has been increased to 5 times, the potential difference across the terminals of the cell increases from 10 V to 30 V. Then, the emf of the cell is

(a) 30 V (b) 60V (c) 50 V (d) 40 V

SOLUTIONS:

62 (i) d) I= 0

(ii) a)1Ω, 6.5 V

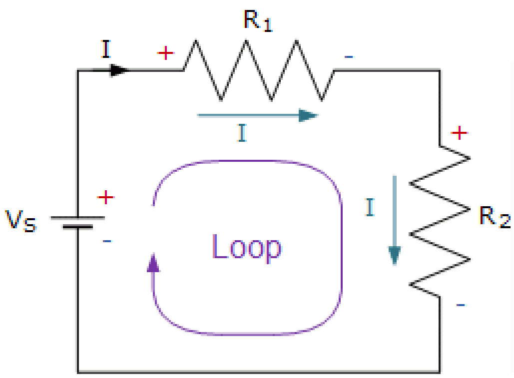
(iii) (b) Internal resistance of a cell decreases with the decrease in temperature of the electrolyte.

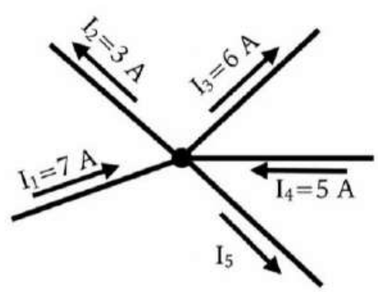
(iv) (d) R=0

(v) (b) 60V

63. **KIRCHHOFF'S RULES**

Electric circuits generally consist of a number of resistors and cells interconnected sometimes in a complicated way. The formulae we have derived earlier for series and parallel combinations of resistors are not always sufficient to determine all the currents and potential differences in the circuit. Two rules, called Kirchhoff's rules, are very useful for analysis of electric circuits. Given a circuit, we start by labelling currents in each resistor by a symbol, say I, and a directed arrow to indicate that a current I flows along the resistor in the direction indicated. If ultimately, I is determined to be positive, the actual current in the resistor is in the direction of the arrow. If I turn out to be negative, the current actually flows in a direction opposite to the arrow. Similarly, for each source (i.e., cell or some other source of electrical power) the positive and negative electrodes are labelled, as well as, a directed arrow with a symbol for the current flowing through the cell.





The directed sum of the potential differences (voltages) around any closed loop is zero.

1.Kirchoff 1^{ST}Law is conservation of

a) Charge b) Energy c) Potential d) Momentum

2.Kirchchoff junction rule can be written as

a) Σ V=0 b) Σ I =0 c) Σ R = 0 d) Σ q = 0

3. Kirchhoff's Voltage Law is the conservation of

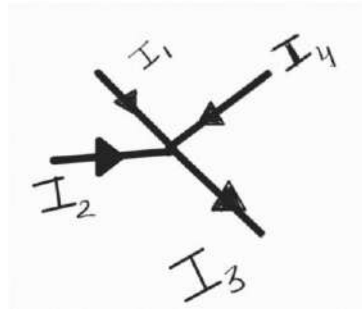
a) Energy b) Charge c) Current d) Momentum

4. Kirchhoff's Voltage Law is applied over

a) Closed Circuit loop b) At a circuit node

c) Acrossbattery d) None of the above

5. Find the current I_3 when I_1=2A, I_2=9A, I_4=4A



SOLUTIONS:

1.a) Charge

2. b) Σ I =0

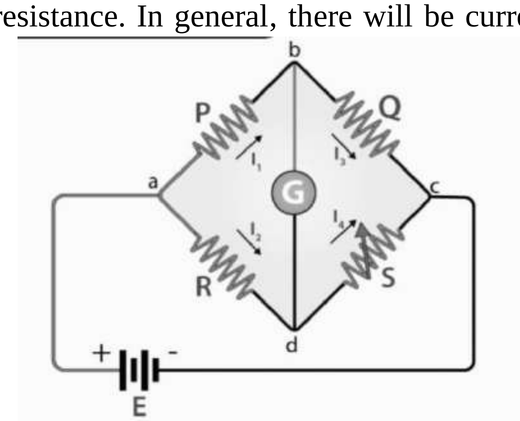
3. a) Energy

4. a) Closed Circuit loop

5. 15A

Case Based/Passage based integrated questions

Q64. As an application of Kirchhoff's rules consider the circuit shown, which is called the Wheatstone bridge. The bridge has four resistors R1, R2, R3 and R4. Across one pair of diagonally opposite points (A and C in the figure) a source is connected. This (i.e., AC) is called the battery arm. Between the other two vertices, B and D, a galvanometer G (which is a device to detect currents) is connected. This line, shown as BD in the figure, is called the galvanometer arm. For simplicity, we assume that the cell has no internal resistance. In general, there will be currents flowing across all the resistors as well as a current I g through G. Of special interest, is the case of a balanced bridge where the resistors are such that I g = 0. We can easily get the balance condition, such that there is no current through G.



1.What is the principle of the Wheatstone bridge?

2.Name the instrument that is used as a null detector in the Wheatstone bridge.

3.Which among the following is a false statement?

a) A galvanometer is used as the null detector in a Wheatstone bridge

b) A galvanometer is an ammeter with low resistance in series

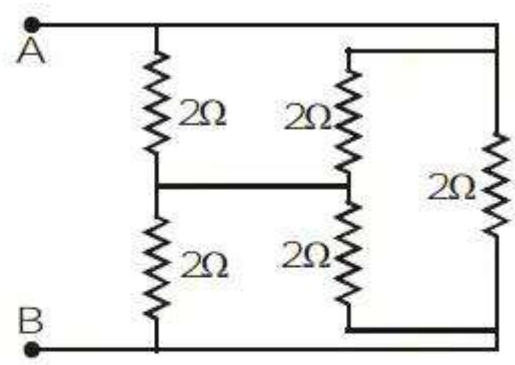
c) Wheatstone bridge is susceptible to high dc current

d) Due to the errors introduced in contact resistance, a Wheatstone bridge cannot be used for accurate measurement

4.PR = QS is the equation of a balanced Wheatstone bridge. Is it true or false?

a) True b) False

5. The equivalent resistance across AB is :



a)1 Ω

b)2 Ω

c)3 Ω

d)4 Ω

SOLUTIONS:

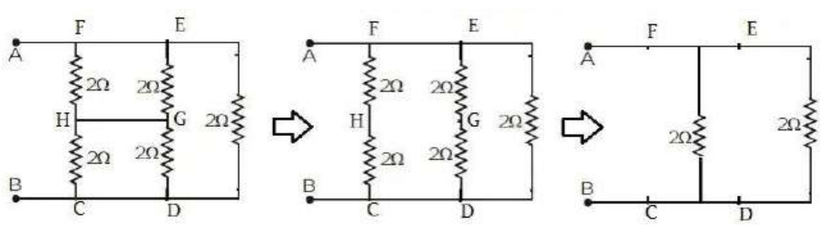
3. c) Wheatstone bridge is susceptible to high dc current

4. b) False

5. a)1 Ω

Here CDEF will represent a balanced Wheatstone bridge. As the each arm resistance is equal to 2Ω so equivalent resistance for bridge is R_{eq}=2Ω. Thus, we can remove the conducting wire GH and the corresponding circuit is as shown in figure.

Equivalent resistance between A and B is R_{AB}=2||2=2/2=1Ω



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Chapter 4

MOVING CHARGES AND MAGNETISM

SECTION A

MCQ

1. An electron having energy 10eV is circulating in path having magnetic field 1.0×10^{-4} Tesla, the speed of the electron will be

   (a) $1.9 \times 10^{6} m/s$ (b) $3.8 \times 10^{6} m/s$ (c) $1.9 \times 10^{12} m/s$ (d) $3.8 \times 10^{12} m/s$

2. A proton passing from a fixed place with constant velocity. If E and B are electric and magnetic field respectively, then which statement is true?

   (a) $E \neq 0, B = 0$ (b) $B \neq 0, E = 0$ (c) $E \neq 0, B \neq 0$ (d) None of the above

3. A solenoid of 1.5 metre length and 4.0 cm diameter possesses 10 turns per cm. A current 5 amp is flowing through it. The magnetic field the axis inside the solenoid is

   (a) $2\pi \times 10^{-3} T$ (b) $2\pi \times 10^{6} T$ (c) $4\pi \times 10^{-3} T$ (d) $2\pi \times 10^{3} T$

4. A particle having charge 100 times that of a electron is revolving in a circular path of radius 0.8 m with one rotation per second. The magnetic field produced at the centre is

   (a) $10^{-7} \mu_0$ (b) $10^{-17} \mu_0$ (c) $10^{-6} \mu_0$ (d) $10^{-15} \mu_0$

5. Biot-Savart law indicates that the moving electrons (velocity v) produce a magnetic field B such that

   (a) $B \perp v$.

   (b) $B \parallel v$.

   (c) it obeys inverse cube law.

   (d) it is along the line joining the electron and point of observation.

6. The coil of a moving coil galvanometer is wound over a metal frame in order to

   (a)Reduce hysteresis

   (b)Increase the sensitivity

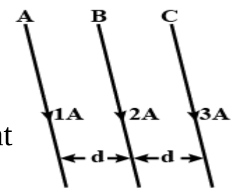
   (c)Increase moment of inertia

   (d) Provide electromagnetic damping

7. Two wires of same length are shaped into a square of side **'a'** and circle of radius **'r'**. If they carry same current, the ratio of the magnetic moment is

   (a)2: π (b) π: 2 (c) π: 4 (d) 4: π

8. Three infinitely long parallel straight current carrying wires A, B and C are kept equal distance from each other as shown in the figure given. The wire C experiences net force **F**. The net force on wire C, when the current in wire A is reversed will be



   (a)Zero (b) $\frac{F}{2}$ (c) F (d) 2F

9. The nature of parallel and anti-parallel currents are

a. Parallel current repels and anti-parallel current attract
b. Parallel current attracts and anti-parallel current repel
c. Both current attract
d. Both current repel.

10. Intensity of magnetic field due to the bar magnet at a point inside a hollow steel-box is

a. Less than outside b. Same as outside c. More than outside d. Zero

1 MARK QUESTIONS

11. Write the expression, in a vector form, for the Lorentz magnetic force $\vec{F}$ due to a charge moving with velocity $\vec{v}$ in a magnetic field $\vec{B}$. What is the direction of the magnetic force?
12. What is figure of merit of a galvanometer?
13. In a certain arrangement, a proton does not get deflected while passing through a magnetic field region. State the condition under which it is possible.
14. Using the concept of force between two infinitely long parallel current carrying conductors, define one ampere of current. (All India 2014)
15. Write the expression, in a vector form, for the Lorentz magnetic force $\overrightarrow{F}$ due to a charge moving with a velocity $\overrightarrow{v}$ in a magnetic field $\overrightarrow{B}$. What is the direction of the magnetic force? (CBSE 2014)
16. Why should be the spring/suspension wire in a moving coil galvanometer have low torsional constant? (All India 2008)
17. What is the underlying principle of a moving coil galvanometer? (CBSE 2019)

18. A coil of area A carrying a steady current I has a magnetic moment $\overrightarrow{m}$ associated with it. Write the relation between $\overrightarrow{m}$, I and A in vector form. (Comptt 2016)

2-MARK QUESTIONS

19. A current carrying loop is free to turn in a uniform magnetic field B. Under what conditions, will the torque acting on it be (i) minimum and (ii) maximum?
20. A current carrying loop is free to turn in a uniform magnetic field B. Under what conditions, will the torque acting on it be (i) minimum and (ii) maximum?
21. A steady current (I_1) flows through a long straight wire. Another wire carrying steady current (I_2) in the same direction is kept close and parallel to the first wire. Show with the help of a diagram how the magnetic field due to current (I_1) exerts a magnetic force on the second wire. Write expression for this force. (All India 2013)
22. A moving coil galvanometer, whose coil resistance is 100 Ω, shows full scale deflection when 1mV is put across it. How can it be converted into a voltmeter of range (0-1V)?
23. How do convert a galvanometer into an ammeter? Why is an ammeter always connected in series? (AI 2005)
24. What is the behaviour of magnetic field lines due to diamagnetic material?

3-MARKS QUESTIONS

25. A long straight wire in the horizontal plane carries a current of 50 A in north to south direction. Give the magnitude and direction of B at a point 2.5 m east of the wire.
26. Write the expression for Lorentz magnetic force on the particle of charge q moving with velocity v in a magnetic field B. Show that no work is done by this force on the charged particle.
27. Derive the expression for the torque τ acting on a rectangular current loop of area A placed in a uniform magnetic field B. Show that $\overrightarrow{\tau} = \vec{m} \text{ X } \overrightarrow{B}$ where $\vec{m}$ is the magnetic moment of the current loop given by $\vec{m} = I\overrightarrow{A}$.
28. Describe the working principle of a moving coil galvanometer. Why is it necessary to use **(i)** a radial magnetic field and **(ii)** a cylindrical soft iron core in a galvanometer? Write the expression for current sensitivity of the galvanometer. Can a galvanometer as such be used for measuring the current? Explain.

5-MARKS QUESTIONS

29. (i)Explain using a labelled diagram the principle and working of a moving coil galvanometer. What is the function of (a) uniform radial magnetic field (b) soft iron core?

    (ii)Define the terms (a) Current sensitivity (b) Voltage sensitivity

    (iii)Explain why does increasing the current sensitivity not necessarily increases the voltage sensitivity

Assertion-Reason

Select the correct answer to these questions from the codes (a), (b), (c) and (d) are as given below

(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true but R is not the correct explanation of A.

(c) A is true but R is false.

(d) A is false and R is also false.

30. **Assertion** Difference between an electric line and magnetic line of force is that electric lines of force are discontinuous and the magnetic field lines are continuous.

    Reason Electric lines of forces do not exist inside a charged conductor but magnetic lines exist inside a magnet.

31. **Assertion** A current carrying solenoid behaves like a bar magnet.

    Reason The circular loop in which the direction of current is clockwise behaves like the South Pole and the one having anticlockwise current behaves like the North Pole.

32. **Assertion** Permanent magnets retain their ferromagnetic property for a long period of time.

    Reason Steel is a diamagnetic material.

33. **Assertion** When a bar magnet is hung freely it points toward geographical poles.

    Reason Magnetic field lines do not intersect.

34. **Assertion** A diamagnetic specimen would move towards the weaker region of the field.

    Reason A diamagnetic specimen is repelled by a magnet.

35. **Assertion** Motion of electron around a positively charged nucleus is different from the motion of a planet around the sun.

    Reason The force acting in both the cases is same in nature.

36.**Assertion** Two parallel conducting wires carrying currents in same direction, come close to each other.

Reason Parallel currents attract and anti-parallel currents repel.

37.**Assertion** A galvanometer cannot as such be used as an ammeter to measure the current across a given section of the circuit.

Reason For this it must be connected in series with the circuit.

38.**Assertion** Magnetic lines of force form continuous closed loops whereas electric lines of force do not.

Reason Magnetic poles always occur in pairs as north pole and south pole.

39.**Assertion** An electron moving along the direction of magnetic field experiences no force.

Reason The force on electron moving along the direction of magnetic field is $F = qVB \sin 0° = qVB$

40. **Assertion** Iron is not a magnet.

Reason Iron is diamagnetic substance

Case study based question

41. Force on a moving charge

Stationary charge creates an electric field but a moving charge creates a magnetic field also that can affect other moving charges. It was observed by Oersted. He saw that if a magnetic needle is placed near current carrying wire it shows slight deflection. The direction of the magnetic field can be determined by using the right hand thumb rule. Magnetic field is the space around a magnet, a current carrying conductor up to which it can attract or repel magnetic material. Force on a moving charge in magnetic field is given by the formula

$\vec{F} = \mathbf{q}\ (\vec{v}\ \mathbf{X} \vec{B})$

Where q = charge on particle

v = velocity of charge particle

B = magnetic field and

F = magnetic force

When a current carrying conductor is placed in an external magnetic field, it experiences a mechanical force. A conductor of length 1 carrying current I held in a magnetic field B at an angle θ with it, experiences a force given by $F = I\ l\ B \sin \theta$.

1. Moving charge can create

(a) Electric field (b) magnetic field

(c) Both electric and magnetic field (d) none of them

2. If a current is flowing from south to north in a straight wire what will be the direction of magnetic field to its left side

(a) Outward (b) inward

(c) Towards right (d) towards left

3. Which of the following cannot be the source of magnetic field?

(a) Current carrying wire (b) moving electron

(c) Moving proton (d) stationary charge

4. Force acting on a conductor of length 10 m carrying a current of 6A kept perpendicular to the magnetic field of 2T is

(a) 60N (b) 120N (c) 90N (d) 100N

5. A straight wire is of mass 100 g and length 1.0 m carrying a current of 5A. It is suspended in a uniform horizontal magnetic field **B**. The magnitude of **B** is (assume that g = 9.8ms")

(a) 0.196T (b) 0.46T (c) 0.15T (d) 3.26T

****

ANSWER KEY

SECTION A

MCQ TYPE (1MARK EACH)

1.(a) $1.9 \times 10^6 m/s$

2.(c) $E \neq 0, B \neq 0$

3. (a) $2\pi \times 10^{-3} T$

4. (b) $10^{-17} \mu_0$

5. (a) B ⊥ v

6. (d) Provide electromagnetic damping.

7. (c) π: 4

8. (a) Zero

9. (b) Parallel current attracts and anti-parallel current repel

10. d) Intensity of magnetic field inside a steel box is zero. No magnetic lines of force pass through the box.

1 MARK

11. $\vec{F} = q(\vec{v} x \vec{B})$. The direction of force is perpendicular to both v and B.

12. It is defined as the current which produces a deflection of one scale division in the galvanometer

13. v is parallel or antiparallel to B

14. Using F/l = μ0 $I_1 I_2$ /2πr. One Ampere is the current which when flowing through two infinitely long, straight parallel conductors of negligible cross section held 1m apart in vacuum develop force of 2 x 10^{-7} N/m of the conductors

15.F= q ($\vec{v}$ X $\vec{B}$), The force acts in a direction given by the thumb of the right hand with fingers circling from $\vec{v}$ to $\vec{B}$.

16. Low torsional constant is basically required to increase the current sensitivity in an MCG.

17. A current carrying coil, in the presence of magnetic field experiences a torque which produces proportionate deflection. Deflection α Torque

18. Magnetic Moment $\vec{m}$ = I $\vec{A}$

2-MARKS

19. Minimum potential energy = – MB when θ = 0 (most stable position)

Maximum potential energy = MB when $\theta = 180°$ (most unstable position)

20. loop will come to equilibrium when torque is zero

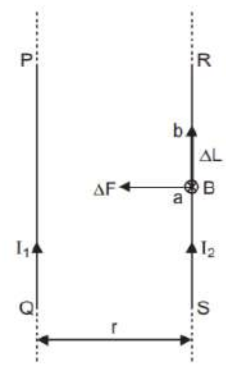
So, $\tau = 0 = M \times B$

$= MB\sin\theta$

$= NiAB\sin\theta$

So, angle between area vector and field is zero than only θ is 0 so that $\sin\theta = 0$. So, for area vector along field direction plane is perpendicular to the field.

21.



Let the given wires PQ and RS separated by a distance 'r'. As the wires carry current, they produce magnetic field around them. The wire Produces magnetic field of intensity B at P on RS, which is equal to $\mu o\, I1 / 2\pi r$ The wire RS carrying current I 2 and placed in a Magnetic field of P Q Experiences a force given by

$F = B\, I_2\, l = (\mu o\, I_1\, I_2 / 2\pi r).\, l$ Similarly, RS also exert an equal and opposite force (attractive for like parallel currents) on the wire PQ, which is equal to

$$F = B\, I_1\, l = (\mu o\, I_1\, I_2 / 2\pi r).\, l \quad N/m$$

22. $Ig = V/G = 1X\ 10^{-3}//100 = 10^{-5}$ A

$V = Ig\, G + Ig\, R,$

$= 10^{-5} (100 + R)$

R = 100000- 100 = 99900 ohms.

23. We know that an ammeter has very low resistance. Thus, in order to convert a galvanometer into an ammeter, a very low shunt resistance must be connected in parallel to galvanometer resistance RG so that the overall resistance of the circuit becomes very small. Thus, a galvanometer can be converted into an ammeter by adding a low shunt resistance in parallel to the galvanometer. It is connected in series so that whole of electric current, which it has to measure, passes through it.

24. A diamagnetic material tends to move from stronger to weaker regions of the magnetic field and hence, decrease the number of lines of magnetic field passing through it. Relative permeability is 1.

25.

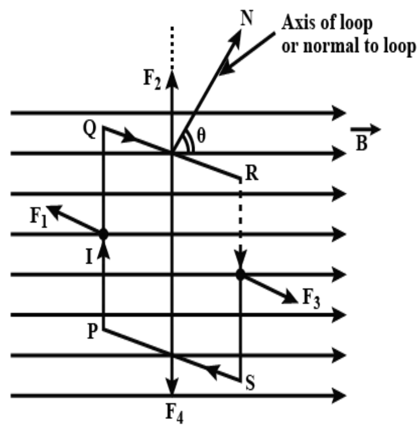
3-MARKS

26. Current, I=50A, Distance, r = 2.5 m, Magnetic field, B = 2πrμoI, B = 4.0×10^{-6} T

According to Maxwell's right hand, the direction of field is upward.

27. Lorentz magnetic force F = q (V x B). As the magnetic force F acts in the direction perpendicular to the direction of velocity V or the direction of motion of the charge particle, so the work done is zero. So, W = F.ds = Fds cosɵ = f ds cos90 = 0

28. Torque on a rectangular current loop in a uniform magnetic field



Let I= current through the coil

a, b = sides of the rectangular loop ,PQ = b & QR= a

A=ab = area of the loop

n= number of turns in the loop

B= magnetic field

Θ= angle between magnetic field B and area vector A

Force exerted on the arm PQ inward

F_1 = I b B [F = ILB]

Force exerted on the arm RS outward

F_3= I b B F1 = F3

Therefore, two equal and opposite forces form a couple which exerts a torque.

Therefore, Magnitude of the torque on the loop is,

τ = F1 x (a/2) sin θ + F3 (a/2) sin θ

= (F1 + F3). (a/2) sin θ

= (IbB + IbB). (a/2) sin θ

⇨ τ = 2IbB (a/2) sin θ
⇨ = IabB sin

= IAB sinθ

magnetic moment of the current loop is

M= IA

τ = MB sinθ = τ = M x B

If loop has n turns then M= nIA

τ = nIAB sinθ

when θ = 90 ^{0} then τmax = nIAB

when θ=0^0 then τ = 0.

29. (i) It keeps the magnetic field line normal to the area vector of the coil

(ii) The cylindrical soft iron core, when placed inside the coil of a galvanometer, makes the magnetic field stronger and radial in the space between it and pole pieces, such that whatever the position of the rotation of the coil maybe, the magnetic field is always parallel to its plane.

Current sensitivity is defined as the deflection produced by the galvanometer when unit current is passed through its coil.

$I_s = \varphi/I = NBA/k$ radian/ampere or division A^{-1}.

No, the galvanometer cannot be used to measure current. it can only detect current but cannot measure as it is not calibrated. The galvanometer coil is likely to be damaged by currents in the (mA/A) range.

5-MARKS

30. (i)A galvanometer is an electromechanical instrument used for the detection of electric currents flowing through electrical circuits. It is a very sensitive instrument which cannot be used for the measurement of large currents. It works on the principle of conversion of electrical energy into mechanical energy while a current is flowing in a magnetic field as it experiences a magnetic torque and hence rotates through an angle proportional to the current flowing through it.

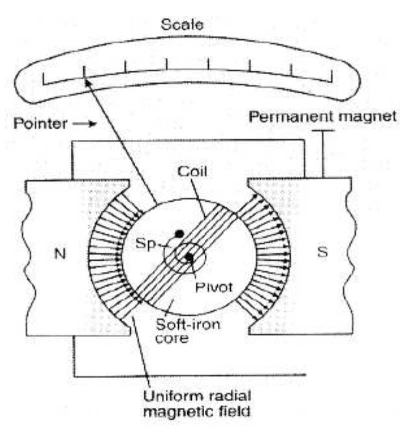
Let I = the current flowing through coil,

B = magnetic field parallel to the coil, and

A = area of the coil.

Deflection acting on the coil is

τ = NIBA sin 90° = NIBA [$\because$ sin 90°=1]



(a) By making a uniform radial magnetic field through a coil, the magnetic field lines become perpendicular to the magnetic moment of a galvanometer.

$\tau = k\Phi$

NIBA $= k\Phi$

$\Phi = (NBAI/k)$

$\therefore \Phi \propto I$

(b) Soft Iron core can make the electromechanical field radial which in turn would increase the magnetic field.

(ii) Definition for the terms :

(a) Current Sensitivity- It is deflection produced per unit current flowing across the galvanometer

. $I_s = \theta/I = NBA/K$

(b) Voltage Sensitivity- It is the minimum change in voltage which produces change in the output of the galvanometer.

$V_s = \theta/V = \theta/IR = NBA/KR$

(iii) Since Voltage sensitivity decreases with the increase in resistance of the coil and the effect of an increase in the number of turns is hence nullified in case of voltage sensitivity so there is no change of voltage sensitivity, whenever there is a change in current sensitivity.

Assertion-Reason

30.(a) Since no electric lines of forces exist inside a charged body, the electric lines of force only travel from positive to negative charge and are discontinuous. Secondly, magnetic lines of force travel from north to south pole and inside the magnet they are from south pole to north pole hence continuous.

31.(a) A solenoid is a type of electromagnet formed by a helical coil of wire whose length is substantially greater than its diameter, its two ends can be visualised as two coils.

32.(c) Permanent magnets retain their ferromagnetic property for a long period of time and steel is a paramagnetic material.

33.(b) It is the property of a magnet to rest in a geographical north and south pole and another property of magnetic field is that magnetic field lines do not intersect.

34.(a) In the case of diamagnetic substances, the magnetic moments of atoms and the orbital magnetic moments have been oriented in such a manner that the vector sum of an atom's magnetic moment becomes zero. An external magnetic field can repel them weakly.

35.(d) Neil Bohr proposed a model, which is familiar as a planetary model of atoms. In Bohr's model, the neutrons and protons occupy a dense central region called the nucleus, and electrons orbit the nucleus much like planets orbiting the sun. Electrons are negatively charged and the nucleus is positively charged. Force in the former case is electrostatic force but in later case it is gravitational force.

36.(a) By using the right hand thumb rule, the direction of the magnetic field can be determined then by using Fleming's right hand rule the direction of force comes towards each other.

37.(d) As the galvanometer is used to check the current flow direction and the magnitude of the direct current. That's why the resistance of the galvanometer is nearly zero. This is somewhere similar to ammeter but both are different devices. Ammeter can only show us the current magnitude not the direction. A Galvanometer's needle can fluctuate in two directions whereas an ammeter's needle can only show one side deflection.

38.(b) Electric lines of forces do not exist inside a charged body, the magnetic lines of force travel from north to south pole and inside the magnet they are from south pole to north pole hence continuous.

39.(a) If the particle is moving along the direction of magnetic field, then ɵ = 0° hence force becomes zero.

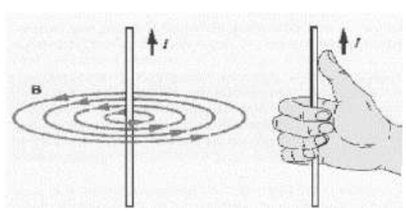
40. c) Assertion is true reason is false. Iron is a ferromagnetic material.

Case study based question

41.

1.(c) stationary charge creates electric field but moving charge creates both electric and magnetic field.

2.(a)



The direction of thumb is from south to north, using right hand thumb rule, if we curl our fingers on the left side, it shows the outward direction.

3.(d) Magnetic field is created around moving charge, a stationary charge cannot create magnetic field.

4.(b) F=ilB Sinɵ = 6x10x2xSin 90° = 120N

5.(a) mg = ilB Sinɵ

$100 x 10^{2} x\ 9.8 = 5x1xBx\ \text{Sin}\ 90°$ B = 0.196T

****

SECTION B

MCQ

Q1. Two parallel conductors carrying 'i' current in the same direction what will be the force being experienced by each conductor (r = distance between the conductors)

(a)Repulsion and $\frac{\mu_0 2i}{4\pi r}$ (b) Repulsion and $\frac{\mu_0 i}{4\pi 2r}$

(c) Attraction and $\frac{\mu_0 i^2}{2\pi r}$ (d) Attraction and $\frac{\mu_0 i}{4\pi 2r}$

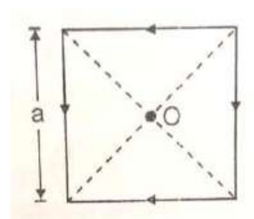
Q2. The magnetic field at a point midway between two parallel long wires carrying currents in the same direction is $10\mu T$. If the direction of the smallest current among them is reversed, the field becomes $30\mu T$. The ratio of the larger to the smaller current in them is

(a) 3 : 1 (b) 2 : 1 (c) 4 : 1 (d) 3 : 2

Q3. An electric current is flowing through a circular coil of radius R. The ratio of the magnetic field at the centre of the coil and that at a distance $2\sqrt{2R}$ from the centre of the coil and on its axis is

(a) $2\sqrt{2}$ (b) 27 (c) 36 (d) 8

Q4. A square coil of side a carries a current l. The magnetic field at the centre of the coil is



(a) $\frac{\mu_0 l}{a\pi}$ (b) $\frac{\sqrt{2}\mu_0 l}{a\pi}$ (c) $\frac{\mu_0 l}{\sqrt{2}a\pi}$ (d) $\frac{2\sqrt{2}\mu_0 l}{a\pi}$

Q5. A current loop in a magnetic field

(a) Can be in equilibrium in one orientation

(b) Can be in equilibrium in two orientations, both the equilibrium states are unstable

(c) Can be in equilibrium in two orientations, one stable while the other is unstable

(d) Experiences a torque whether the field is uniform or non – uniform in all orientations

Q6. Force on a current carrying conductor in a magnetic field is

(a) BIL tan Ө (b) BI / Lsin Ө (c) BILsin Ө (d) BILcos Ө

Q7. A current carrying loop is placed in a uniform magnetic field. The torque acting on it does not depend upon (a)Area of loop (b) Value of current (c) Magnetic field (d) None of these

Q8. What is the magnitude of magnetic force per unit length on a wire carrying a current of 4 amperes and making an angle of 30º with the direction of magnetic field of 2T?

(a)2 N/m (b) 3 N /m (c) 4 N/m (d) 5 N/m

Q9. We can convert moving coil galvanometer into voltmeter by:

(a)Introducing resistance of large value in parallel.

(b)Introducing resistance of small value in series

(c)Introducing resistance of large value in series.

(d)Introducing resistance of small value in parallel

1 MARK QUESTIONS

Q10. In a certain region of space, electric field E " and magnetic field B " are perpendicular to each other. An electron enters in the region perpendicular to the directions of both B E and " " and moves undeflected. Find the velocity of the electron.

Q11. Two identical charged particles moving with same speed enter a region of uniform magnetic field. If one of these enters normal to the field direction and the other enters along a direction at 30º with the field. What would be the ratio of their angular frequencies?

Q12. An α particle and a proton are moving in the plane of the paper in a region where there is a uniform magnetic field $\vec{B}$ directed normal to the plane of the paper. If the two particle have equal linear momenta, what will be the ratio of the radii of their trajectories in the field?

Q13. A beam of protons projected along +x-axis experiences a force due to a magnetic field along –y-axis. What is the direction of the magnetic field?

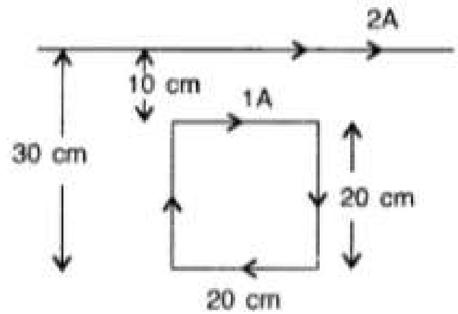
2 MARKS QUESTIONS

Q14. Can we decrease the range of an ammeter?

Q15. An electron and proton, moving parallel to each other in the same direction with equal momenta, enter into a uniform magnetic field which is at right angle to their velocities. Trace the trajectories in the magnetic field.

Q16.An ammeter of resistance 0.6 Ω can measure current up to 1.0 A. Calculate (i) The shunt resistance required to enable the ammeter to measure current up to 5.0 A (ii) The combined resistance of the ammeter and the shunt. (Delhi 2013)

Q17. A square loop of side 20 cm carrying current of 1 A is kept near an infinite long straight wire carrying current of 2A in the same plane as shown in the figure. Calculate the magnitude and direction of the net force exerted on the loop due to the current carrying conductor.



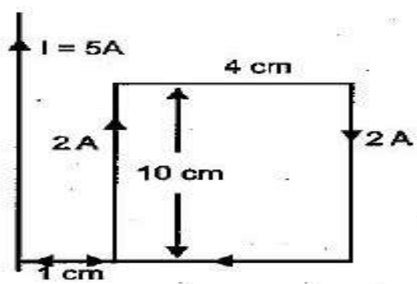
3-MARKS QUESTIONS

Q18. (a) Write the expression for the magnetic force acting on a charged particle moving with velocity v in the presence of magnetic field B.

(b)A neutron, an electron and an alpha particle moving with equal velocities, enter a uniform magnetic field going into the plane of the paper as shown. Trace their paths in the field and justify your answer.

5-MARKS QUESTIONS

Q19. A rectangular loop of wire as shown in the figure of size 4cm x 10cm carries a steady current of 2A A straight long wire carrying 5A current is kept near the loop as shown fig. If the loop and the wire are coplanar find (a) Write an expression for torque. (b)The torque acting on the loop and (c) the magnitude and direction of the loop due to the current carrying wire



Assertion-Reason

Select the correct answer to these questions from the codes (a), (b), (c) and (d) are as given below

(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true but R is not the correct explanation of A.

(c) A is true but R is false.

(d) A is false and R is also false.

Q20. **Assertion** The poles of magnet cannot be separated by breaking into two pieces.

Reason The magnetic dipole moment will be reduced to half when broken into two equal pieces.

Q21. **Assertion** When a bar magnet is kept in an external uniform magnetic field, it starts oscillating.

Reason A restoring torque acts on the dipole when kept in the magnetic field.

Q22. **Assertion** Two parallel wires carrying currents in the opposite direction, attract each other.

Reason Parallel currents repel and antiparallel currents attract.

Q23. **Assertion** Gauss's theorem is not applicable in magnetism.

Reason Magnetic monopoles do not exist.

Q24. **Assertion** Magnetic field produced by a current carrying solenoid is independent of its length and cross-sectional area.

Reason There is a uniform magnetic field inside the solenoid.

Q25. **Assertion** If a charged particle is projected in a region, where B is perpendicular to velocity of projection, then the net force acting on the particle is independent of its mass.

Reason The particle is performing rectilinear motion.

Q26. **Assertion** When a charged particle moves in a region of magnetic field such that its velocity is at some acute angle with the direction of field, its trajectory is a helix.

Reason Perpendicular component of velocity causes a rotating centripetal force and the parallel component of velocity does not produce any force.

Q27. **Assertion** For a current carrying wire loop of N turns, placed in a region of a uniform magnetic field B, the torque acting on it is given by m x B.

Reason Whenever the magnetic moment m is perpendicular to B, then torque on the loop will be zero.

Q28**. Assertion** The current sensitivity of a galvanometer is the deflection of current per unit current passing through the coil.

Reason The galvanometer can be used as a detector to check if a current is flowing in the circuit.

Q29. **Assertion** Magnetic field lines always form closed loops.

Reason Moving charges or currents produce a magnetic field.

Case study based question

Q30. **Magnetic moment**

The directional property of magnets was also known since ancient times. A thin long piece of a magnet, when suspended freely, pointed in the north-south direction. Magnetic field is responsible for the most notable property of a magnet. It is a force that pulls on other ferromagnetic materials, such as iron, steel, nickel, cobalt, etc., and attracts or repels other magnets. Magnet's magnetic moment is a vector that characterises the magnet's overall magnetic properties. It is also called magnetic dipole moment and usually denoted by **m.**

For a bar magnet, the direction of the magnetic moment points from the magnet's south to north-pole and the magnitude relates to how strong and how far apart these poles are.

1. In a uniform magnetic field the net magnetic force on the dipole

(a) Is always zero

(b) Depends on the orientation of the dipole

(c) Can never be zero

(d) Depends on the strength of the dipole

2. Torque acting on a magnetic dipole in uniform magnetic field at an acute angle is

(a) Zero (b) Nonzero (c) Equal to force (d) None of these

3. The magnetic dipole moment of a circular coil current carrying I and area Ais

(a) IA (b) NIA (c) $\mu_0 nI$ (d) nIAB

4. Which of the following cannot behave as a magnetic dipole

(a) Electron revolving around nucleus (b) Current loop

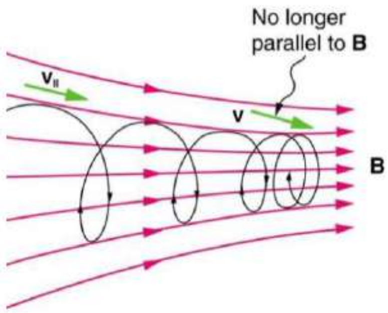
(c) Diamagnetic materials (d) All of them

5. The ultimate individual unit in any magnet is a

(a) south-pole (b) north-pole (c) Quadrupole (d) Dipole

Q 31. FORCE ON A CHARGE IN ELECTRIC AND MAGNETIC FIELD

A point charge q (moving with a velocity v and located at r at a given time (t) in the presence of both the electric field E and magnetic field B. The force on an electric charge q due to both of them can be written as $F = q [E + v \times B] = F_{el} + F_{mag}$ .It is called the 'Lorentz force'.



1. If the charge q is moving under a field, the force acting on the charge depends on the magnitude of field as well as the velocity of the charge particle, what kind of field is the charge moving in?

(a) Electric field (b) Magnetic field

(c) Both electric and magnetic field perpendicular to each other (d) None of these

2. The magnetic force acting on the charge ‘q’ placed in a magnetic field will vanish if

(a) if v is small (b) If v is perpendicular to B (c) If v is parallel to B

(d) None of these

3. If an electron of charge -e is moving along + X direction and magnetic field is along + Z direction, then the magnetic force acting on the electron will be along

(a) + X axis (b) - X axis (c) - Y axis (d) + Y axis

4. The vectors which are perpendicular to each other in the relation for magnetic force acting on a charge particle are

(a) F and v (b) F and B (c) v and B (d) All of these

5. A particle moves in a region having a uniform magnetic field and a parallel, uniform electric field. At some instant, the velocity of the particle is perpendicular to the field direction. The path of the particle will be

(a) A straight line (b) A circle (c) A helix with uniform pitch (d) A helix with non-uniform pitch

****

ANSWER KEY

SECTION B

MCQ

1. (c) Attraction and $\frac{\mu_0 i^2}{2\pi r}$
2. (b) 2 : 1
3. (b) 27
4. (d) $\frac{2\sqrt{2}\mu_0 l}{a\pi}$
5. (c) Can be in equilibrium in two orientations, one stable while the other is unstable
6. (c) BILsinϴ
7. (d) None of these
8. (c) 4N/m hint: BILsinϴ
9. (c) introducing resistance of large value in series

1 MARK

10. Net force on electron moving in the combined electric field E and magnetic field B is

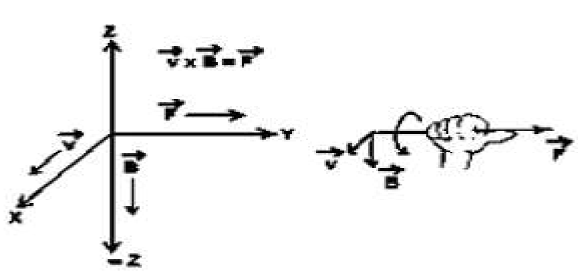
F = e (E + V X B)

Since electron moves undeflected then F = 0

e (E + V X B) = 0

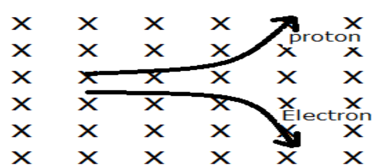
V = l E l/l B l

11. 1:1, The angular frequency does not depend on the speed of the particle or radius of its orbit.
12. 1:2 (r = mv/qB = p/qB, for equal p, r α 1/q)
13. The direction of Magnetic field is towards positive direction of z axis.



2-MARKS

14. An ammeter is basically a permanent magnet moving coil (PMMC) instrument which deflects for very small amount of current (in mA range). Its only possible to increase the range of an ammeter but we cannot decrease the range of an ammeter. The range of an ammeter can be easily increased by adding a shunt resistance of very low value to bypass the major part of the current through the resistance path instead of ammeter. This increases the range of an ammeter by reducing the actual current flow through the ammeter. There is a way to decrease the range of an ammeter but it is not practically feasible. If we decrease the restoring torque by reducing spring stiffness inside the ammeter it will decrease the range of the ammeter. We are basically increasing the sensitivity of the ammeter. But reducing spring stiffness causes large stray errors in the readings and is therefore not practically feasible.
15. A magnetic field does not exert any force on a charge moving parallel or antiparallel to the field direction. Since they are travelling in the direction of the magnetic field, there will be no force acting on them. Hence their paths will remain the same after entering the magnetic field.



16. (i) Shunt resistance, S=IgG/I –Ig

1x 0.6 /(5-1)
0.15 ohm

(ii) Total resistance,
1/R= 1/.6 +1/.15
= (50+ 200) /30
= 250/30
Therefore, R = 30/250 = 0.12 0hms

17. We are given:

$I_1 = 2A$, $I_2 = 1A$

$r_1 = 10$ cm, $r_2 = 30$ cm

$\mu_o = 4 \pi$ x 10-7 TmA^{-1}

We have

Now net force on the side will be;

$F = \mu_o I_1 I_2 l (1/r_1 - 1/r_2)$

$F = 2x\ 10^{-7}\ x\ 1x2x\ (20x10^{-2})\ [\ 1/10x10^{-2} - 1/30x10^{-2}]$

$F = 5.33\ x\ 10^{-7}\ N$

The direction of force is towards the infinitely long straight wire.

3-MARKS

18. Lorentz force = magnetic force + electric force

$F = [\ Qvb \sin\theta + Qe]$

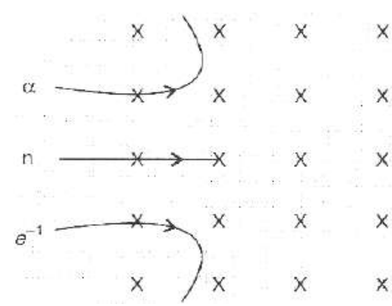
We know that a charged particle will experience a force when it enters a magnetic field. The magnetic field will move the charged particle in a circular path, as the force is perpendicular to the velocity of particle. The radius of the circular path will be given by

$mv^2 / r = Bqv$

$r = mv / Bq$

As B and v are constant, we can write

$r \propto m/q$



The neutron will move along the straight line as it has no charge.

The electron will inscribe a circle of radius smaller than that of the alpha particle as the mass to charge ratio of the alpha particle is more than that of the electron. So, the alpha particle will move in the clockwise direction and the electron will move in anticlockwise direction according to the right-hand rule.

5 MARKS

19. (a) $\tau = MB \sin\theta = \tau = M \times B$

(b) $\tau = M\times B = Mb\sin\theta$

here M and B are in the same direction so

$\theta = 0, \therefore \tau = 0$

© we know, FB = © l × B

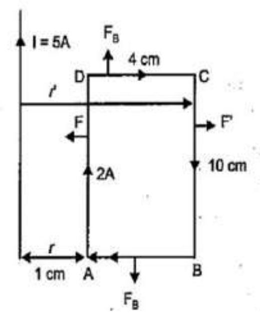
Force between two current carrying wires is given by

$F = (\mu_0/2\pi).\ (I_1 I_2/r) \times l = (\mu_0/2\pi) \times (5 \times 2/\ 1 \times 10^{-2}) \times 0.10$

$F = (\mu_0/2\pi).\ 100$

And $F' = (\mu_0/2\pi) \times (5 \times 2/\ 1 \times 10^{-2}) \times 0.10$

$F' = (\mu_0/2\pi) \times 20$



Now, resultant force on the loop,

$F_{net} = F - F' = (\mu_0/2\pi)\ (100 - 20)$

$= 2 \times 10^{-7} \times 80 = 16 \times 10^{-6}$ N

The direction of net force is towards the straight wire i.e., attractive.

Assertion-Reason

20.(b) The magnetic dipole moment will be reduced to half when broken into two equal pieces and every atom behaves like a dipole so the dipole of a magnet cannot be separated.

21.(a) When a bar magnet is placed in a uniform magnetic field. Then the bar magnet will experience only torque and no force, and this torque on the bar magnet will be acting on both ends, and will be equal but opposite in direction.

22.(d) Parallel currents attract and antiparallel currents repel.

23.(a) Gauss's law of magnetism is different from that for electrostatics because electric charges do not necessarily exist in pairs but magnetic monopoles do not exist.

24.(b) **B** $=\mu_0 Ni$, from this formula we see the dependence of B in current and inside a solenoid it is uniform.

25.(c) Force =q(V x B) it is independent of mass and if v and B are perpendicular to each other, the particle describes a circle.

26.(a) A charged particle moves in a circle when its velocity is perpendicular to the magnetic field. When it forms an acute angle with the magnetic field, it can be resolved in two components, parallel and perpendicular. The perpendicular components tend to move it in a circle, the parallel components tend to move along the magnetic field to form a helical motion of uniform radius and pitch.

27.(c) Torque, $\tau = mB\sin\theta$

Here $\theta = 90°$, Sin 90° = 1 so torque will be maximum.

28.(b) A galvanometer is a device that is used to detect small electric current or measure its magnitude. The current sensitivity of a galvanometer is the deflection of current per unit current passing through the coil $I_s = \frac{NAB}{k}$

29.(b) Assertion is the property of a magnet while reason is one of the sources of magnetic field.

Case study based question

30. 1.(a) The forces of magnitude Mb act opposite to each other on two poles, hence net force acting on the dipole due to external magnetic field is zero.
2.(b) Forces acting on the poles are along different lines of action constituting a couple hence non zero torque.
3.(a) The magnetic dipole moment of a current loop is the product of the current passing through the loop and the area inside the loop.
4.(c)Materials with no unpaired, or isolated electrons are considered diamagnetic. Diamagnetic substances do not have magnetic dipole moments.
5.(d)Every magnet has two poles,no monopole exists.

31.1. (b) Magnetic field

2.(c) If v is parallel to B

3.(d) + Y axis

4.(d) All of these

5.(d) A helix with non-uniform pitch

****

SECTION C

MCQ

Q1. The magnetic force acting on a charged particle of charge $-2\mu C$ in a magnetic field of 2T acting in y direction, when the particle velocity is $(2\hat{\imath}+\hat{\jmath})\times 10^6 ms^{-1}$, is

(a) 4 N in z direction

(b) 8 N in y direction

(c) 8 N in z direction

(d) 8 N in $-z$ direction

Q2. Two long parallel wires carry currents i_1 and i_2 such that $i_1 > i_2$. When the currents are in the same direction, the magnetic field at a point midway between the wires is $6\times 10^{-6}T$. If the direction of i_2 is reversed, the field become $3\times 10^{-5}T$. The ratio of $\frac{i_1}{i_2}$ is

(a) $1/2$ (b) 2 (c) $2/3$ (d) $3/2$

Q3. A straight wire carrying current l is made in circular loop. If M is the magnetic moment associated with the loop, then the length of the wire is

(a) $\sqrt{\frac{4\pi M}{l}}$ (b) $\sqrt{\frac{2\pi M}{l}}$ (c) $\sqrt{\frac{\pi M}{l}}$ (d) $\sqrt{\frac{\pi M}{2l}}$

Q4. Two similar coils of radius R are lying concentrically with their planes at right angles each other. The currents flowing in them are I and 2I, respectively. The resultant magnetic field induction at the centre will be

(a) $\frac{\sqrt{5}\mu_0 l}{2R}$ (b) $\frac{3\mu_0 l}{2R}$ (c) $\frac{\mu_0 l}{2R}$ (d) $\frac{\mu_0 l}{R}$

Q5. An electron is projected with uniform velocity along the axis of a current carrying long solenoid. Which of the following is true?

(a) The electron will be accelerated along the axis.

(b) The electron path will be circular about the axis.

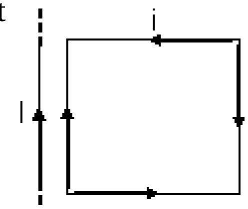
(c) The electron will experience a force at 45° to the axis and hence execute a helical-path.

(d) The electron will continue to move with uniform velocity along the axis of the solenoid.

Q6.In a certain region of space electric field $\vec{E}$ and magnetic field $\vec{B}$ are perpendicular to each other .An electron enters particularly to both fields and moves undeflected . The velocity of electron is

(a)E / B (b) B / E (c) $\vec{E}$ X $\vec{B}$ (d) $\vec{E}\,.\,\vec{B}$

Q7. A rectangle loop carrying a current (i) is situated near a long straight wire such that the wire is parallel to the one of the sides of the loop and is in the plane of the loop. If a steady current i is established in wire as shown in the figure below, the loop will



(a) Rotate about an axis parallel to the wire (b) Move away from the wire or towards right
(c) Move towards the wire or towards left (d) Remain stationary

Q8. A wire in the form of a circular loop, of one turn carrying a current, produces magnetic field B at the centre. If the same wire is looped into a coil of two turns and carries the same current, the new value of magnetic induction at the Centre is

(a)B (b) 2B (c) 4B (d) 8B

Q9.When a magnetic dipole of moment $\vec{M}$ rotates freely about its axis from unstable equilibrium to stable equilibrium in a magnetic field $\vec{B}$, the rotational kinetic energy gained by it is :

(a)–M.B (b) $\frac{2}{M.B}$ (c) 2M.B (d) $\frac{M}{B}$

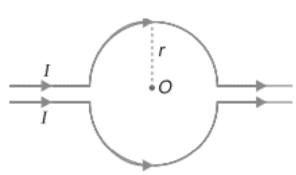
Q10.The current sensitivity of a galvanometer increases by 20%. If its resistance also increases by 20%, the voltage sensitivity will be

(a)Decrease by 1% (b) Increased by 10% (c) Increased by 5% (d)Decrease by 4%

1 MARK QUESTIONS

Q11. An electron, passing through a region is not deflected. Are you sure that there is no magnetic field in that region?

Q12.What is the value of magnetic field at point O due to current flowing in the wires?



Q13. A long straight wire carries a steady current I along the Positive y-axis in a co-ordinate system. A particle of charge +Q is moving with a velocity $\vec{v}$ along the x-axis. In which direction will the particle experience a force?

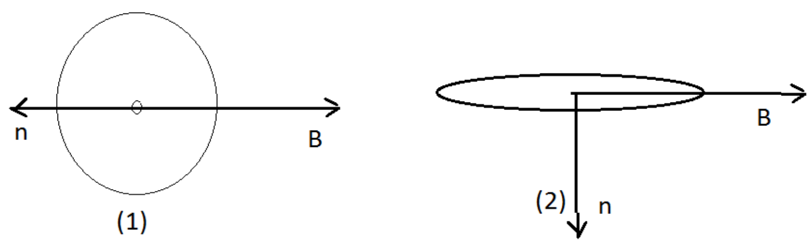
2-MARK QUESTIONS

Q14. A wire AB is carrying a steady current of 6A and is lying on the table. Another wire CD carrying 4A is held directly above AB at a height of 1mm. Find the mass per unit length of the wire CD so that it remains suspended at its position when left free. Give the direction of the current flowing in CD with respect to that in AB. [Take the value of $g=10ms^{-2}$] [All India 2013]

Q15. A galvanometer of resistance 'G' can be converted into a voltmeter of range (0-V) volts by connecting a resistance 'R' in series with it. How much resistance will be required to change its range from 0 to v/2?

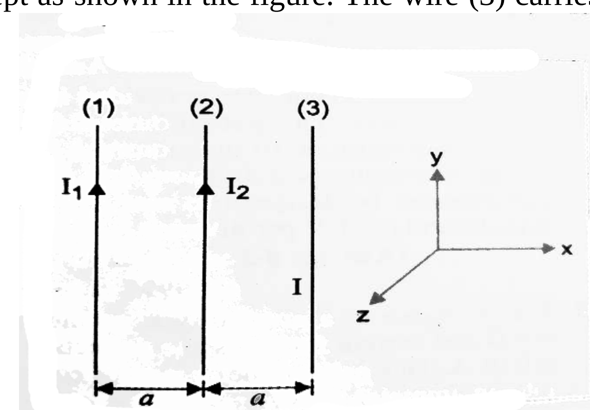
Q16. A current loop is placed in a uniform magnetic field in the following orientations (1) and (2). Calculate the magnetic moment in each case.

1.



3-MARKS QUESTIONS

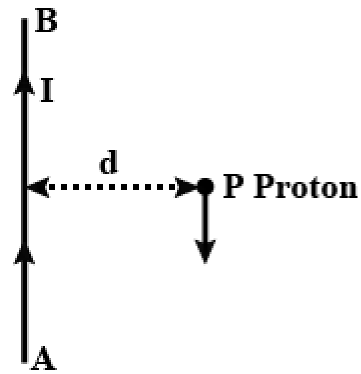
Q17. Three long straight parallel wires are kept as shown in the figure. The wire (3) carries a current I



(a)The direction of the flow of current I in the wire 3, is such that the net force on wire 1 due to the other two wires is zero

(b)By reversing the direction of current I , the net force on wire 2 due to the other two wires becomes zero. What will be the direction of the current I in the two cases? Also obtain the magnitudes of currents I_1, I_2 and I.

Q18. A long straight wire AB carries a current I. A proton P levels with a speed V, parallel to the wire at a distance d from it in a direction opposite to the current. What is the force experienced by the proton and what is its direction?



5-MARK QUESTIONS

Q19. (a) State the principle of working of a galvanometer

(b) A galvanometer of resistance G is converted into a voltmeter to measure upto V volts by connecting a resistance R1 in series with the coil. If a resistance R2 is connected in series with it then it can measure upto V/2 volts. Find the resistance, in terms of R1 and R2, required to be connected to convert it into a voltmeter that can read upto 2 V. Also find the resistance G of the galvanometer in terms of R1 and R2.

(c) **"**Increasing the current sensitivity of a galvanometer may not necessarily increase its voltage sensitivity." Justify the statement.

Assertion-Reason

Select the correct answer to these questions from the codes (a), (b), (c) and (d) are as given below

(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true but R is not the correct explanation of A.

(c) A is true but R is false.

(d) A is false and R is also false.

20. **Assertion:** Steady current is the only source of magnetic field.

Reason: Only moving charge can create magnetic field.

21. **Assertion:** A magnetic field does not interact with a stationary charge.

Reason: A moving charge produces a magnetic field.

22. **Assertion:** When velocity of electron is perpendicular to B it will perform circular motion.

Reason: Magnetic force is perpendicular to velocity.

23. **Assertion:** A beam of electrons can pass undeflected through a region of E and B.

Reason: Force on moving charged particles due to magnetic field may be zero in some cases.

24. **Assertion:**If the path of a charged particle in a region of uniform electric and magnetic field is not a circle, then its kinetic energy will not remain constant.

Reason: In a combined electric and magnetic field region, a moving charge experiences a net force $F = qE + q(v \times B)$, where symbols have their usual meanings.

25. **Assertion:** If we increase the current sensitivity of a galvanometer by increasing the number of turns, its voltage sensitivity also increases.

Reason: Resistance of a wire also increases with N.

26. **Assertion:** When a magnetic dipole is placed in a non uniform magnetic field, only a torque acts on the dipole.

Reason: Force would not act on dipole if magnetic field were non uniform.

27. **Assertion:** Galvanometer can as such be used as an ammeter to measure the value of the current in given circuit

Reason: It gives a full-scale deflection for a current of the order of ampere.

28. **Assertion:** Diamagnetic materials can exhibit magnetism.

Reason Diamagnetic materials have permanent magnetic dipole moments.

29. **Assertion:** Paramagnetic materials can exhibit magnetism.

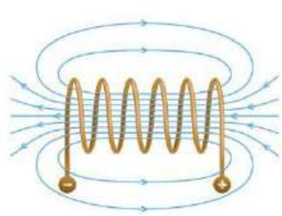
Reason: Paramagnetic materials have permanent magnetic dipole moments.

Case study based question

Q30.

Magnetic Field due to a Solenoid

Seema wound a very long insulated copper wire on a plastic pipe and carefully took the pipe out. The two ends of the copper wires are then attached to a battery. This cylindrical shape of copper wire is called a solenoid and this solenoid is used in several devices such as door bell, door locks, speakers etc. The magnetic field of a solenoid is given below



The magnetic field strength of a solenoid having n turns is **B** $=\mu_0 nI$, where, I is the current flowing in the solenoid, n is number of turns per unit length and μ_0 is the permeability of free space.

1. A long solenoid has 400 turns per meter and it is used as an electromagnet. If 1.5A current is flowing through it, what is the strength of the electromagnet

(a) 0.008 T (b) 0.4 T (c) 0.6 T (d) 0.007 T

2. Solenoid has length l, N turns and carrying a current I, what will be the magnetic field inside the solenoid

(a) μ_0 nlI (b) $\frac{\mu 0\, NI}{l}$ (c) $\mu 0\ nl^2$ (d) None of these

3. The strength of magnetic field in a solenoid cannot be affected by

(a) Increasing its length (b) Decreasing the value of current

(c) Decreasing the number of turns (d) None of these

4. The strength of magnetic field outside a solenoid is

(a) Infinity (b) Zero

(c) Double the value of field inside

(d) Half the value of the field inside

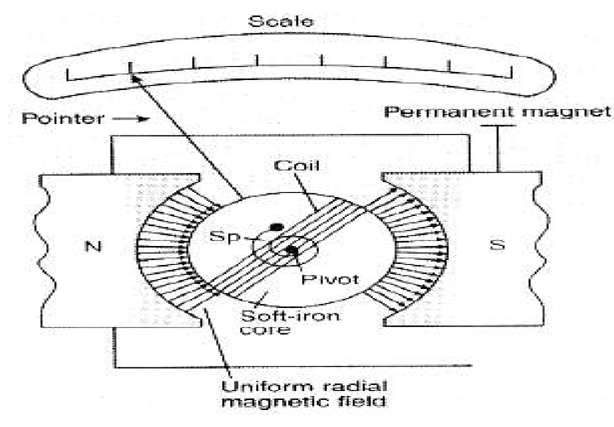
5. The nature of magnetic field lines passing through the current carrying solenoid is

(a) Closed loop

(b) Discontinuous curve

(c) Straight line

(d) None of these



SOURCE BASED QUESTION

Q31. Analog voltmeters and ammeters work by measuring the torque exerted by a magnetic field on a current carrying coil. The reading is displayed by means of the deflection of a pointer over a scale. The adjacent figure shows the essentials of a galvanometer, on which both Analog ammeters and Analog voltmeters are based. Assume that the coil is 2.1 cm high, 1.2 cm wide has 250 turns and is mounted so that it can rotate about an axis (into the page) in a uniform radial magnetic field with B = 0.23 T. for any orientation of the coil, the net magnetic field through the coil is perpendicular to the normal vector of the coil (and thus parallel to the plane of coil) A spring SPSP provides a counter torque that balance the magnetic torque so that a given steady current I in the coil results in a steady angular deflection ϕ. The greater the current is greater the deflection is and thus greater the torque required of the spring is A current of 100 μ_A produces an angular deflection of 28°

1. What must be the torsional constant K of the spring?

(a) 2.6 x 10^{-8} Nm/degree (b) 5.2x10^{-8} Nm/degree

(c) 2.6 x 10^{-4} Nm/degree (d) 5.2x10^{-6} Nm/degree

2. If we reduce the value of this K to half of its value then the deflection would be

(a) 28^0 (b) 56^0 (c) 14^0 (d) none

3. If the value of magnetic field is put equal to 0.69 T and K=15.6×10^{-8} K=15.6×10^{-8} Nm/degree. Then the deflection would be

(a) <28^0 (b) =28^0 (c) 14^0 (d) none

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ANSWER KEY

SECTION C

MCQ

1.(d) 8 N in $-z$ direction

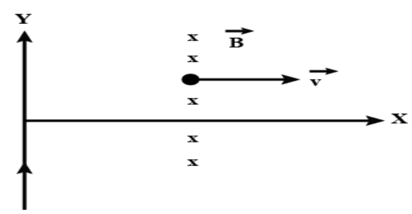
2. (d) $3/2$
3. (a) $\sqrt{\frac{4\pi M}{l}}$
4. (a) $\frac{\sqrt{5}\mu_0 l}{2R}$
5. (d) The electron will continue to move with uniform velocity along the axis of the solenoid.
6. (a) E /B (hint: qE = qvB)
7. (c) Move towards the wire or towards left
8. (c) 4B
9. (c) 2MB
10. (d) decrease by 4%

1-MARK

11. No, if an electron enters parallel to a magnetic field, no force acts and the electron remains undeflected.

12. Zero, because the upper and lower current carrying conductors are identical and so the magnetic fields caused by them at the centre O will be equal and opposite.

13. From Fleming's left-hand rule, thumb points along + y direction, so the direction of magnetic force will be along + y axis (or in the direction of flow of current).



14. Weight per unit length of the wire must be supported by magnetic force per unit length.

$(m/l)\ g = \mu_0 I_1 I_2/2\pi r$

$(m/l) = (\mu_0 I_1 I_2/2\pi r)\ g$

$= 4\pi \times 10^{-7} \times 6 \times 4/\ 2\pi\ (10^{-3})\ (10)$

$= 2 \times 10^{-7} \times 6 \times 4/\ 10^{-3} \times 10$

$= 48 \times 10^{-5}$ kg/m

= 0.48 mg/m.

15. Given: resistance of galvanometer = G Ω

Range of voltmeter (RL)= (0-V) volts

Resistance to be connected in parallel= R

R'=? where range is (0-V/2) volts

In the first case ig= V/ (R+G) ….(i)

In the second case ig= V/2/ (R'+G) …. (ii)

[ig is the maximum current which can flow through galvanometer]

From equation (i) and (ii) on solving we get

R'= (R-G) / 2

16. (a) -mB (b) Zero

3 MARKS

17.(a) Net force experienced by wire (1) can be zero only when the current in wire (3) flows along -J i.e. downwards it means that force acting on the wire (1) due to wire (3) and wire (2) are equal and opposite

$\mu_0 I_1 I/2\pi(2a) = \mu_0\, I_1 I_2/2\pi(a)$

Therefore, $I = 2I_2$

(b) when direction of current in wire (3) is reversed then current should be along +j i.e., upwards. For this case net force on wire (2) becomes zero, which means that the force due to wire (1) and wire (3) are equal and opposite

$\mu_0 I_1 I_2/2\pi a = \mu_0\, I_2\, I/2\pi(a)$

therefore $I = I_1$

$I=I_1=2\, I_2$

18. Magnetic field due to the straight wire AB at a perpendicular, distance r from it.

$$B = \mu_0 I/(2\pi r)$$

Therefore, force on proton moving with velocity 'v' perpendicular to B, is

$$F = qvB = \mu_0 Iqv/(2\pi r)$$

The direction of force on proton acts in plane of paper towards right.

5 MARKS

19. (a) Galvanometer works on the principle of torque on a coil carrying current in a magnetic field. The torque acting on the coil is proportional to the magnitude of electric current. The coil is connected to a pointer and the pointer of the galvanometer is calibrated to show correct deflection on a scale.

(b) Let the resistance of the galvanometer be R_G.

Let the max. current carrying capacity be I.

From the given data,

$V = I (R_G + R_1)$

$V/2 = I (R_G + R_2)$

From the equations,

$2 = (R_G + R_1)/ (R_G + R_2)$

$R_G = R_1 - R_2$

Let the resistance required to read 2V be R_3

$2V = I (R_G + R_3)$

$2 (R_G + R_1) = R_G + R_3$

$R_3 = R_G + 2R_1$

$R_3 = 3R_1 – 2R_2$

(c) Due to deflecting torque, the coil rotates and suspension wire gets twisted. A restoring torque is set in the suspension wire.

$NIBA = k\theta$ (In equilibrium)

$I = k/(NBA) . \theta$

$I = G\theta$

Where, $G = k / (NBA)$

It is known as galvanometer constant.

$\theta/I = NBA / k$

Therefore, current sensitivity of the galvanometer is the deflection per unit current.

$\theta/V = (NBA/k). (I/V) = (NBA/k). 1/R$

Therefore, voltage sensitivity is the deflection per unit voltage. It depends on the resistance also.

Assertion-Reason

20.(d) moving charge, electron, current carrying wire, naturally occurring magnet all these can create magnetic field.

21.(a) Stationary charge doesn't get affected by magnetic field, moving charge creates magnetic field.

22.(a) If F⊥V, at all instants then motion will be circular.

23.(b) For velocity selector the electrons can pass undeflected, when velocity and magnetic field are parallel , in that case force can be zero, both are correct but reason is not correct explanation of assertion.

24.(a) F = q E+ q(v × B) this is called Lorentz force.

Due to electric field, acceleration a $=\frac{qE}{m}$, hence velocity will not remain constant.

25.(c) current sensitivity $I_S = \frac{\phi}{I} = \frac{NAB}{k}$

voltage sensitivity $V_S = \frac{NAB}{kR}$

$V_S = \frac{I_S}{R}$

26. (d) In a non-uniform magnetic field both the torque and force will act.

27.(d) Galvanometer is used to detect the direction of current in a circuit, it gives full scale deflection to the current of microampere range.

28.(c) Diamagnetic materials get repelled in magnetic fields so they exhibit magnetism but they don't have unpaired electrons so we can say that they don't have dipole moment.

29.(a) Paramagnetic materials have unpaired electrons so they exhibit magnetism.

Case study based

30. 1.(d) **B** $=\mu_0 nI$

where n= 400 and I = 1.5A

putting values B= 0.007 T

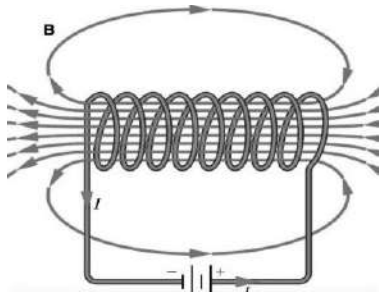
2. (b) Derivation of magnetic field inside a solenoid.

3. (d) **B** $=\mu_0 nI$

where n is number of turns per unit length.

4. (b) The magnetic field outside the solenoid is so weak that it is taken to be zero.

5. (a)



The magnetic field lines in a solenoid form closed loop.

SOURCE BASED QUESTION

31. Due to deflecting torque, the coil rotates and suspension wire gets twisted. A restoring torque is set in the suspension wire.

τ = MB sin90

= NiAB

Also, $\tau = K\ \theta$

$K = \tau/\ \theta = NIAB/\ \theta = (250 \text{ x}100 \text{ x}10^{-6}\text{x}2.1\text{x}1.2\text{x}10^{-4})/28$

$= 5.2\text{x}10^{-8}$ Nm/degree

(b) $5.2\text{x}10^{-8}$ Nm/degree

2. (b) 56^o using $\tau = K\ \theta$

3. (b) $=28^o$ using $\theta = \tau/\ K$

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Question Bank

Chapter-5 Magnetism and Matter

SECTION A

MCQ

Q1. When freely suspended, a magnet comes to rest in the direction

(a) North- South (b) East –West (c) South – East (d) None of the above

Q2. Magnetic lines of force always form

(a) Closed loops (b) open loops (c) both a and b (d) None of the above

Q3. The SI unit of magnetic field strength is

(a) Tesla (b) Weber (c) Tesla meter (d) Tesla meter /ampere

Q4. The SI unit of magnetic pole strength is

(a) ampere/metre^2 (b) ampere –meter (c) ampere-meter^2 (d) ampere^2 /meter

Q5. The SI unit of magnetic dipole moment is

(a) ampere –meter^2 (b) ampere –meter (c) ampere-meter^2 (d) ampere^2 /meter

Q6. Magnetic dipole moment is

(a) Scalar (b) vector (c) none

Q7. The torque acting on a magnet with magnetic dipole moment M at an angle θ with the magnetic field B is

(a) $\tau = MB\cos\theta$ (b) $\tau = MB \sin \theta$ (c) $\tau = MB \tan \theta$ (d) None

Q8. Magnetic lines of force

(a) Emanate from N- pole and enter into S- pole

(b) Emanate from S- pole and enter into N- pole

(c) Emanate from S pole to infinity

(d) Emanate from N pole to infinity

Q9. The meniscus of a liquid contained in one of the limbs of a narrow U-tube is placed between the pole-pieces of an electromagnet with meniscus in a line width the field. When the electromagnet is switched on, the liquid is seen to rise in the limb. This indicates that the liquids is

(a) Ferromagnetic (b) paramagnetic (c) Diamagnetic (d) non-magnetic

Q10. For a paramagnetic substance, the magnetic susceptibility is directly proportional to

(a) T (b) T^2 (c) T^0 (d) T^{-1}

Q11. The domain formation is a necessary feature of

(a) Diamagnetism (b) Paramagnetism (c) ferromagnetism (d) All of these

Q12.If a magnetic substance is kept in a magnetic field, then which of the following substances is thrown out

(a) Diamagnetism (b) Paramagnetism (c) ferromagnetism (d) All of these

Q13.Above Curie's temperature ferromagnetic substances behaves like (CBSE 2020)

(a) paramagnetic (b) diamagnetic (c) superconductor (d) no change

Q14.A permanent magnet attracts

(a) all substances (b) only ferromagnetic substances

(c) some substances and repels others (d) ferromagnetic substances and repels all others

Q15.Susceptibility is positive for

(a) paramagnetic substances (b) diamagnetic substances

(c) non- magnetic substances (d) all of the above

1 MARK QUESTIONS

Q16. What is the SI unit of magnetic dipole moment?

Q17. Can two magnetic field lines intersect?

Q18. What is the direction of magnetic dipole moment?

Q19. What is the torque acting on a bar magnet of magnetic moment M in a uniform magnetic field B?

Q20. What is the SI unit of magnetic flux density?

Q21. Are the magnetic moment of a bar magnet and its equivalent solenoid, having the same magnetic field equal?

Q22. Why do magnetic lines of force form continuous closed loops?

Q23. What is magnetic susceptibility? (CBSE 2018)

Q24. What is permeability of the material?

Q25(A). Which of the following substances are diamagnetic? (CBSE 2013)

Bi, Al, Na, Cu, Ca and Ni

(B) The susceptibility of a magnetic material is 1.9×10^{-5}. Name the type of magnetic materials it represents.

2 MARKS QUESTIONS

Q26. (a) Define magnetic field strength. (b) Give its SI unit.

Q27. Define magnetic dipole moment. Is it scalar or vector?

Q28. Give four properties of magnetic field lines.

Q29. Define intensity of magnetization of a magnetic material.

Q30. What are permanent magnets? Give examples.

Q31. Write three points of differences between diamagnetic paramagnetic and ferromagnetic-material. (CBSE 2019)

3 MARK QUESTIONS

Q32. (a) What is the name given to the curves, the tangent to which at any point gives the direction of magnetic field at that point?

(b)Can two such curves intersect each other? Justify your answer.

5 MARK QUESTIONS

Q33. (a) Derive an expression for magnetic field intensity due to a magnetic dipole at a point on its axial line.

(b)A magnetised needle of magnetic moment $4.8 X 10^{-2} JT^{-1}$ is placed at 30° with the direction of uniform magnetic field of $3 X 10^{-2}$ T. Calculate the torque acting on the needle. (CBSE2012)

Q34. Explain the following –

(a) Why are the field lines repelled when a diamagnetic material is placed in an external uniform magnetic field?

(b) Draw the magnetic field lines for a current carrying solenoid, when a rod made of – (i) Copper (ii) Aluminium (iii) Iron are inserted within the solenoid.

Assertion and Reason Type Questions

Select the correct answer to these questions from the codes (a), (b), (c) and (d) are as given below

(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true but R is not the correct explanation of A.

(c) A is true but R is false.

(d) A is false and R is also false.

Q35**.Assertion:** Difference between an electric line and magnetic line of force is that electric lines of force are discontinuous and the magnetic field lines are continuous.

Reason: Electric lines of forces do not exist inside a charged conductor but magnetic lines exist inside a magnet.

Q36**.Assertion:** A current carrying solenoid behaves like a bar magnet.

Reason: The circular loop in which the direction of current is clockwise behaves like the South Pole and the one having anticlockwise current behaves like the North Pole.

Q37**.Assertion:** Permanent magnets retain their ferromagnetic property for a long period of time.

Reason: Steel is a diamagnetic material.

Q38**. Assertion:** When a bar magnet is hung freely it points toward geographical poles.

Reason: Magnetic field lines do not intersect.

Q39. **Assertion:** A diamagnetic specimen would move towards the weaker region of the field.

Reason: A diamagnetic specimen is repelled by a magnet.

Q40.**Assertion:** Motion of electron around a positively charged nucleus is different from the of a planet around the sun.

Reason: The force acting in both the cases is same in nature.

Q41.**Assertion:** Two parallel conducting wires carrying currents in same direction, come close to each other.

Reason: Parallel currents attract and anti-parallel currents repel.

Q42.**Assertion:** A galvanometer cannot as such be used as an ammeter to measure the current across a given section of the circuit.

Reason: For this it must be connected in series with the circuit.

Q43.**Assertion:** Magnetic lines of force form continuous closed loops whereas electric lines of force do not.

Reason: Magnetic poles always occur in pairs as North Pole and South Pole.

Q44. **Assertion:** An electron moving along the direction of magnetic field experiences no force.

Reason: The force on electron moving along the direction of magnetic field is $F = qVB \sin 0° = 0$

****

ANSWERS-SECTION A

MCQ

1. (a) North- South
2. (a) Closed loops
3. (a) Tesla
4. (b)Ampere –meter
5. (a) ampere-meter^2
6. (b) vector
7. (b) τ = MB sin θ
8. (a) Emanate from N- pole and enter into S- pole
9. (b) Paramagnetic
10. (d) T^{-1}
11. (c) ferromagnetism
12. (a) Diamagnetism
13. (a) paramagnetic
14. (b) only ferromagnetic substances
15. (a) paramagnetic substances

1 MARK

16. Ampere –metre^2 or JT^{-1}

17. No, magnetic field lines cannot intersect as at the point of intersection there are two directions of magnetic field which is not possible.

18. The direction of magnetic dipole moment is from South Pole to North Pole.

19. Torque τ =M X B = MBsinθ

20. Weber/meter^2, Tesla, Newton/ ampere -meter

21. Yes as the bar magnet and solenoid produces equal magnetic field

22. Magnetic lines of force form continuous closed loops because a magnet is always a dipole and as a result, the net magnetic flux of a magnet is always zero.

23. The measure of the magnetisation of the material is called magnetic susceptibility.

24. In electromagnetism, the measure of the resistance of a material against the formation of a magnetic field is called permeability.

25(A). Diamagnetic substances are Bi and Cu.

25(B). It represents Paramagnetic substance.

2 MARKS

26.(a) The magnetic field strength at any point in a magnetic field is defined as the force experienced by unit north pole placed at that point. b) SI unit is Tesla.

27. Magnetic dipole moment is the product of pole strength and magnetic length of the magnet.

28. (i) Magnetic field lines start from a North Pole and end on a South pole.

(ii) Magnetic field lines do not intersect each other.

(iii) Magnetic field lines are crowded where the field is stronger and farther apart where the field lines are weaker.

(iv) Magnetic field lines form closed loops.

29. The intensity of magnetization of a magnetic material is defined as the magnetic moment developed per unit volume of the material when it is placed in a magnetizing field.

30. The substances which at room temperature retain their ferromagnetism for a long time are called permanent magnets. Examples – Cobalt, Steel, Alnico and Ticonal.

31.

PROPERTIES	Diamagnetic material	Paramagnetic material	Ferromagnetic material
Effect of Magnet	Weakly repelled by a magnet.	Weakly attracted by a magnet.	Strongly attracted by a magnet
Effect of Temperature	No effect.	With the rise of temperature, it becomes a diamagnetic.	Above curie point, it becomes a paramagnetic
Permeability	Little less than unity	Little greater than unity	Very high

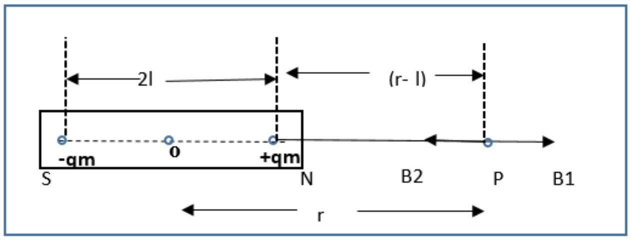
3 MARKS

32.(a) These curves are magnetic field lines. No two such lines intersect each other.

(b) Two such curves never intersect each other, if they do so, then there will be two directions at the point of intersection, which is not possible.

5 MARKS

33.(a)



Consider a magnetic dipole (or a bar magnet) SN of length 2l having South Pole at S and North Pole at N. The strength of south and north poles are – qm and + qm respectively.

Magnetic moment of magnetic dipole m = qm 2l, its direction is from S to N.

Consider a point P on the axis of magnetic dipole at a distance r from mid-point O of dipole.

The distance of point P from N-pole, r_1= (r – l).

The distance of point P from S-pole, r_2= (r + l)

Let B1 and B2 be the magnetic field intensities at point P due to north and south poles respectively. The directions of magnetic field due to North Pole is away from N-pole and due to South Pole is towards the S-pole. Therefore,

$$B_1 = \frac{\mu_0}{4\pi} \frac{q_m}{(r-l)^2} \text{ from N to P and}$$

$$B_2 = \frac{\mu_0}{4\pi} \frac{q_m}{(r+l)^2} \text{ from P to S}$$

B1>B2 and direction of resultant is from N to P and magnitude is given by

$$B = B_1 - B_2 = \frac{\mu_0}{4\pi} \frac{2(qm\ 2l)r}{(r^2-l^2)2}$$

But qm 2l =M magnetic dipole moment

$$B = \frac{\mu_0}{4\pi} \frac{2(M\ )r}{(r^2-l^2)2}$$

For a short dipole

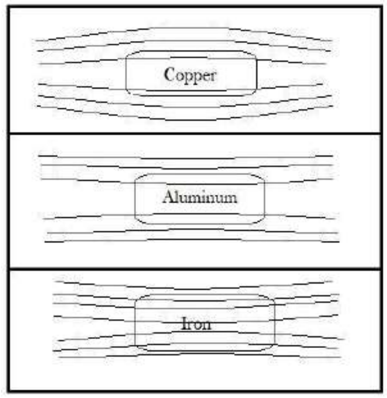
$$B = \frac{\mu_0}{4\pi} \frac{2M}{r^3}$$

(b) Torque $\tau = MB \sin\theta = 4.8X10^{-2}X3X10^{-2} \sin 30 = 7.2x10^{-4}$ Nm.

34. (a) Diamagnetic materials are the materials whose atoms do not possess any permanent magnetic dipole moment due to the presence of electrons that are paired with each other, called paired electrons. This is the reason why when a diamagnetic material is placed in an external magnetic field, the magnetic field lines are repelled.

On the application of an external magnetic field, it creates a magnetic field in the diamagnetic material opposite to the direction of the applied field which causes a repulsive force. This is the reason why when a diamagnetic material is placed in an external magnetic field, the magnetic field lines are repelled.

(b) Magnetic field lines of a current carrying solenoid: When current passed through the solenoid, it acts as bar magnet. One end of the solenoid acts as North Pole and another end acts as South Pole. The magnetic field starts at North Pole and ends at South Pole. The magnetic field lines are always parallel.



Copper:

Copper is a diamagnetic material. The magnetic field produced by the material is repulsive. Thus, the magnetic field lines diverge outward.

Aluminium:

Aluminium is a paramagnetic material. The magnetic field is strengthened around the material. Thus, the magnetic field of lines converges lightly.

Iron:

Iron is a ferromagnetic material. The magnetic field is far strong around the material. Thus, the magnetic field of lines converges heavily.

Assertion and Reason

35.(a) Since no electric lines of forces exist inside a charged body, the electric lines of force only travel from positive to negative charge and are discontinuous. Secondly, magnetic lines of force travel from north to South Pole and inside the magnet they are from South Pole to North Pole hence continuous.

36.(a) A solenoid is a type of electromagnet formed by a helical coil of wire whose length is substantially greater than its diameter, its two ends can be visualised as two coils.

37.(c) Permanent magnets retain their ferromagnetic property for a long period of time and steel is a paramagnetic material.

38.(b) It is the property of a magnet to rest in a geographical north and south pole and another property of magnetic field is that magnetic field lines do not intersect.

39.(a) In the case of diamagnetic substances, the magnetic moments of atoms and the orbital magnetic moments have been oriented in such a manner that the vector sum of an atom's magnetic moment becomes zero. An external magnetic field can repel them weakly.

40.(d) Neil Bohr proposed a model, which is familiar as a planetary model of atoms. In Bohr's model, the neutrons and protons occupy a dense central region called the nucleus, and electrons orbit the nucleus much like planets orbiting the sun. Electrons are negatively charged and the nucleus is positively charged. Force in the former case is electrostatic force but in later case it is gravitational force.

41.(a) By using the right hand thumb rule, the direction of the magnetic field can be determined then by using Fleming's right hand rule the direction of force comes towards each other.

42.(d) As the galvanometer is used to check the current flow direction and the magnitude of the direct current. That's why the resistance of the galvanometer is nearly zero. This is somewhere similar to ammeter but both are different devices. Ammeter can only show us the current magnitude not the direction. A Galvanometer's needle can fluctuate in two directions whereas an ammeter's needle can only show one side deflection.

43.(b) Electric lines of forces do not exist inside a charged body, the magnetic lines of force travel from north to south pole and inside the magnet they are from south pole to north pole hence continuous.

44.(a) If the particle is moving along the direction of magnetic field then $\theta = 0°$ hence force becomes zero.

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SECTION B

Q1. Torque acting on a coil is maximum when the coil is placed

(a) Parallel to the magnetic field

(b) at an angle of 30° to the magnetic field

(c) at any position in a uniform magnetic field

(d) Perpendicular to the magnetic field

Q2. A long current carrying solenoid produces a magnetic field B along its axis. If the current is halved and number of turns/cm is doubled, the magnetic field becomes

(a) B/2 (b) B (c) 8B (d) 2B

Q3. The magnetic field due to a bar magnet at an equatorial point is B, its magnetic field at an axial point at the same distance is

(a) 2B (b) B/2 (c) 4B (d) B

Q 4. Current do not flow between two charged particles when connected if they have same

(a) Capacitance (b) potential (c) charge (d) none of these

Q5. Which of the following is responsible for the earth's magnetic field?

(a) Convective currents in earth's core

(b) Divertive current in earth's core.

(c) Rotational motion of earth.

(d) Translational motion of earth.

Q6. Magnetic field can be produced by

(a) a stationary charge (b) a moving charge (c) a changing electric field (d) Both b and c

Q7. Which of the following statements is true about magnetic field intensity?

(a). Magnetic field intensity is the number of lines of force crossing per unit volume.

(b). Magnetic field intensity is the number of lines of force crossing per unit area.

(c). Magnetic field intensity is the magnetic induction force acting on a unit magnetic pole.

(d). Magnetic field intensity is the magnetic moment per unit volume.

Q8. The meniscus of a liquid contained in one of the limbs of a narrow U-tube is placed between the pole-pieces of an electromagnet with meniscus in a line with the field. When the electromagnet is switched on, the liquid is seen to rise in the limb. This indicates that the liquids is

(a)Ferromagnetic (b)Paramagnetic (c) Diamagnetic (d) non-magnetic

Q9.In a permanent magnet at room temperature

(a) Magnetic moment of each molecule is zero
(b) The individual molecules have non-zero magnetic moment which are all perfectly aligned.
(c) Domains are partially aligned.
(d) Domains are all perfectly aligned

Q10.Ferromagnetic Material used in transformer must have

(a) Low Permeability & High Hysteresis Loss
(b) High Permeability & Low Hysteresis Loss
(c) High Permeability & High Hysteresis Loss
(d) Low Permeability & Low Hysteresis Loss

Q11.If the magnetising field on a ferromagnetic material is increased, if permeability is

(a) Decreased (b) Increased (c) unaffected (d)May be decreased or increased

Q12.Electromagnets are made of Soft Iron because Soft Iron has

(a) Small Susceptibility & Small Retentivity
(b) Large Susceptibility & Small Retentivity
(c) Large Permeability & Large Retentivity
(d) Small Permeability & Large Retentivity.

1 MARK QUESTIONS

Q13.How does the (i) pole strength ii) Magnetic moment of each part of a bar magnet change if it is cut into two equal pieces transverse to length?

Q14. A magnetic field interacts with a moving charge and not with a stationary charge. Why?

3.The susceptibility of a magnetic materials is -4.2×10^{-6}. Name the type of magnetic material it represents. (CBSE 2010)

Q15.The susceptibility of a magnetic material is 1.9×10^{-5}. Identify the types of magnetic material. (CBSE 2011)

Q16.The susceptibility of a magnetic material is -2.6×10^{-5}. Identify the types of magnetic material.

2 MARKS QUESTIONS

Q17. When is the torque acting on a dipole (a) Maximum (b) Minimum

Q18. Derive an expression for torque acting on a magnetic dipole placed in a uniform magnetic field.

Q19.Why is the core of an electromagnet made of ferromagnetic materials?

Q20.In what way is the behaviour of a diamagnetic material different from that of paramagnetic when kept in an external magnetic field.

Q21.Explain Curie's law for a paramagnetic substance.

3-MARKS QUESTIONS

Q22.A short bar magnet of magnetic moment $0.9JT^{-1}$ is placed with its axis at 30° to a uniform magnetic field. It experiences a torque of 0.063J. Calculate (i) the magnitude of the magnetic field (ii) in which orientation the bar magnet will be in stable equilibrium? (CBSE2012)

Q23. (a)Define the term magnetic susceptibility and write its relation in terms of relative magnetic permeability. (b)Two magnetic materials A and B have relative magnetic permeabilities of 0.96 and 500. Identify the magnetic materials A and B.

5-MARKS QUESTIONS

Q24. A short bar magnet of is placed with its axis at 30° to a uniform magnetic field of 0.16T. It experiences a torque 0.032J (a) Calculate the magnitude of the magnetic moment of the magnet. (b) In which orientation the magnet will be in stable equilibrium with the magnetic field? (c) Find the PE in stable equilibrium.

Assertion and Reason Type Questions

Assertion-Reason

Select the correct answer to these questions from the codes (a), (b), (c) and (d) are as given below

(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true but R is not the correct explanation of A.

(c) A is true but R is false.

(d) A is false and R is also false.

Q25.**Assertion** The poles of magnet cannot be separated by breaking into two pieces.

Reason The magnetic dipole moment will be reduced to half when broken into two equal pieces.

Q26.**Assertion** When a bar magnet is kept in an external uniform magnetic field, it starts oscillating.

Reason A restoring torque acts on the dipole when kept in the magnetic field.

Q27.**Assertion** Two parallel wires carrying currents in the opposite direction, attract each other.

Reason Parallel currents repel and antiparallel currents attract.

Q28. **Assertion** Gauss's theorem is not applicable in magnetism.

Reason Magnetic monopoles do not exist.

Q29.**Assertion** Magnetic field produced by a current carrying solenoid is independent of its length and cross-sectional area.

Reason There is a uniform magnetic field inside the solenoid.

Q30. **Assertion** If a charged particle is projected in a region, where B is perpendicular to velocity of projection, then the net force acting on the particle is independent of its mass.

Reason The particle is performing rectilinear motion.

Q31.**Assertion** When a charged particle moves in a region of magnetic field such that its velocity is at some acute angle with the direction of field, its trajectory is a helix.

Reason Perpendicular component of velocity causes a rotating centripetal force and the parallel component of velocity does not produce any force.

Q32. **Assertion** For a current carrying wire loop of N turns, placed in a region of a uniform magnetic field B, the torque acting on it is given by m x B.

Reason Whenever the magnetic moment m is perpendicular to B, then torque on the loop will be zero.

Q33.**Assertion** The current sensitivity of a galvanometer is the deflection of current per unit current passing through the coil.

Reason The galvanometer can be used as a detector to check if a current is flowing in the circuit.

Q34. **Assertion** Magnetic field lines always form closed loops.

Reason Moving charges or currents produce a magnetic field.

****

SECTION B- ANSWERS

1. (d) Perpendicular to the magnetic field
2. (b) B
3. (a) 2B
4. (b) potential
5. (a) Convective currents in earth's core
6. (d) Both b and c
7. (c). Magnetic field intensity is the magnetic induction force acting on a unit magnetic pole.
8. (b) Paramagnetic
9. (c) Domains are partially aligned.
10. (b) High Permeability & Low Hysteresis Loss
11. (a) Decreased
12. (b) Large Susceptibility & Small Retentivity.

1-MARK

13.When a bar magnet of magnetic moment (M = m2L) is cut into two equal pieces transverse to its length, its (i) the pole strength remains unchanged ii) the magnetic moment is reduced to half.

14. A moving charge experiences a force in an external magnetic field due to the interaction of two magnetic fields, one which is produced due to motion of the charge and other due to the external magnetic field, while a stationary charge does not experience any such force.

15.Susceptibility of material is negative, so given material is diamagnetic.

16.The material having positive and small susceptibility is paramagnetic material.

The material having negative and small susceptibility is diamagnetic material.

2-MARKS

17.Torque acting on a dipole is a) Maximum when θ is 90° and b) Minimum when θ is 0° or 180

18. Force on N pole = qm B along B

Force on S pole = qm B opposite to B

This give rise to a torque given by

τ = Force X perpendicular distance

$= qmB \times 2l\sin\theta = MB\sin\theta$

19.Ferromagnetic material has a high permeability. So on passing current through windings, it gains sufficient magnetism immediately.

20.A diamagnetic specimen would move towards the weaker region of the field while a paramagnetic specimen would move towards the stronger region.

21.Curie law states that magnetization of paramagnetic substance is directly proportional to the external magnetic field applied. But as the substance is heated, it's magnetization is inversely proportional to the temperature of substance.

Thus, magnetization of paramagnetic substance M = $\frac{CB}{T}$

where C is curie constant, B is external magnetic field and T is the temperature of substance.

3 MARKS

22. (i) B= $\frac{\tau}{M sin\theta}$ = $\frac{0.063}{0.9 sin 30}$ =0.14T

(ii) When θ = 0° U= -MBcos 0 = -MB

P.E of the bar magnet will be minimum and it will be in stable equilibrium when it is parallel to the magnetic field**.**

23. (a) Magnetic Susceptibility: It is defined as the ratio of the magnetisation M to the magnetising field intensity H. It is denoted by χ_m .

$$\chi_m = \frac{M}{H}$$

Magnetic susceptibility in terms of magnetic permeability.

$$\chi_m = \mu_r - 1$$

(b) A is a diamagnetic material, B is a ferromagnetic material.

5 MARKS

24**.** (a) Torque) τ = MB sin θ

M = τ/B sin θ

= $\frac{0.032}{0.16}$ sin 30

= 0.4JT^{-1}

(b) For stable equilibrium θ = 0°

(c) PE is given by U = -MBcos0 = -0.4X 0.16 = -0.064J

Assertion and Reason

25.(b) The magnetic dipole moment will be reduced to half when broken into two equal pieces and every atom behaves like a dipole so the dipole of a magnet cannot be separated.

26.(a) When a bar magnet is placed in a uniform magnetic field. Then the bar magnet will experience only torque and no force, and this torque on the bar magnet will be acting on both ends, and will be equal but opposite in direction.

27.(d) Parallel currents attract and antiparallel currents repel.

28.(a) Gauss's law of magnetism is different from that for electrostatics because electric charges do not necessarily exist in pairs but magnetic monopoles do not exist.

29.(b) $B = \mu_0 nI$, from this formula we see the dependence of B in current and inside a solenoid it is uniform.

30.(c) Force =q(V x B) it is independent of mass and if v and B are perpendicular to each other, the particle describes a circle.

31.(a) A charged particle moves in a circle when its velocity is perpendicular to the magnetic field. When it forms an acute angle with the magnetic field, it can be resolved in two components, parallel and perpendicular. The perpendicular components tend to move it in a circle, the parallel components tend to move along the magnetic field to form a helical motion of uniform radius and pitch.

32.(c) Torque, $\tau = mB\sin\theta$

Here $\theta = 90°$, $\sin 90° = 1$ so torque will be maximum.

33.(b) A galvanometer is a device that is used to detect small electric current or measure its magnitude. The current sensitivity of a galvanometer is the deflection of current per unit current passing through the coil $I_s = \frac{NAB}{k}$

34.(b) Assertion is the property of a magnet while reason is one of the sources of magnetic field.

****

SECTION C

Q1. The maximum torque acting on a rectangular coil of 2cm X 5cm, having 200 turns and carrying a current of 2A is

(a) 0.4 Nm (b) 4 Nm (c) 40 Nm (d) 0.04 Nm

Q2. A toroid of n turns, mean radius R and cross-sectional radius a carries current I. It is placed on a horizontal table taken as X-Y plane. Its magnetic moment M

(a) is non-zero and points in the Z-direction by symmetry.

(b) points along the axis of the toroid.

(c) is zero, otherwise there would be a field falling as $1/r^3$ at large distances outside the toroid.

(d) is pointing radially outwards

Q3. A long magnet is cut into two parts such that the ratio of their lengths is 2:1. What is the ratio pole strength of both the section?

(a). 1:2 (b). 2:1 (c). 4:1 (d) Equal

Q4. The susceptibility of a ferromagnetic material is χ at 27^0C . At what temperature will its susceptibility be 0.5χ.

(a) 54^0C (b) 327^0 C (c) 600^0 C (d) $237\,^0$C

Q5. A paramagnetic sample shows a net magnetism of 8 Am $^{-1}$ when placed in an external magnetic field of 0.6 T at a temperature of 4K. when the same sample is placed in an external magnetic field of 0.2 T at a temperature of 16 K, the magnetization will be

(a) $\frac{32}{3}$ Am $^{-1}$ (b) $\frac{2}{3}$ Am $^{-1}$ (c) 6 Am $^{-1}$ (d) 2.4 Am $^{-1}$

Q6. The SI unit of Magnetic Permeability is

(a) $WA^{-1}m^{-1}$

(b) $NA^{-1}m^{-1}$

(c) NA^{-2}

(d) $Both\ WA^{-1}m^{-1}$ and NA^{-2}

Q7.Needles N1, N2 and N3 are made of a ferromagnetic, a paramagnetic and a diamagnetic substance respectively. A magnet when brought close to them will

(a) Attract N1 strongly but repel N2 and N3 weakly.

(b) Attract all 3 of them

(c) Attract N1 and N2 strongly but repel N3

(d) Attract N1 strongly, N2 weakly and repel N3 weakly.

1MARK QUESTIONS

Q8. When a bar magnet of magnetic moment (M = m2L) is cut into two equal pieces transverse to its length, its (i) the pole strength remains unchanged (ii) the magnetic moment is halved.

Q9. The permeability of a magnetic material is 0.9983. Name the type of magnetic materials it represents. (CBSE 2011)

Q10.Susceptibility of iron is more than that of copper. What does this statement imply?

Q11. The magnetic field lines prefer to pass through iron than air. Explain why? (CBSE 2011)

Q12. Mention two characteristic properties of the material suitable for making core of a transformer. (CBSE 2012)

2 MARK QUESTIONS

Q13.A hypothetical bar magnet (AB) is cut into two equal parts. One part is now kept over the other, so that the pole C2 is above C1. If M is the magnetic moment of the original magnet, what would be the magnetic moment of the combination, so formed?

Q14. State Gauss's law for magnetism. Explain its significance. CBSE (2019)

Q15. A iron rod of length L and magnetic moment M is bent in the form of a semicircle. Find its magnetic moment.

Q16. How will you decide whether the magnetic field at a point is due to some current carrying conductor or earth?

Q16(B). A small magnetised needle P is placed at the origin of x-y plane with its magnetic moment pointing along the y-axis. Another identical magnetised needle Q is placed in two positions, one by one.

Case 1: at (a, 0) with its magnetic moment pointing along x-axis.

Case 2: at (0, a) with its magnetic moment pointing along y-axis.

(a) In which case is the potential energy of P and Q minimum?

(b) In which case is P and Q not in equilibrium? Justify your answers. (CBSE 2023)

Q17.The magnetic susceptibility of magnesium at 300K is 1.2×10^5. At what temperature will its magnetic susceptibility become 1.44×10^5? (CBSE 2019)

Q18. Show diagrammatically the behaviour of magnetic field lines in the presence of

(i) paramagnetic and

(ii) diamagnetic substances. How does one explain this distinguishing feature? (CBSE 2020)

Q19.Two substances A and B have their relative permeabilities slightly greater and slightly less than 1 respectively. What do you conclude about A and B as far as their magnetic materials are concerned?

3 MARK QUESTIONS

Q20. A rectangular current carrying loop EFGH is kept in a uniform magnetic field as shown below in the figure.

i) What is the direction of magnetic moment of current loop?

ii) When is the torque acting on the loop (a) maximum (b) minimum?

E F

H G

Q21. Write three important properties of the magnetic field lines due to a bar magnet.

Q22. A short bar magnet placed with its axis at 30° with a uniform magnetic field of 0.1 T experiences a torque of $4X10^{-2}$J. Find the magnetic moment of the magnet.

Q23. A bar magnet of magnetic moment 6 JT^{-1} is aligned at 60 ° with uniform external magnetic field of 0.44T. Calculate the work done to align its magnetic moment i) normal to the magnetic field ii) opposite to the magnetic field.

Q24. A bar magnet of magnetic moment m and moment of inertia I (about centre perpendicular to length) is cut into two equal pieces, perpendicular to its length. Let T be the period of oscillations of the original magnet about an axis through mid-point, perpendicular to the length, in a magnetic field. What would be the similar Time Period T for each piece?

Q25. On what factors does the pole strength of a magnet depends?

Q26. Show that the time period (T) of oscillations of a freely suspended magnetic dipole of magnetic moment (m) in a uniform magnetic field (B) is given by T= $2\pi\sqrt{I/MB}$, where I is a moment of inertia of the magnetic dipole. (CBSE 2019)

Q27. For a magnetising field of intensity 2 x 10^3 Am^{-1}, aluminium at 280 K acquires intensity of magnetisation of 4.8 x 10^{-2} Am^{-1},. If the temperature of the metal is raised to 320 K, what will be the intensity of magnetisation?

5 MARK QUESTIONS

Q28. (a) Two magnets of magnetic moments m and $\sqrt{3}$m are joined to form a cross (+).The combination is suspended freely in a uniform magnetic field. In equilibrium position the magnet of magnetic moment m makes an angle θ with the field. Find θ.

(b) A coil of N turns and radius R carries a current I It is unwound and rewound to make another coil of radius R/2, current I remaining the same. Calculate the ratio of magnetic moments of the new coil and the original coil. (CBSE 2012, 2015)

Q29. A small compass needle of magnetic moment 'm' is free to turn about an axis perpendicular to the direction of uniform magnetic field 'B'. The moment of inertia of the needle about the axis is 'I'. The needle is slightly disturbed from its stable position and then released. Prove that it executes simple harmonic motion. Hence deduce the expression for its time period. (CBSE 2013)

Assertion and Reason Type Questions

Select the correct answer to these questions from the codes (a), (b), (c) and (d) are as given below

(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true but R is not the correct explanation of A.

(c) A is true but R is false.

(d) A is false and R is also false.

Q30. **Assertion** Steady current is the only source of magnetic field.

Reason Only moving charge can create magnetic field.

Q31. **Assertion** A magnetic field does not interact with a stationary charge.

Reason A moving charge produces a magnetic field.

Q32**.** **Assertion** When velocity of electron is perpendicular to **B** it will perform circular motion.

Reason Magnetic force is perpendicular to velocity.

Q33. **Assertion** A beam of electrons can pass undeflected through a region of E and B.

Reason Force on moving charged particles due to magnetic field may be zero in some cases.

Q34. **Assertion** If the path of a charged particle in a region of uniform electric and magnetic field is not a circle, then its kinetic energy will not remain constant.

Reason In a combined electric and magnetic field region, a moving charge experiences a net force $F = qE + q(v \times B)$, where symbols have their usual meanings.

Q35. **Assertion** If we increase the current sensitivity of a galvanometer by increasing the number of turns, its voltage sensitivity also increases.

Reason Resistance of a wire also increases with N.

Q36. **Assertion** When a magnetic dipole is placed in a non uniform magnetic field, only a torque acts on the dipole.

Reason Force would not act on dipole if magnetic field were non uniform.

Q37. **Assertion** Galvanometer can as such be used as an ammeter to measure the value of the current in given circuit

Reason It gives a full-scale deflection for a current of the order of ampere.

Q38. **Assertion** Diamagnetic materials can exhibit magnetism.

Reason Diamagnetic materials have permanent magnetic dipole moments.

Q39. **Assertion** Paramagnetic materials can exhibit magnetism.

Reason Paramagnetic materials have permanent magnetic dipole moments.

CASE STUDY BASED QUESTION

Q40. MAGNETIC BEHAVIOUR OF MATERIALS

Before nineteenth century, scientists believed that magnetic properties were confined to a few materials like iron, cobalt and nickel. But in 1846, Curie and Faraday discovered that all the materials in the universe are magnetic to some extent. These magnetic substances are categorized into two groups. Weak magnetic materials are called diamagnetic and paramagnetic materials. Strong magnetic materials are called ferromagnetic materials. According to the modern theory of magnetism, the magnetic response of any material is due to circulating electrons in the atoms. Each such electron has a magnetic moment in a direction perpendicular to the plane of circulation. In magnetic materials all these magnetic moments due to the orbital and spin motion of all the electrons in any atom, vectorially add upto a resultant magnetic moment. The magnitude and direction of these resultant magnetic moment is responsible for the behaviour of the materials. For diamagnetic materials X is small and negative and for paramagnetic materials X is small and positive. Ferromagnetic materials have large X and are characterized by nonlinear relation between B and H.

Questions: Answer any four of the following

1. The universal (or inherent) property among all substances is
   (a) Diamagnetism
   (b) Paramagnetism
   (c) Ferromagnetism
   (d) Both (a) and (b)
2. When a bar is placed near a strong magnetic field and it is repelled, then the material of bar is
   a) Diamagnetic
   b) Ferromagnetic
   c) Paramagnetic
   d) Anti-ferromagnetic
3. Magnetic susceptibility of a diamagnetic substance
   (a) Decreases with temperature
   (b) Is not affected by temperature
   (c) Increases with temperature
   (d) First increases then decreases with temperature
4. The value of the magnetic susceptibility for a super conductor is
   (a) Zero (b) Infinity (c) +1 (d) -1
5. Which of the following is weakly repelled by a magnetic field
   (a) Iron (b) Cobalt (c) Steel (d) Copper

41. Torque & Potential energy of a Dipole

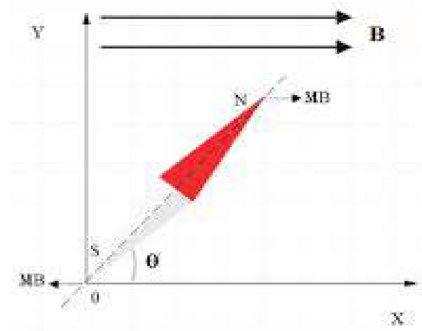
The pattern of iron fillings, i.e. the magnetic field lines give us an approximate idea of magnetic field **B**. We may at times be required to determine the magnitude of B accurately. This is done by placing a small compass needle of known magnetic moment **m** and moment of inertia **I** and allowing it to oscillate in the magnetic field. This arrangement is shown in the fig.

The torque on the needle is τ = m x B

In magnitude τ = mBsinϴ

The magnetic potential energy is given by

U_m = -m.B



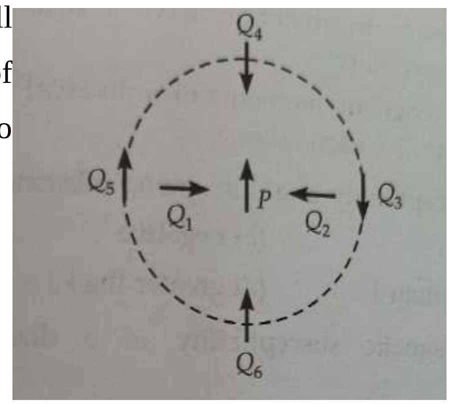
1.A bar magnet is held perpendicular to a uniform magnetic field. If the couple acting on a magnet is to be halved, by rotating it, the angle by which it is to be rotated is

(a) 30^0 (b) 60^0 (c) 45^0 (d) 90^0

2. The couple acting on a magnet of length 10 cm and pole strength 15 Am, kept in a field of V = 2 x 10^{-5} T at an angle 30^0 is

(a) 1.5 x 10^{-5} Nm (b) 1.5 x 10^{-3} Nm © 1.5 x 10^{-2} Nm (d) 1.5 x 10^{-6} Nm

3. The figure below shows the various positions of small magnetised needles P and Q. The arrows show the direction of their magnetic moments. Which configuration corresponds to lowest potential energy among all the configurations shown.



(a) PQ_3 (b) PQ_4 © PQ_5

(d)PQ_6

4. Two wires of the same length are shaped into a square and a circle if they carry the same current, ratio of magnetic moments is

(a) 2 : π (b) π : 2 (c) π : 4 (d) 4 : π

SOURCE BASED QUESTION

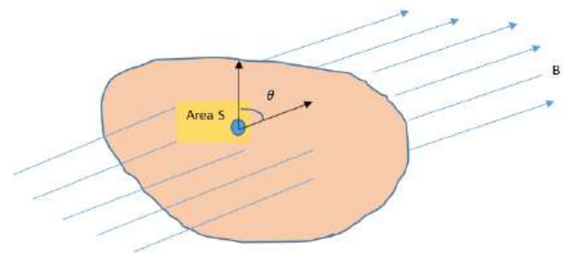
42. Gauss Law of Magnetism

Consider a small area element ΔS of a closed surface S .The magnetic flux through ΔS is defined as $\Delta\varphi_B$ = B. ΔS .We divide area element into many small area elements and calculate the individual flux through each. Then net flux φ_B is

$$\sum \quad \Delta\varphi_B = \sum \quad B.\Delta S = 0$$

Compare this with Gauss's Law of electrostatics. The flux through a closed surface in that case is

$$\sum \quad B.\Delta S = q/\epsilon_o$$



Where q is electric charge enclosed by the surface. The difference between Gauss Law of magnetism and that for electrostatics is a reflection of the fact that isolated magnetic poles (monopoles) are not known to exist. There are no sources or sinks of B: the simplest magnetic element is a dipole or a current loop. All magnetic phenomena can be explained in terms of arrangement of dipoles and /or current loops. "The net magnetic flux through any closed surface is zero".

1. Statement 1 : We cannot separate the poles of a magnet by breaking it into 2 pieces Statement 2 : Magnetic monopoles do not exist
   a) Both the statements are correct
   b) Only statement 1 is correct
   c) Only statement 2 is correct
   d) Both are wrong
2. From Gauss's Law in magnetism we can conclude that
   a) $\sum \quad B.\Delta S = q/\epsilon_o$
   b) Monopoles do not exist
   c) Electric charges exist as monopoles
   d) Current loop is the source of magnetism
3. Which of the following is true?
   a) Magnetic flux through a closed surface is zero
   b) Magnetic field lines are non-intersecting
   c) Magnetic monopoles do not exist
   d) All the above
4. The surface integral of magnetic field over a closed surface is equal to
   a) Zero b) q/ϵ_o c) total electric flux d) current loop

****

SECTION C - ANSWERS

1. (a) 0.4 Nm
2. (c) is zero, otherwise there would be a field falling as $1/r^3$ at large distances outside the toroid.
3.(d). Equal
4. (b) 327^0 C

$$\frac{x_1}{x_2} = \frac{T_2}{T_1}$$

$$\frac{x_1}{0.5\, x_1} = \frac{T_2}{273 + 27}$$

$T_2 = 600\, K = 600 - 273 = 327^0$ C

5.(b) $\frac{2}{3}$ Am $^{-1}$

Here M_1 = 8 Am^{-1} and B_1 = 0.6 T

$T_1 = 4\, K$, B_2 = 0.2 T, $T_2 = 16\, K$

Then for Paramagnetic materials, Magnetisation, M = (CB/T) from Curies law

Now in first case ,

$$M_1 = \frac{CB_1}{T_1}$$

secondly

$$M_2 = \frac{CB_2}{T_2}$$

$\frac{M_1}{M_2} = \frac{B_1}{B_2}\, x\, \frac{T_2}{T_1}$

$\frac{M_1}{M_2}$ = (0.6/0.2) x (16/4)

$$\frac{8}{M_2} = 3\, x\, 4$$

Hence $M_2 = \frac{2}{3}$ Am $^{-1}$

6.$(d) Both\ \ WA^{-1}m^{-1}$ and NA^{-2}

7. (d) Attract N1 strongly, N2 weakly and repel N3 weakly.

1 MARK

8. When a bar magnet of magnetic moment (M = m2L) is cut into two equal pieces transverse to its length, its (i) the pole strength remains unchanged ii) the magnetic moment is halved.

9. μ is < 1 and > 0, so magnetic material is diamagnetic.

10. Iron is a ferromagnetic substance while and copper is diamagnetic, the susceptibility of iron is much larger.

11. The magnetic field lines prefer to pass through iron than air because the permeability of iron is much larger than air.

12. Two Characteristics Properties

- High magnetic susceptibility
- High permeability

2 MARKS

13. The magnetic moment of each half bar magnet is M /2 but oppositely directed, so net magnetic moment of combination $\frac{M}{2}$ - $\frac{M}{2}$ =0 (zero).

14. According to Gauss's Law in magnetism, the net magnetic flux through a closed surface is Zero. It signifies that in magnetism, isolated monopoles do not exist.

15. M = mL

New magnetic moment is M' = m (2R)

Relation between R and L

π R = L

R = L/ π

M'= m (2L/ π)

16(A). Place a compass needle at the given point .If it stays in the North-South direction, then the magnetic field is due to earth. If the needle points along any direction other than North –South, then the field is due to some current carrying conductor. If the current is switched off, the needle will orient itself along the North-South direction.

16 (B). (a) Case-1 because for lowest potential energy configuration, magnetic moment should be parallel.

(b) Case-2 because stability is inversely proportional to potential energy.

17. The susceptibility of a paramagnetic substance is inversely proportional to the absolute temperature. X $\propto$ 1/T.

$\chi = c\frac{\mu_0}{T}$

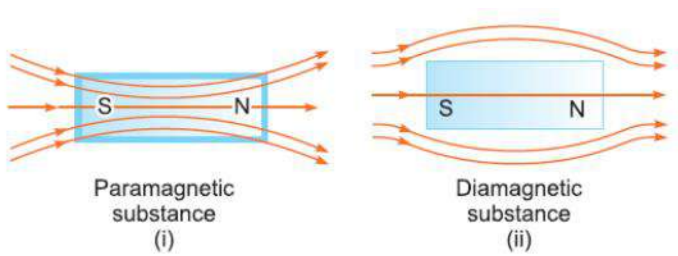
i.e. χ x T = Constant , Given T1 = 300 K

$$\frac{x_1}{x_2} = \frac{T_2}{T_1}$$

$$T_2 = \frac{x_1}{x_2} \quad T_1$$

$$= \frac{1.2 \times 10^5}{1.44 \times 10^5} \; X\, 300 = 250\, K$$

18. This distinguishing feature is because of the difference in their relative permeability. Relative permeability is the ratio of the permeability of a specific medium to the permeability of free space. The relative permeability of diamagnetic substance is less than 1, so the magnetic lines of force do not prefer passing through the substance whereas the relative permeability of paramagnetic substance.



19.The material which has relative permeabilities slightly greater one are paramagnetic whereas the material which has relative permeabilities slightly lesser than one are diamagnetic.

A → Paramagnetic

B → Diamagnetic

3 MARKS

20. (i) Direction of magnetic moment M of the current loop is perpendicular to the plane of the paper and directed inward. (ii) Torque acting on the current loop is a) maximum when M is perpendicular to B b) minimum when M is parallel to B.

21. **(**i) Magnetic field lines start from a North Pole and end on a South Pole. ii) Magnetic field lines form closed loops iii) Magnetic field lines do not intersect each other.

22. τ = MB sin θ

M = $\frac{\tau}{B sin\theta}$ = $\frac{4X10^{-2}}{0.1 sinsin\, 30}$ = 0.8 JT^{-1}

23. (i) W = MB (cos$\theta 1 - cos\theta 2$)

= 6 X 0.44 X (cos 60 – cos 90)

= 1.32J

(ii) W = 6 X 0.44 X (cos 60 – cos 180)

= 3.96 J

24. The time period of oscillation of the magnet is $T = 2\pi\sqrt{\frac{I}{MB}}$

But $I = \frac{ML^2}{12}$

When the bar magnet is cut into 2 equal pieces, perpendicular to its length, then moment of inertia of each piece of magnet about an axis perpendicular to length, passing through its centre is

$$I' = \frac{M(L/2)^2}{12 X\, 2} = \frac{ML^2}{12}\ \frac{1}{8}$$

Also, magnetic dipole moment M'=M/2

Its time period of oscillation is $T' = 2\pi\sqrt{\frac{I'}{M'B}} = \pi\sqrt{\frac{I}{MB}}$

25. The pole strength of a magnet depends on i) its area of cross section ii) nature of its material iii) its state of magnetisation

26. τ = MB sin θ

Also τ = Iα

MB sin θ = Iα

MB θ = Iα for small angle

$$\alpha = \frac{MB\theta}{I}$$

But $\alpha = \omega^2\ \theta$

So $\omega = \sqrt{\frac{MB}{I}}$

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{I}{MB}}$$

27. Given T1 = 280 K

$H_1 = 2 \text{ x } 10^3\ Am^{-1}$

$I_1 = 4.8 \text{ x } 10^{-2}\ Am^{-1}$

Using the relation,

$x_1 = \frac{I_1}{H_1}$

$x_1 = \frac{4.8 \ x \ 10^{-2}}{2 \ x \ 103}$ = 2.4 x 10^{-5}

Now, according to the Curie's law, X $\propto$ 1/T.

$\frac{x_1}{x_2} = \frac{T_2}{T_1}$ T2 = 320 K

$x_2 = \frac{280}{320}$ x 2.4 x 10^{-5} = 2.1×10^{-5}

Now, the intensity of magnetisation,

$$I_2 = X_2 \, H_2$$

Since, H is independent of the temperature, i.e. $H_1 = H_2$

$I_2 =$ **(**2.1×10^{-5}) x (2 x 10^{3}) = 4.2 x 10^{-2} ^{2} Am^{-1}

5 MARKS

28. Consider a magnetic dipole (or a bar magnet) SN of length 2l having South Pole at S and North Pole at N. The strength of south and north poles are – qm and + qm respectively.

Magnetic moment of magnetic dipole m = qm 2l, its direction is from S to N.

Consider a point P on the axis of magnetic dipole at a distance r from mid-point O of dipole.

The distance of point P from N-pole, r1= (r – l).

The distance of point P from S-pole, r2= (r + l)

Let B1 and B2 be the magnetic field intensities at point P due to north and south poles respectively. The directions of magnetic field due to North Pole is away from N-pole and due to South Pole is towards the S-pole. Therefore,

$B_1 = \frac{\mu_0}{4\pi} \ \frac{q_m}{(r-l)^2}$ from N to P and

$B_2 = \frac{\mu_0}{4\pi} \ \frac{q_m}{(r+l)^2}$ from P to S

$B_1 > B_2$ and direction of resultant is from N to P and magnitude is given by

$B = B_1 - B_2 = \frac{\mu_0}{4\pi} \frac{2(qm \ \ 2l)r}{(r^2-l^2)2}$

But qm 2l =M magnetic dipole moment

$$B = \frac{\mu_0}{4\pi}\frac{2(M\ )r}{(r^2-l^2)2}$$

For a short dipole

$$B = \frac{\mu_0}{4\pi}\frac{2M}{r^3}$$

b. If L is the length of the wire

L =N X 2πR = N' X 2πR/2

No of turns in the new coil N' = 2N

Original magnetic moment = M = NIA = NI X πR^2

New magnetic moment M' = N' I A' = 2NI X $(\pi\ R/2)^2$

M'/M =1/2

29. If magnetic compass of dipole moment m is placed at angle θ in uniform magnetic field, and released it experiences a restoring torque

Restoring torque, τ = – magnetic force × perpendicular distance = – qmB. (2a sin θ),

τ = – mB sin θ, where qm = pole strength, m = qm.2a (magnetic moment)

Negative sign shows that restoring torque acts in the opposite direction to that of defecting torque. In equilibrium, the equation of motion

$I\frac{d^2\theta}{dt^2}$ = MBθ as θ is very small

$$\frac{d^2\theta}{dt^2} = -\frac{MB}{I}\theta$$

$$\frac{d^2\theta}{dt^2} = -\omega^2\theta \qquad \alpha = -\omega^2\theta$$

It represents the simple harmonic motion with angular frequency ω

Expression for Time period:

We have, $\omega^2 = -\frac{MB}{I}$

But T $= \frac{2\pi}{\omega} = 2\pi\sqrt{I/MB}$

Assertion and Reason

30.(d) moving charge, electron, current carrying wire, naturally occurring magnet all these can create magnetic field.

31.(a) Stationary charge doesn't get affected by magnetic field, moving charge creates magnetic field.

32.(a) If F⊥V, at all instants then motion will be circular.

33.(b) For velocity selector the electrons can pass undeflected, when velocity and magnetic field are parallel , in that case force can be zero, both are correct but reason is not correct explanation of assertion.

34.(a) F = q E+ q(v × B) this is called Lorentz force.

Due to electric field, acceleration a $=\frac{qE}{m}$, hence velocity will not remain constant.

35.(c) current sensitivity $I_S = \frac{\phi}{I} = \frac{NAB}{k}$

voltage sensitivity $V_S = \frac{NAB}{kR}$

$V_s = \frac{I_S}{R}$

36. (d) In a non-uniform magnetic field both the torque and force will act.

37. (d) Galvanometer is used to detect the direction of current in a circuit, it gives full scale deflection to the current of microampere range.

38.(c) Diamagnetic materials get repelled in magnetic fields so they exhibit magnetism but they don't have unpaired electrons so we can say that they don't have dipole moment.

39.(a) Paramagnetic materials have unpaired electrons so they exhibit magnetism.

Case Study Based Question

40. 1.(a) Diamagnetism

2.(a) Diamagnetic

3.(b) is not affected by temperature

4.(d) -1

5.(d) Copper

41. 1.(b) 60^0

2.(a) 1.5 x 10^{-5} Nm

3.(d) PQ_6

4.(c) π : 4

Source Based

42.1. (a) Both the statements are correct

2. (b) Monopoles do not exist

3. (d) All the above

4. (a) Zero

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QUESTION BANK

CHAPTER: ELCTROMAGNETIC INDUCTION & ALTERNATING CURRENT

Section A

1 Mark Questions

Q1. A coil of N turns and area A is rotated at the rate of n rotations per second in a magnetic field of intensity B, the magnitude of the maximum magnetic flux will be

(a)NAB (b)nAB (c) NnAB (d)2πnNAB

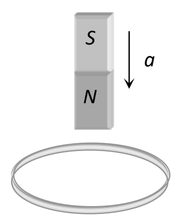
Q2. In electromagnetic induction, the induced e.m.f. in a coil is independent of

(a)Change in the flux (b) Time (c)Resistance of the circuit (d) none of the above

Q3. Lenz's law is consequence of the law of conservation of

(a)Charge (b) Momentum (c) Mass (d) Energy

Q4. A metallic ring is attached with the wall of a room. When the north pole of a magnet is brought near to it, the induced current in the ring will be



(a) First clockwise then anticlockwise (b) In clockwise direction

(c) In anticlockwise direction (d)First anticlockwise then clockwise

Q5. Lenz's law is expressed by the following formula (here e = induced e.m.f., ϕ = magnetic flux in one turn and N = number of turns)

(a) $e = -\phi \frac{dN}{dt}$ (b) $e = -N\frac{d\phi}{dt}$ (c) $e = -\frac{d}{dt}\left(\frac{\phi}{N}\right)$ (d) $e = N\frac{d\phi}{dt}$

Q6. A moving conductor coil in a magnetic field produces an induced e.m.f. This is in accordance with

(a) Amperes law (b) Coulomb law (c) Lenz's law (d) Faraday's law

Q7. The self-inductance of a coil is 5 henry, a current of 1 amp change to 2 amp within 5 second through the coil. The value of induced e.m.f. will be

(a) 10 volt (b) 0.10 volt (c)1.0 volt (d) 100 volt

Q8. The self-inductance of a solenoid of length L, area of cross-section A and having N turns is

(a) $\frac{\mu_0 N^2 A}{L}$ (b) $\frac{\mu_0 NA}{L}$ (c) $\mu_0 N^2 LA$ (d) $\mu_0 NAL$

Q9. A magnet is brought towards a coil (i) speedily (ii) slowly, then the induced e.m.f will be respectively

(a) More in first case and more in first case

(b) More in first case and equal in both case

(c) Less in first case and more in second case

(d) Less in first case and equal in both case

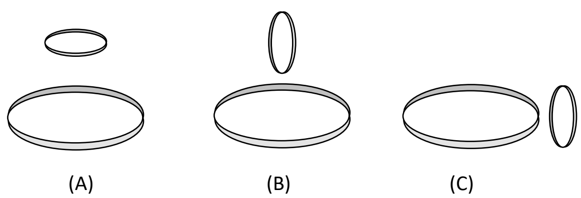
Q10. The direction of induced e.m.f. during electromagnetic induction is given by

(a) Faraday's law (b) Lenz's law (c) Maxwell's law (d) Ampere's law

Q11. The unit of magnetic flux is

(a) weber/m^2 (b) Weber (c)Henry (d) Ampere/m

Q12. Two circular coils can be arranged in any of the three situations shown in the figure. Their mutual inductance will be



(a) Maximum in situation (A) (b) Maximum in situation (B)

(c) Maximum in situation (C) (d) The same in all situations

Assertion Reason Questions

Directions: (a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c) If assertion is true but reason is false.

(d) If the assertion and reason both are false.

Q13. **Assertion** : Magnetic flux can produce induced e.m.f.

Reason: Lenz established induced e.m.f. experimentally.

Q14. **Assertion** : An induced emf is generated when magnet is withdrawn from the solenoid.

Reason: The relative motion between magnet and solenoid induces emf.

Q15. **Assertion** : A transformer cannot work on dc supply.

Reason: dc changes neither in magnitude nor in direction.

Q16. **Assertion** : . EMF induce in coil when flux link with coil changes

Reason: It induce to oppose the cause which produce It

Q17. **Assertion** : Magnetic flux link with coil is directly proportional to current.

Reason: Self-inductance will not play any role in linking of magnetic flux with coil.

Q18. **Assertion** : Lenz law is based on conservation of energy.

Reason : Constant current is able to induce emf in coil.

Q19. What is the SI unit of magnetic flux?

Q20. What is Faraday law electromagnetic induction?

2-Marks Questions

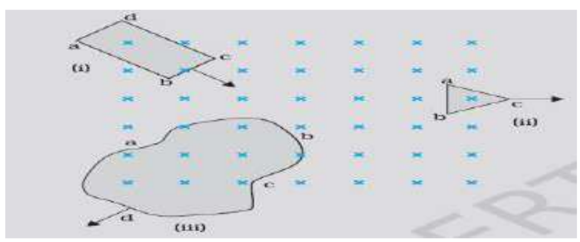
Q21. State and Explain Lenz's law?

Q22. What are the factors on which self-inductance depends?

3-Marks Questions

Q23. Define the coefficient of self-inductance (L). Write its unit. Write the two factors on which the self-inductance of along solenoid depends.

Q24. Figure shows planar loops of different shapes moving out of or into a region of a magnetic field which is directed normal to the plane of the loop away from the reader. Determine the direction of induced current in each loop using Lenz's law.



Q25. Obtain an expression for the self-inductance of a long solenoid. Hence define one henry.

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Section A

Answer Key

1 (a) Since ϕ = NBA cosθ ; For ϕ to be maximum; cosθ = max = 1 so ϕ_{max} = NBA.

2. (c) Because induced e.m.f. is given by $E = -N\dfrac{d\phi}{dt}$.

3. (d) The energy of the field increases with the magnitude of the field. Lenz's law infers that there is an opposite field created due to increase or decrease of magnetic flux around a conductor so as to hold the law of conservation of energy.

4. (c) As it is seen from the magnet side induced current will be anticlockwise.

5. (b)

6. (d)

7. (c) $e = -L\dfrac{di}{dt} \Rightarrow e = 5\times\dfrac{1}{5} = 1\ volt$

8. (a)

9. The magnitude of induced e.m.f. is directly proportional to the rate of change of magnetic flux. Induced charge doesn't depend upon time.

10. (b)

11. (b)

12. (a) As maximum linkage of magnetic flux is possible in A situation .

13. (d) E.M.F. induces, when there is change in magnetic flux. Faraday did experiment in which, there is relative motion between the coil and magnet, the flux linked with the coil changes and e.m.f. induces.

14. (a) as there is relative motion between solenoid and magnet gives change in flux

15. (a) Transformer works on ac only, ac changes in magnitude as well as in direction.

16. (a)

17. (c)

18 (c)

19. The SI unit of magnetic flux is weber or tesla – metre

20. Whenever the magnetic flux linked with an electric circuit changes an e.m.f. is induced in the circuit. The phenomenon is called electromagnetic induction.

21. The direction of induced current due to the change in magnetic flux through a closed-loop is always such that it opposes the change or cause which produces it.

when Lenz law is applied to it, it will be

$E \propto -d\Phi/dt$ where a negative sign shows the opposing nature of induced emf. It is based on the principle of conservation of energy.

22. $L = (\mu_0 N^2 A) / l$

- It depends on number of turns N
- It depends on area of cross section A
- Permeability of core material μ_0

23. From self-induction, we know that if I is the strength of the current flowing through a coil at any time ϕ is amount of magnetic flux linked with the coil at that time. It is found that

$$\phi \propto I, \quad \phi \propto LI \qquad \ldots(i)$$

L is a constant of proportionality and is called coefficient of self induction or self inductance of the coil.

S.I Unit $\frac{\text{volt sec}}{\text{Amp}}$ or Henry

The value of L depends upon the number of turn of the coil, area of cross-section and nature of material of the core on which coil is wound.

24. (i) The magnetic flux through the rectangular loop abcd increases, due to the motion of the loop into the region of magnetic field, The induced current must flow along the path bcdab so that it opposes the increasing flux.

(ii) Due to the outward motion, magnetic flux through the triangular loop abc decreases due to which the induced current flows along bacb, so as to oppose the change in flux.

(iii) As the magnetic flux decreases due to motion of the irregular shaped loop abcd out of the region of magnetic field, the induced current flows along cdabc, so as to oppose change in flux.

Note that there are no induced current as long as the loops are completely inside or outside the region of the magnetic field.

25. Consider current I flowing through a long solenoid of area A,

Let N be the total number of turns in the solenoid,

Total flux, $\phi = NBA$

Here, $B=\mu_0 nI$

Where, n is no. of turns per unit length of the solenoid, N=nl

$$\phi=nl\times\mu_0 nIA$$

$$\Rightarrow\phi=\mu_0 n^2 AlI \quad .... (1)$$

Also, $\phi=LI$ .... (2)

From equation (1) & (2)

$$I\mu_0 n_2 Al=LI$$

$$L=\mu_0 n^2 Al$$

$$L=\mu_0 N^2 A \quad \text{where} \quad (n=N/l)$$

One henry(1H) can be defined as: If current is changing at a rate of 1A/s in a coil inducing an emf of 1volt in it, then the inductance of the coil is one henry.

****

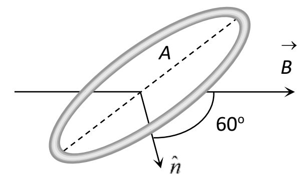
SECTION B

1-Mark Questions

Q1. A coil of area 100 cm^2 has 500 turns and magnetic field of 0.1 Wb/m^2 is perpendicular to the coil. The field is reduced to zero in 0.1 *second*. The induced e.m.f. in the coil is

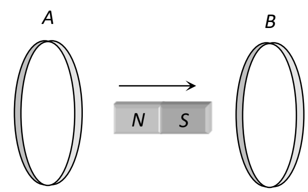
(a) 1 *V* (b) 5 *V* (c) 50 *V* (d) Zero

Q2. A coil of area $A = 2\ m^2$ is situated in a uniform magnetic field $B = \sqrt{3}.0\ wb/m^2$ and area vector makes an angle of 30° with respect to the magnetic field as shown in figure. The value of the magnetic flux through the area *A* would be equal to



(a) 2 *weber* (b)1 *weber* (c)3 *weber* (d) $\frac{3}{2}$ *weber*

Q3. In the diagram shown if a bar magnet is moved along the common axis of two single turn coils *A* and *B* in the direction of arrow



(a) Current is induced only in *A* & not in *B*
(b) Induced currents in *A* & *B* are in the same direction
(c) Current is induced only in *B* and not in *A*
(d) Induced currents in *A* & *B* are in opposite directions

Q4. Magnetic flux ϕ (in *weber*) linked with a closed circuit of resistance 10 *ohm* varies with time

t (in seconds) as $\phi = 5t^2 - 4t + 1$

The induced electromotive force in the circuit at $t = 0.2$ *sec*. is

(a) 0.4 *volts* (b) – 0.4 *volts* (c)– 2.0 *volts* (d) 2.0 *volts*

ASSERTION AND REASON

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c) If assertion is true but reason is false.

(d) If the assertion and reason both are false.

Q5. **Assertion** : The induced e.m.f. will be same and current will be different in two identical loops of copper and aluminium, when rotated with same speed in the same magnetic field.

Reason : Induced e.m.f. is proportional to rate of change of magnetic field while induced current depends on resistance of wire.

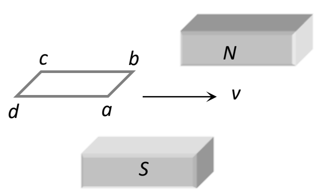
Q6. **Assertion**: In the phenomenon of mutual induction, self-induction of each of the coils persists.

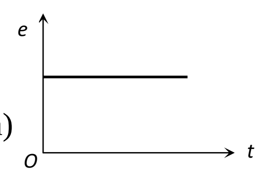
Reason: Self-induction arises when strength of current in same coil changes. In mutual induction, current is changing in both the individual coils.

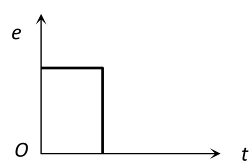
Q7. **Assertion** : Only a change in magnetic flux will maintain an induced current the coil.

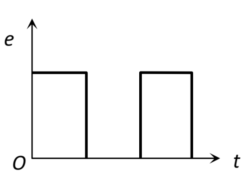
Reason : The presence of large magnetic flux through a coil maintains a current in the coil.

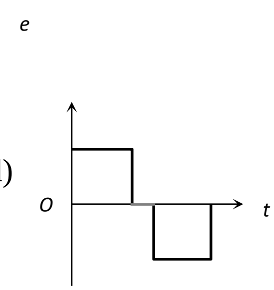
Q8. A horizontal loop *abcd* is moved across the pole pieces of a magnet as shown in fig. with a constant speed *v*. When the edge *ab* of the loop enters the pole pieces at time t = 0 *sec*. Which one of the following graphs represents correctly the induced emf in the coil



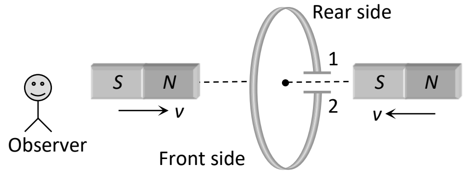
(a) 

(b) 

(b) 

(d) 

Q9. The north and south poles of two identical magnets approach a coil, containing a condenser, with equal speeds from opposite sides. Then



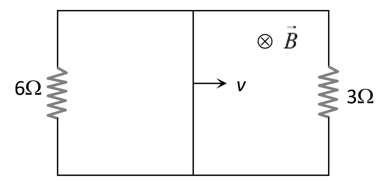
(a) Plate 1 will be negative and plate 2 positive

(b) Plate 1 will be positive and plate 2 negative

(c) Both the plates will be positive

(d) Both the plates will be negative

Q10. A rectangular loop with a sliding connector of length l = 1.0 m is situated in a uniform magnetic field B = 2T perpendicular to the plane of loop. Resistance of connector is r = 2Ω. Two resistance of 6Ω and 3Ω are connected as shown in figure. The external force required to keep the connector moving with a constant velocity v = 2m/s is



(a) 6 N (b) 4 N

(c) 2 N (d) 1 N

Q11. What is the principle used in the A.C. generator?

2-Marks Questions

Q12. Two identical circular loops of metal wire are lying on a table without touching each other. Loop-A carries a current which increases with time. Then what type of force is present between them?

Q13. If a square loop of conducting material is moved with a constant velocity fully inside a uniform magnetic field perpendicular to the field, will the current be induced in it?

3-Marks Questions

Q14. Current in a circuit falls from 5.0A to 0.0A in 0.1s. If an average emf of 200V induced, give an estimate of the self-inductance of the circuit.

Q15. What is mutual induction. Derive an expression for mutual induction between two coils.

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Section B (Answer Key)

1. (b) $e = -\frac{N(B_2 - B_1)A\cos\theta}{\Delta t}$

$$= -\frac{500 \times (0 - 0.1) \times 100 \times 10^{-4} \cos 0}{0.1} = 5V$$

2.(b) Angle between normal to the plane of the coil and direction of magnetic field is θ

$\therefore$ Flux linked with coil $\phi = BA\cos\theta = \sqrt{3}.0 \times 2 \times \cos 30^{o} \Rightarrow \phi = 3$ weber

3. (d)

4. (d) $e = -\frac{d\phi}{dt} = -(10t - 4) \Rightarrow (e)_{t=2} = -(10 \times 0.2 - 4) = 2\ volt$

5. (a) Since both the loops are identical (same area and number of turns) and moving with a same speed in same magnetic field. Therefore same emf is induced in both the coils. But the induced current will be more in the copper loop as its resistance will be lesser as compared to that of the aluminium loop.

6. (b) Mutual inductance is the phenomenon according to which an opposing e.m.f. produce flux in a coil as a result of change in current or magnetic flux linked with a neighboring coil. But when two coils are inductively coupled, in addition to induced e.m.f. produced due to mutual induction, also induced e.m.f. is produced in each of the two coils due to self-induction.

7. (c) Presence of magnetic flux cannot produce current.

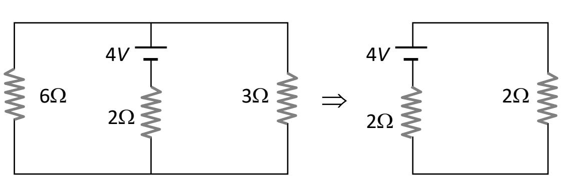
8. (d) When loop enters in field between the pole pieces, flux linked with the coil first increases (constantly) so a constant emf induces, when coil entered completely within the field, no flux change so $e = 0$. When coil exit out, flux linked with the coil decreases, hence again emf induces, but in opposite direction.

9. (b) The direction of induce current is 2 to 1 hence electron will move from 1 to 2 hence 1 is positive and 2 is negative

10. (c) Motional emf $e = Bvl \Rightarrow e = 2 \times 2 \times 1 = 4\ V$

This acts as a cell of emf $E = 4\ V$ and internal resistance $r = 2\Omega$.

This simple circuit can be drawn as follows



Current through the connector $i = \frac{4}{2+2} = 1\ A$

$\therefore$ magnetic force on connector $F_m = Bil = 2\times1\times1 = 2\ N$ (Towards left)

11. In A.C. generator uses the principle of electromagnetic induction which states that when the coil is rotated in a uniform magnetic field so that the flux through its continuous changes, an emf is induced in it.

12. As current In A is increasing in clock wise direction then current induce in b in anticlockwise direction it seems to be the current each section of both conductor is anti-parallel hence they will repel each other.

13.If a loop of conducting material is moved with a constant velocity well inside a uniform magnetic field perpendicular to the field, there will not be induced current in it because to induce a current, emf induced depends upon the rate of change of magnetic flux linked with it. In this case, flux through the loop remains constant. Hence there will be no induced current in the loop.

14. Given that, initial current, I_1=5.0A

Final current, I_2=0.0A

Change in current, $dI=I_1-I_2$=5A

Time taken for the change, t=0.1s

Average emf, e=200V

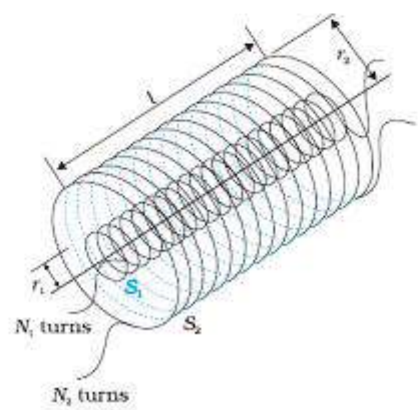
For self-inductance (L) of the coil, we have the relation for average emf as,

$$e=L\frac{dI}{dt}$$

$$L=\frac{e}{dI/dt} =200/\frac{5}{0.1}$$

Therefore, the self-induction of the coil is 4H

15 Let us consider two long co-axial solenoids each of length l, as shown in figure. Let the radius of the inner solenoid S1 be r_1 and the number of turns per unit length by n_1. Let the corresponding quantities for the outer solenoid S_2 are r_2 and n_2, respectively.



Let N_1 and N_2 be the total number of turns of coils S1 and S2, respectively. When a current I_2 is set up through S_2, it in turn sets up a magnetic flux through S_1. Let us denote it by Φ_1.

The corresponding flux linkage with solenoid S_1 is given by,

$N_1\Phi_1 = M_{12} I_2$ ....(1)

M_{12} is called the mutual inductance of solenoid S_1 with respect to solenoid S_2.

It is also referred to as the coefficient of mutual induction.

The magnetic field due to the current I_2 in S_2 is $\mu_0 n_2 I_2$. The resulting flux linkage with coil S_1 is,

$N_1\Phi_1 = (n_1 l)(\pi r_1^2)(\mu_o n_2 I_2) = [\mu_o n_1 n_2 \pi r_1^2 l] I_2$ ....(2)
where $(n_1 l)$ is the total number of turns in solenoid S_1. Thus, from Eq. (1) and Eq. (2), we get
$M_{12} = \mu_0 n_1 n_2 \pi r_1^2 l$

We now consider the reverse case. A current I_1 is passed through the solenoid S1 and the flux linkage with coil S_2 is,

$N_2\Phi_2 = M_{21} I_1$

M_{21} is called the mutual inductance of solenoid S_2 with respect to solenoid S_1.

As done in previous case, we can also get the relation for M_{21} as

$M_{21} = \mu_0 n_1 n_2 \pi r_1^2 l$

Hence if the two solenoid coils are of equal length, then $M_{12} = M_{21} = M = \mu_0 n_1 n_2 \pi r_1^2 l$

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SECTION C

1-MARK QUESTIONS

Q1. In electromagnetic induction, the induced charge in a coil is independent of

(a) Change in the flux (b)Time (c)Resistance in the circuit (d) None of the above

Q2. A coil of 40 Ω resistance has 100 turns and radius 6 mm is connected to ammeter of resistance of 160 ohms. Coil is placed perpendicular to the magnetic field. When coil is taken out of the field, 32 μ C charge flows through it. The intensity of magnetic field will be

(a) 6.55 T (b) 5.66 T (c) 0.655 T (d) 0.566 T

Q3. A coil having n turns and resistance R Ω is connected with a galvanometer of resistance $4R\Omega$. This combination is moved in time t seconds from a magnetic field W_1 weber to W_2 weber. The induced current in the circuit is

(a) $-\frac{W_2 - W_1}{5\ Rnt}$ (b) $-\frac{n(W_2 - W_1)}{5\ Rt}$ (c) $-\frac{(W_2 - W_1)}{Rnt}$ (d) $-\frac{n(W_2 - W_1)}{Rt}$

Q4. An infinitely long cylinder is kept parallel to an uniform magnetic field B directed along positive z axis. The direction of induced current as seen from the z axis will be

(a) Clockwise of the +ve z axis

(b) Anticlockwise of the +ve z axis

(c) Zero

(d) Along the magnetic field

Q5. A coil has an area of 0.05 m^2 and it has 800 turns. It is placed perpendicularly in a magnetic field of strength $4 \times 10^{-5}\ Wb/m^2$, it is rotated through 90^o in 0.1 sec. The average e.m.f. induced in the coil is

(a) 0.056 V (b) 0.046 V (c) 0.026 V (d) 0.016 V

ASSERTION AND REASON

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c) If assertion is true but reason is false.

(d) If the assertion and reason both are false.

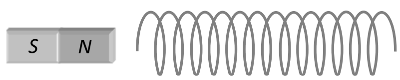
Q6. **Assertion**: The quantity L/R possesses dimensions of time.

Reason : To reduce the rate of increases of current through a solenoid should increase the time constant (L/R).

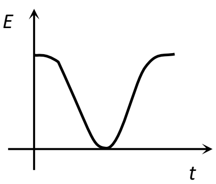
Q7. **Assertion** : When two coils are wound on each other, the mutual induction between the coils is maximum.

Reason: Mutual induction does not depend on the orientation of the coils.

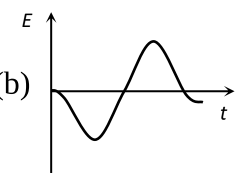
Q8. The variation of induced emf (E) with time (t) in a coil if a short bar magnet is moved along its axis with a constant velocity is best represented as



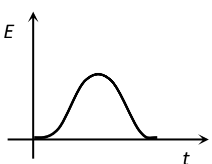
(a)



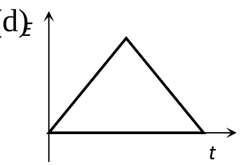
(b)



(c)



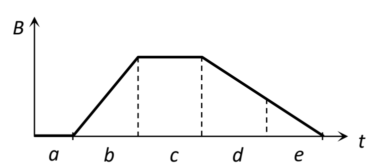
(d)



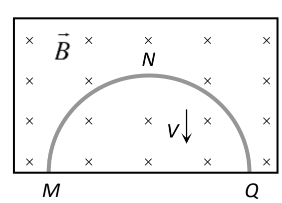
Q9. The graph gives the magnitude B(t) of a uniform magnetic field that exists throughout a conducting loop, perpendicular to the plane of the loop. Rank the five regions of the graph according to the magnitude of the emf induced in the loop, greatest first

(a) b > (d = e) < (a = c) (b) b > (d = e) > (a = c)

(c) b < d < e < c < a (d) b > (a = c) > (d = e)



Q10. A thin semicircular conducting ring of radius R is falling with its plane vertical in a horizontal magnetic induction B. At the position MNQ, the speed of the ring is V and the potential difference developed across the ring is



(a) Zero (b) $B v \pi R^2/2$ and M is at higher potential

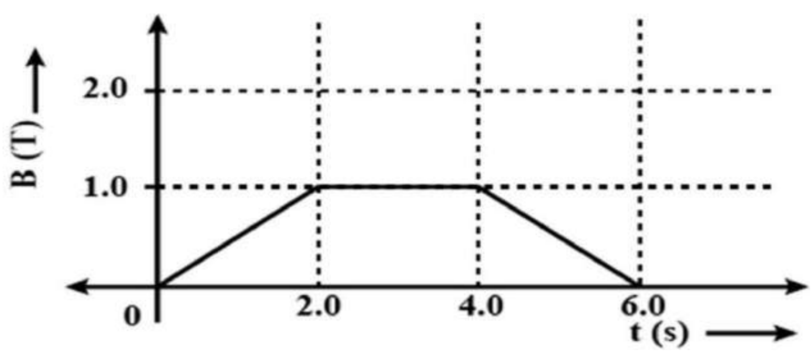
(c) πRBV and Q is at higher potential (d) 2RBV and Q is at higher potential

Q11. A conducting rod of length 2l is rotating with constant angular speed ω about its perpendicular bisector. A uniform magnetic field $\vec{B}$ exists parallel to the axis of rotation. The e.m.f. induced between two ends of the rod is

(a) $B\omega l^2$ (b) $\frac{1}{2}B\omega l^2$ (c) $\frac{1}{8}B\omega l^2$ (d) none of these

2-MARKS QUESTONS

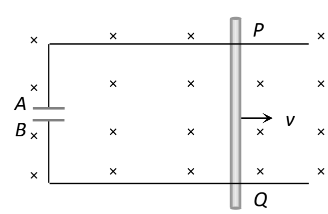
12. The magnetic field through a circular loop of wire, 12cm in radius and 8.5Ω resistance, changes with time as shown in the figure. The magnetic field is perpendicular to the plane of the loop. Calculate the current induced in the loop .



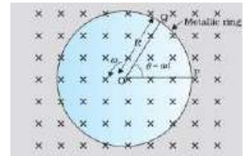
13. A short solenoid of radius a, number of turns per unit length n, and length L is kept coaxially inside a very long solenoid of radius b, number of turns per unit length n. What is the mutual inductance of the system?

3-Marks Questions

Q14. A conducting rod PQ of length L = 1.0 m is moving with a uniform speed v = 2 m/s in a uniform magnetic field $B = 4.0\,T$ directed into the paper. A capacitor of capacity C = 10 μF is connected as shown in figure. Find the charge store in capacitor.

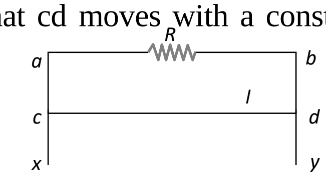


Q15. A conducting rod rotates with angular speed w with one end at the centre and other end at circumference of a circular metallic ring of radius R, about an axis passing through the centre of the coil perpendicular to the plane of the coil A constant magnetic field B parallel to the axis is present everywhere shown in fig. Show that the emf. between the centre and the metallic ring is $\frac{1}{2}$ BwR^2

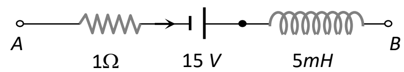


Q16. What is mean by Self Induction. Derive an expression for self-inductance which shows that it is not depend upon emf and current induce in It.

Q17. A wire cd of length l and mass m is sliding without friction on conducting rails ax and by as shown. The vertical rails are connected to each other with a resistance R between a and b. A uniform magnetic field B is applied perpendicular to the plane abcd such that cd moves with a constant velocity v.Find the required velocity



Q18. The network shown in the figure is a part of a complete circuit. If at a certain instant the current i is 5 A and is decreasing at the rate of $10^3 A/s$ then find $V_A - V_B$ is



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SECTION C (ANS KEY)

1-Marks Questions

1.(b) We know that $e = \frac{d\phi}{dt}$

But e=iR and $i = \frac{dq}{dt} \Rightarrow \frac{dq}{dt}R = \frac{d\phi}{dt} \Rightarrow dq = \frac{d\phi}{R}$

2. (d) $q = -\frac{N}{R}(B_2 - B_1)A\cos\theta$

$$32\times10^{-6} = -\frac{100}{(160+40)}(0-B)\times\pi\times(6\times10^{-3})^2\times\cos 0^o$$

$\Rightarrow B = 0.565\ T$

3. (b) $i = \frac{e}{R} = \frac{-N}{R}\frac{(\phi_2 - \phi_1)}{\Delta t} = \frac{-n(W_2 - W_1)}{5Rt}$

4. (c) Since the magnetic field is uniform therefore there will be no change in flux hence no current will be induced.

5. (d) $e = -\frac{NBA(\cos\theta_2 - \cos\theta_1)}{\Delta t}$

$= -\frac{800\times4\times10^{-5}\times0.05\,(\cos 90^o - \cos 0^o)}{0.1} = 0.016$ V

6. (b) The relation of induced emf is $e = \frac{Ldi}{dt}$ and current i is given by $i = \frac{e}{R} = \frac{1}{R}.\frac{L.di}{dt} \Rightarrow$

$\frac{di}{dt} = i\frac{R}{L} = \frac{i}{L/R}$.

In order to decreases the rate of increase of current through solenoid. We have to increase the time constant $\frac{L}{R}$.

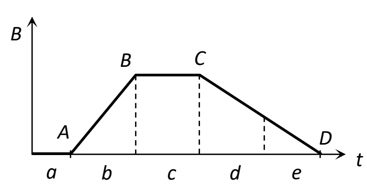
7. (c) The manner in which the two coils are oriented, determines the coefficient of coupling between them.

$M = K^2.L_1L_2$

When the two coils are wound on each other, the coefficient of coupling is maximum and hence mutual inductance between the coil is maximum.

8. (b) As the magnet moves towards the coil, the magnetic flux increases (nonlinearly). Also there is a change in polarity of induced emf when the magnet passes on to the other side of the coil.

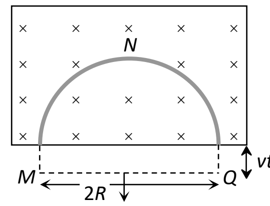
9. (b) Induced emf $e = A\frac{dB}{dt}$



i.e. $e \propto \frac{dB}{dt}$ (= slope of B – t graph)

In the given graph slope of AB > slope of CD, slope in the ‘a’ region = slope in the ‘c’ region = 0, slope in the ‘d’ region = slope in the ‘e’ region $\neq 0$. That’s why $b > (d = e) > (a = c)$

10. (d) Rate of decrease of area of the semicircular ring $-\frac{dA}{dt} = (2R)\, V$



According to Faraday's law of induction induced emf

$e = -\frac{d\phi}{dt} = -B\frac{dA}{dt} = -B\,(2RV)$

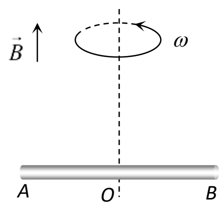
The induced current in the ring must generate magnetic field in the upward direction. Thus Q is at higher potential.

11.(d) Potential difference between

O and A is $V_0 - V_A = \frac{1}{2}Bl^2\omega$

O and B is $V_0 - V_B = \frac{1}{2}Bl^2\omega$

so $V_A - V_B = 0$



2-MARKS QUESTIONS

12. $.\varepsilon = --d\varphi/dt$

$\varepsilon = --d(BA)/dt$

$\varepsilon = --AdB/dt$

0<t<2 I= -- (3.14x 0.12x0.12x1)/2x 8.5= --0.0026A

2<t<4 I=0

4<t<6 I=0.0026A

13. $M = \mu_0 n_1 n_2 \pi a^2 L$

3-Marks Questions

14. Q = CV = C (Bvl) = $10 \times 10^{-6} \times 4 \times 2 \times 1 = 80\ \mu C$

According to Fleming's right hand rule induced current flows from Q to P. Hence P is at higher potential and Q is at lower potential. Therefore A is positively charged and B is negatively charged.

15. As the rod is rotated, free electrons in the rod move towards the outer end due to Lorentz force and get distributed over the ring. Thus, the resulting separation of charges produces an emf across

the ends of the rod. At a certain value of emf, there is no more flow of electrons and a steady state is reached. Using Eq. (6.5), the magnitude of the emf generated across a length dr of the rod as it moves at right angles to the magnetic field is given by

dE = BV dr . Hence $E=\int dE = \int BVdr = \oint_0^R BVdr$

$V= \omega r$

$E= B\omega \oint_0^R r\,dr = \frac{B\omega R^2}{2}$

16. Coefficient of Self-Induction

Consider current I flowing through a long solenoid of area A,

Let N be the total number of turns in the solenoid,

Total flux, $\phi=NBA$

Here, $B=\mu_0 nI$

Where, n is no. of turns per unit length of the solenoid

$N=nl \Rightarrow \phi=nl\times\mu_0 nIA$

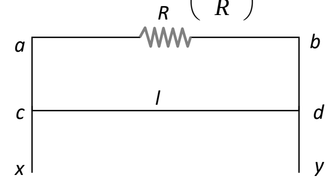
$\Rightarrow \phi=\mu_0 n^2 AlI$ ....(1)Also,

$\phi=LI$........(2)

From equation (1) & (2) $\mu_0 n^2 Al=L \Rightarrow L=\mu_0 n^2 Al$

$L=\mu_0 N^2 A / l$ --- this equation show that it is independent on emf and current

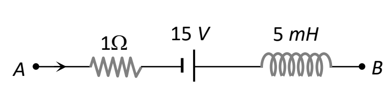
17. (b) Due to magnetic field, wire will experience an upward force $F = Bil = B\left(\frac{Bvl}{R}\right)l \Rightarrow F = \frac{B^2vl^2}{R}$



If wire slides down with constant velocity then

$$F = mg \Rightarrow \frac{B^2vl^2}{R} = mg \Rightarrow v = \frac{mgR}{B^2l^2}$$

18. (c) By using Kirchoff's voltage law



$$V_A - i\,R + E - L\frac{di}{dt} = V_B \Rightarrow V_B - V_A = 15\ volt.$$

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QUESTION BANK

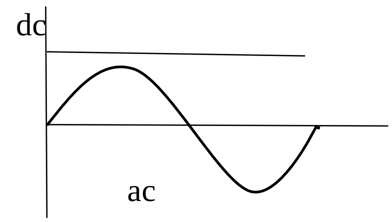
CHAPTER: ALTERNATING CURRENT

TOPICS COVERED: Alternating currents, peak and rms value of alternating current/ voltage, reactance and impedance.

SECTION A

COMPETENCY BASED QUESTIONS

Q1.An alternating current is that whose magnitude changes continuously with time and direction reverses periodically why the current that flows with same magnitude in same direction is direct current,



(i)If an ammeter is used to measure alternating current in circuit, which value of current will it read

(a) Peak (b) rms (c) Instantaneous (d) Average

(ii) If T is the time period of given alternating current, then how much time it requires to reach its peak value starting from zero

(a)T (b) T/2 (c) T/4 (d) T/8

(iii) What is the average value of alternating current over one complete cycle

(a)0 (b) I_o (c) $I_o/2$ (d) $I_o/4$

(iv)For a 220 V mains of alternating voltage peak value will be………………………

220 V b)220/ $\sqrt{2}$ V c) 220 $\sqrt{2}$ V d) 110 V

(v)How will you write an equation to represent alternating voltage with frequency 10 cycles per second and amplitude 100?

Q2. A DC ammeter cannot be used to measure an alternating current because

(a)DC ammeter will get damage
(b) average value of AC for complete cycle is zero
(c) alternating current cannot pass through DC ammeter
(d) alternating current changes its polarity

Q3. Why the use of ac voltage is preferred over dc voltage?

(a) Generation of ac is more economical than dc
(b) AC can be stepped up and stepped down
(c) It can be transmitted with lower energy loss
(d) All of the above

Assertion & Reasoning

(A) Assertion A and reason R are both true and R is the correct explanation of A

(B) Assertion A and reason R are both true but R is not the correct explanation of A

(C) Assertion A is true but reason R is false

(D) Both assertion A and reason R are false

Q4. A: An alternating EMF leads alternating current by phase angle $\pi/2$ in a purely inductive circuit.

R: Inductive reactance decreases when frequency of source increases.

Q5. A: Alternating current is more dangerous than direct current.

R: Alternating current changes its polarity periodically.

Q6. A: A capacitor block dc but allow ac to pass through it.

R: Capacitive reactance is inversely proportional to frequency.

Q7. A: In an ac circuit having and inductance coil, the frequency of ac is increased, current decreases.

R: Current is inversely proportional to frequency.

SA-I (2 MARKS EACH)

Q8.(i) Define root mean square value of an alternating current.

(ii) Write the relation between peak and root mean square value of alternating current.

Q9.The EMF of an AC source is given as: $\mathcal{E} = 100 \sin 314\, t$

Find peak value of alternating emf and frequency.

Q10.A light bulb is rated as 50 W for 220 V AC supply of 50 Hz, Calculate resistance of the bulb and rms current through the bulb.

Q11.Draw the graphs showing variation of inductive reactance and capacitive reactance with frequency of applied ac source.

Q12. The reactance of a capacitor at 50 Hz is 10 ohms, if frequency is doubled, then what will be the value of reactance?

SA-II (3 MARKS EACH)

Q13.What is inductive reactance? If an ac voltage is applied across an inductance L, find an expression for the current I flowing in the circuit. Also show the phase relationship between current and voltage in a phasor diagram.

Q14.What is capacitive reactance? If an ac voltage is applied across a capacitance C, find an expression for the current I flowing in the circuit. Also show the phase relationship between current and voltage in a phasor diagram.

Q15.If the frequency of alternating current is tripled, how will it affect resistance R, inductive reactance X_L and capacitive reactance X_C?

Q16.For a given ac circuit, differentiate between resistance, reactance and impedance.

LA (5 MARKS)

Q17.(a) Differentiate between the term inductive reactance and capacitive reactance of an ac circuit.

(b) If an inductor and a resistor are connected in series in an ac circuit, what will be the mathematical expression for the impedance of this circuit. How will the impedance get affected when the frequency of applied signal is decreased and why?

ANSWER KEY

SECTION A

1.(i) b) rms
(ii) c) T/4
(iii) a) 0
(iv) c) 220 $\sqrt{2}$ V
(v) $\mathcal{E} = 100 \sin 20 \pi t$

2. (b) average value of AC for complete cycle is zero

3. (d) All of the above

4. (c) Assertion A is true but reason R is false

5. (b) Assertion A and reason R are both true but R is not the correct explanation of A

6. (a) Assertion A and reason R are both true and R is the correct explanation of A

7. (a) Assertion A and reason R are both true and R is the correct explanation of A

8. (i) root mean square is that value of current which produces the same heating effect in a given resistor as is produced by the given alternating current when passed for the same time. It is denoted by I_{rms}.

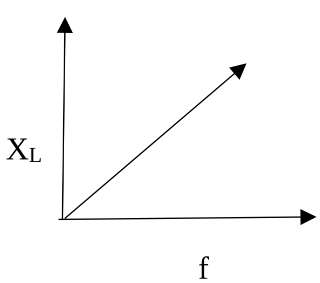
ii) $I_{rms} = I_{peak} / \sqrt{2} = 0.707\, I_{peak}$

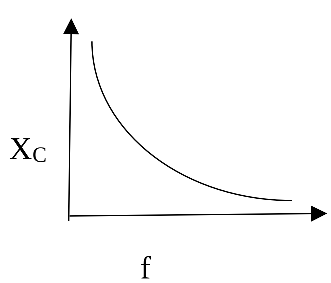
9. peak value of alternating emf = 100 V , for frequency: $2\pi f = 314$, so f = 50 Hz

10. Resistance of bulb $R = V^2_{rms}/P = (220 \times 220)/50 = 968$ ohms

$I_{rms} = P / V_{rms} = 50/220 = 0.227$ A

11.





12. Capacitive reactance, $X_C = 1/\omega C = 1/(2\pi f C) = 1/100\pi C$

X_C, capacitive reactance when frequency is doubled = $1/(2\pi(2f)C) = 1/200\pi C = X_C/2$

13. Inductive reactance is the opposition offered by the inductor in flow of ac. It is denoted by X_L.

Let $\mathcal{E} = \mathcal{E}_o \sin \omega t$ be the emf of ac source connected with inductor in the circuit

Then an alternating current flows through the inductor, a back emf $-L\frac{dI}{dt}$ is set up which opposes the applied emf.

Net instantaneous emf = $\mathcal{E} - L\,dI/dt$

But this emf must be zero because there is no resistance in the circuit

So, $$\mathcal{E} - L\frac{dI}{dt} = 0$$

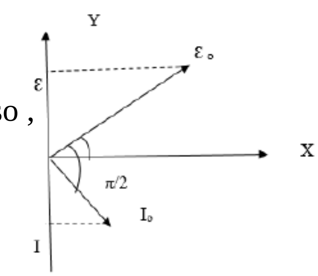
$$\mathcal{E} = L\frac{dI}{dt}$$

$$\mathcal{E}_o \sin w\,t = L\frac{dI}{dt}$$

$$dI = \frac{\mathcal{E}o}{L}\sin wtdt$$

Integrating, $$\int dI = \int\frac{\mathcal{E}o}{L}\sin wtdt$$

$$I = -\frac{\mathcal{E}o}{wL}\cos wt + \text{constant}$$



Over the time period T, cos wt = 0 and average value of I must be 0 so ,

integration constant = 0 hence, $$I = -\frac{\mathcal{E}o}{wL}\cos wt$$

$$= -\frac{\mathcal{E}o}{wL}\sin(\pi/2 - wt)$$

$$I = I_o\ \sin(wt - \pi/2)$$

14. Capacitive reactance is the opposition offered by the inductor in flow of ac. It is denoted by X_C.

Let $\mathcal{E} = \mathcal{E}_o \sin w\,t$ be the emf of ac source connected with inductor in the circuit

Due to the continuous charging and discharging of capacitor plates, a continuous but alternating current exist in the circuit.

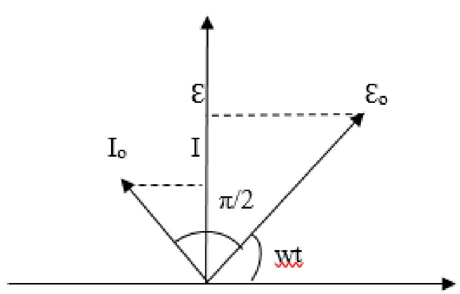
At any time t, Potential difference across the capacitor plates = applied emf

$V = \mathcal{E} = \mathcal{E}_o \sin w\,t$

But $V = Q/C$

Or $Q = CV = C\,\mathcal{E}_o \sin w\,t$

Current at instant t will be,



$I = \frac{dQ}{dt}$ = d (C $\mathcal{E}_o$ sin w t)/dt

I = w C $\mathcal{E}_o$ cos w t

I = I_o cos wt

I = I_o sin (wt + $\pi/2$)

15. R remains unaffected, inductive reactance get tripled and capacitive reactance become one third of the original value

16.

RESISTANCE	REACTANCE	IMPEDANCE
It can be seen in both ac and dc circuits	It can be seen only in ac circuits	It can be seen only in ac circuits
Happen due to resistor in a circuit	Happen due to inductor or capacitor in a circuit	Happen due to resistor and inductor or capacitor or both in a circuit
Represented by R	Represented by X	Represented by Z
It doesn't have a phase angle	It has a phase angle	It has a phase angle

17. (a)

INDUCTIVE REACTANCE	CAPACITIVE REACTANCE
Opposition offered by the inductor in flow of current	Opposition offered by the capacitor in flow of current
Depends directly on frequency of ac	Depends inversely on frequency of ac.
Allow dc	Block dc

(b) $Z^2 = R^2 + X_L^2$, if frequency of applied signal is decreased, the term $X_L = \omega L$ also decreased and as a result value of impedance decreased consequently.

****

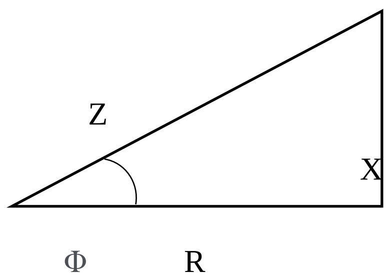
SECTION B

COMPETENCY BASED QUESTIONS

Q1. Quantity that measures the opposition offered by a circuit to the flow of current is called impedance. For an ac circuit, reactance corresponding to inductor and capacitor is also considered, along with resistance. So, impedance for the ac circuit can be given mathematically as

$Z^2 = R^2 + X^2$, where X is the reactance.

Impedance triangle is a right-angled triangle given as in the diagram and satisfy the above mathematical equation.



Also phase angle Φ between current and voltage can be given by using this impedance triangle

(i) Impedance for a purely capacitive circuit depends on

(a) f (b) 2f (c) 1/f (d) 1/2f

(ii) Impedance for a purely inductive circuit depends on

(a) f (b) 2f (c) 1/f (d) 1/2f

(iii) For ac circuit containing resistor only, value of Φ will be

(a)0 (b) π/2 (c) - π/2 (d) π

(iv) What is the impedance of a capacitor with capacitance C in an ac circuit having source of frequency 50 Hz

(a) 1/C (b) 1/50 C (c)1/100 C (d) 1/314 C

(v) What are the dimensions of impedance?

Assertion & Reasoning

(a) Assertion A and reason R are both true and R is the correct explanation of A

(c) Assertion A and reason R are both true but R is not the correct explanation of A

(d) Assertion A is true but reason R is false

(e) Both assertion A and reason R are false

Q2.A: Current in purely inductive or purely capacitive circuit is wattless.

R: No power is dissipated when current flows through a purely inductive or capacitive circuit

Q3.A: If a capacitor is connected to a dc source, it will have infinite reactance.

R: Reactance of capacitor is directly proportional to frequency.

Q4.A: At resonance, impedance is minimum.

R: For an ac circuit, inductive and capacitive reactance are equal and opposite at resonance.

Q5.For an inductive circuit with zero resistance, the current lags behind the applied voltage by an angle……….

0^o b) 30^o c)60^o d) 90^o

SA-I (2 MARKS EACH)

Q6. Which one is more dangerous----- a 220 V ac or a 220 V dc, explain?

Q7. Why capacitor block dc but pass ac through it, explain?

Q8. Why inductor provides an easy way to dc while resistive to ac?

SA-II (3 MARKS EACH)

Q9. A 50 μF capacitor is connected to a 100V, 50 Hz ac supply

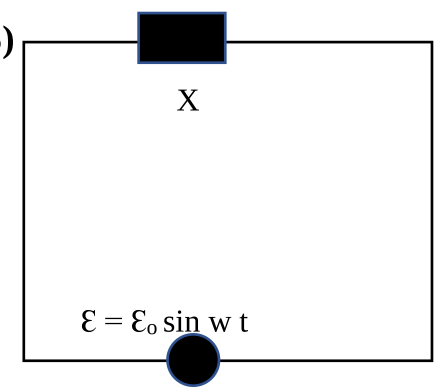
(i)Determine rms value of current

(ii)What is the net power absorbed by circuit in one complete cycle.

LA (5 MARKS)

Q10. If X, an unknown circuit element is connected to the source as shown in the diagram, such that the current through X is given as

$I = Io \sin (wt + \pi/2)$



(i)Identify the device X?

(ii)Write expression for the reactance of X.

(iii) Draw phasor diagram for device X

(iv) Draw a graph showing variation of reactance of device X with frequency.

(v) What happen if the source is replaced by a dc source?

SECTION B-ANSWER KEY

1.(i) c) 1/f

(ii) a) f

(iii) a) 0

(iv) d) 1/314 C

(V) $M^1 L^2 T^{-3} A^{-2}$

2.a) Assertion A and reason R are both true and R is the correct explanation of A.

3.c) Assertion A is true but reason R is false

4.a) Assertion A and reason R are both true and R is the correct explanation of A.

5.d) 90^o

6.peak value of 220 V ac is 220 √2 V = 311 V while for 220 V dc it is 220 V so, 220 V ac is more dangerous.

7. For a capacitor, capacitive reactance is $X_c = 1/ 2 \pi f C$ means capacitive reactance depends inversely on frequency f

8.For dc with zero frequency, capacitor show infinite reactance and block dc while allow ac to pass through it.

For an inductor, inductive reactance is $X_L = 2 \pi f L$

So, for dc with zero frequency, inductor will show zero reactance and give it easy way to pass.

While for ac with some finite frequency, inductive reactance will show some finite value and cause opposition in the flow of current.

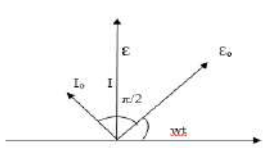
9.C = 50 uF, V_{rms} = 100 V, f = 50 Hz

$I_{rms} = V_{rms} / X_c = 2 \pi f C V_{rms} = 1.57$ A

$P_{av} = V_{rms} . I_{rms} . \cos \pi/2 = 0$

10. (i) Capacitor (ii) $X_C = 1/wC$

(iii)



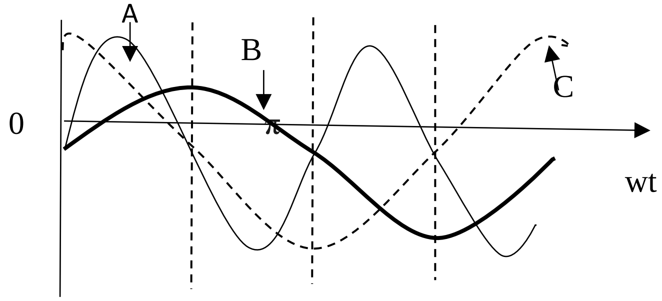
(iv)

(v) for dc, f = 0 so w = 0, hence capacitor block dc

SECTION C

COMPETENCY BASED QUESTIONS

Q1. A device X is connected to an alternating source $\mathcal{E} = \mathcal{E}_o \sin wt$. The variation of voltage, current and power in one cycle is shown in the graph



i) Identify X

ii) Which of the curves represent voltage, current and power consumed in the circuit

iii) How does its impedance vary with frequency?

SA-I (2 MARKS EACH)

Q2."An alternating current of frequency 15 cps can be used for lighting purpose", true/ false. Justify your answer.

Q3."For a very high frequency, capacitor behaves as a conductor", true/ false. Justify your answer.

Q4."At resonance, inductive reactance is equal to capacitive reactance", true/ false. Justify your answer.

Q5."An alternating current doesn't show any magnetic effect", true/ false. Justify your answer.

SA-II (3 MARKS EACH)

Q6.An alternating source of 220 V is connected to a circuit having a device "A", a current of 0.5 A flows, which lag behind the applied voltage in phase by $\pi/2$. If the same voltage is applied to another device "B", same current flows but now it is in phase with the applied voltage.

(i) Name the devices A and B

(ii) Draw the phasor diagram for device A

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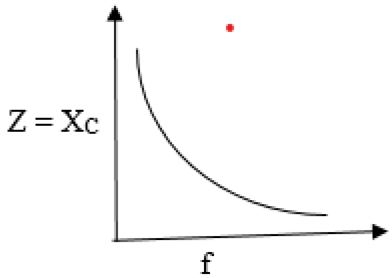
SECTION C-ANSWERS

1.(i) Device X is a capacitor.

(ii) curve A represents power; curve B represents voltage and curve C represents Current

(iii)



2.true, in this case fluctuation will be so rapid that due to persistence of vision bulb seems glowing

3.true, at very high frequency, capacitive reactance become negligibly small and capacitor behaves like a pure conductor.

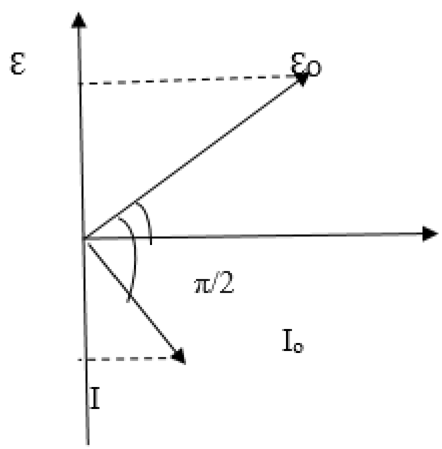
4.True, at resonance value of current is maximum and impedance is minimum, which is possible if inductive reactance and capacitive reactance are equal.

5.False, an alternating current produces a magnetic field whose magnitude and direction changes periodically.

6.i) A is inductor

B is resistor

ii) Phasor diagram



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QUESTIONS ONLY

Question Types Includes: 1) MCQ 2) VSA 3) SA-I 4) SA-II 5) LA 6) Assertion and reason 7) Case study.

SECTION A

MULTIPLE CHOICE QUESTION

Q1.Power delivered by the source of the circuit becomes maximum, when

(a) $\omega L = \omega C$ (b) $\omega L = 1/\omega C$ (c) $\omega L = -(1/\omega C)^2$ (d) $\omega L = \sqrt{\omega C}$

Q2. The power factor of LCR circuit at resonance is

(a) 0.707 (b) 1 (c) Zero (d) 0.5

Q3. The phase difference between the current and voltage of LCR circuit in series combination at resonance is

(a) 0 (b) $\pi / 2$ (c) π (d) $-\pi$

Q4. What will be the phase difference between virtual voltage and virtual current, when the current in the circuit is wattless

(a) 90° (b) 45° (c) 180° (d) 60°

Assertion Reasoning Question:

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c) If assertion is true but reason is false.

(d) If the assertion and reason both are false

Q5. **Assertion** : A bulb connected in series with a solenoid is connected to ac source. If a soft iron core is introduced in the solenoid, the bulb will glow brighter.

Reason : On introducing soft iron core in the solenoid, the inductance decreases.

Q6. Which of the following is constructed on the principle of electromagnetic induction:

(a) Galvanometer (b) a.c. generator (c) Generator (d) Voltmeter

Q7. A transformer is based on the principle of

(a) Mutual inductance (b) Self-inductance (c) Ampere's law (d) Lenz's law

Q8. A transformer is employed to

(a) Obtain a suitable dc voltage (b) Convert dc into ac

(c) Obtain a suitable ac voltage (d) Convert ac into dc

Q9. Quantity that remains unchanged in a transformer is

(a) Voltage (b) Current (c) Frequency (d) None of above

Q10. **Assertion**: Soft iron is used as a core of transformer.

Reason: Area of hysteresis is loop for soft iron is small

SHORT ANSWER TYPE I (2MARKS EACH)

Q11.What is wattless current?

Q12.Mention the two characteristic properties of the material suitable for making core of a transformer.

Q13.A generator developed an emf of 120V and has terminal potential difference of 115V, when the armature current is 25A. What is the resistance of armature?

SHORT ANSWER TYPE II (3MARKS EACH)

Q14.A circuit is set up by connecting inductance L = 100 mH, resistor R = 100 Ω and a capacitor of reactance 200 Ω in series. An alternating emf of $150\sqrt{2}$ V, 500/π Hz is applied across this series combination. Calculate the power dissipated in the resistor.

LONG ANSWER TYPE (5MARKS EACH)

Q15. (a) What is impedance?

(b) A series LCR circuit is connected to an ac source having voltage $V = V_0 \sin \omega t$. Derive expression for the impedance, instantaneous current and its phase relationship to the applied voltage. Find the expression for resonant frequency.

Q16. Explain with the help of a labelled diagram, the principle and working of an ac generator. Write the expression for the emf generated in the coil in terms of speed of rotation. Can the current produced by an ac generator be measured with a moving coil galvanometer?

Q17. Describe briefly, with the help of a labelled diagram, the basic elements of an ac generator. State its underlying principle. Show diagrammatically how an alternating emf is generated by a loop of wire rotating in a magnetic field. Write the expression for the instantaneous value of the emf induced in the rotating loop.

Q18. State the working of ac generator with the help of a labelled diagram. The coil of an ac generator having N turns, each of area A, is rotated with a constant angular velocity ω. Deduce the expression for the alternating emf generated in the coil. What is the source of energy generation in this device?

Q19. (a) Describe briefly, with the help of a labelled diagram, the working of a step-up transformer.

(b) Write any two sources of energy loss in a transformer.

(c) A step-up transformer converts a low voltage into high voltage. Does it not violate the principle of conservation of energy? Explain.

CASE STUDY TYPE (4 MARKS EACH)

Q20. When electric power is transmitted over great distances, it is economical to use a high voltage and a low current to minimize the I^2R loss in the transmission lines. Consequently, 350-kV lines are common, and in many areas even higher-voltage (765-kV) lines are under construction. At the receiving end of such lines, the consumer requires power at a low voltage (for safety and for efficiency in design). Therefore, a device is required that can change the alternating voltage and current without causing appreciable changes in the power delivered. The ac transformer is that device. In its simplest form, the ac transformer consists of two coils of wire wound around a core of iron. The coil on the left, which is connected to the input alternating voltage source and has N1 turns, is called the primary winding (or the primary). The coil on the right, consisting of N 2 turns and connected to a load resistor R, is called the secondary winding (or the secondary). The purpose of the iron core is to increase the magnetic flux through the coil and to provide a medium in which nearly all the flux through one coil passes through the other coil. Eddy current losses are reduced by using a laminated core. Iron is used as the core material because it is a soft ferromagnetic substance and hence reduces hysteresis losses. Typical transformers have power efficiencies from 90% to 99%. In the discussion that follows, we assume an ideal transformer, one in which the energy losses in the windings and core are zero.

1. Name the different types of losses involve in transformer.
2. How to minimise eddy current losses in transformer?
3. What cause the Hysteresis loss?
4. Which type of transformer used at the receiving end?

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ANSWERS-SECTION A

Question Types Includes 1) MCQ 2) VSA 3) SA-I 4) SA-II 5) LA 6) Assertion and reason 7) Case study.

MULTIPLE CHOICE QUESTION

1. (a) ωL =ωC
2. (b) 1
3. (a) 0
4. (a) 90°
5. (d) If the assertion and reason both are false
6. (b) a.c. generator
7. (a) Mutual inductance
8. (c) Obtain a suitable ac voltage
9. (c) Frequency
10. (a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

SHORT ANSWER TYPE I (2MARKS EACH)

11. When pure inductor and/or pure capacitor is connected to ac source, the current flows in the circuit, but with no power loss; the phase difference between voltage and current is π/ 2.

12. Two characteristic properties: (i) Low hysteresis loss (ii) Low coercivity

13. R= E-V/I = 0.2Ω.

SHORT ANSWER TYPE II (3MARKS EACH)

14. $X_L = \omega L = 2\pi\nu L = 100\Omega$

$$Z = \sqrt{R^2 + (Xc - XL)^2} \quad = 100\sqrt{2}\ \Omega$$

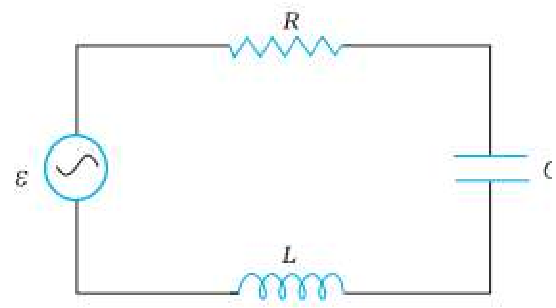
$$P_{dissipated} = (Vrms/Z)^2\ R = 225W$$

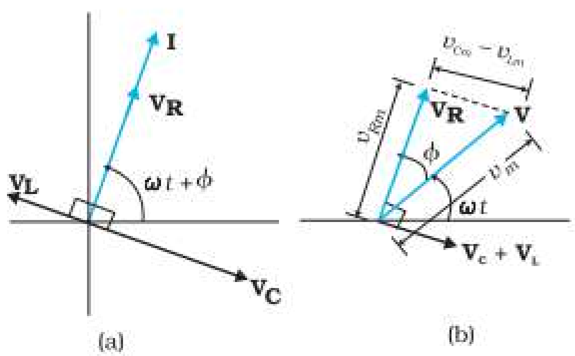
LONG ANSWER TYPE (5MARKS EACH)

15.(a) The opposition offered by the combination of a resistor and reactive component to the flow of ac is called impedance. Mathematically it is the ratio of rms voltage applied and rms current produced in circuit i.e., Z= $\frac{Vrms}{\mathrm{Irms}}$. Its unit is ohm (Ω)

(b)

From the circuit shown in Fig. , the resistor, inductor and capacitor are in series. Therefore, the ac current in each element is the same at any time, having the same amplitude and phase. Let it be $i = i_m \sin(\omega t+\varphi)$ where φ is the phase difference between the voltage across the source and the current in the circuit





Let **I** be the phasor representing the current in the circuit. Further, let $\mathbf{V_L}$, $\mathbf{V_R}$, $\mathbf{V_C}$, and **V** represent the voltage across the inductor, resistor, capacitor and the source, respectively. We know that $\mathbf{V_R}$ is parallel to **I**, $\mathbf{V_C}$ is $\pi/2$ behind **I** and $\mathbf{V_L}$ is $\pi/2$ ahead of **I**. $\mathbf{V_L}$, $\mathbf{V_R}$, $\mathbf{V_C}$, and **I** are shown in Fig. with appropriate phase-relations.

The length of these phasors or the amplitude of $\mathbf{V_L}$, $\mathbf{V_R}$, and $\mathbf{V_C}$, are:

$V_{Rm} = i_m R$, $v_{Cm} = i_m X_C$, $v_{Lm} = i_m X_L$

From phasor diagram we have

$\mathbf{V_L} + \mathbf{V_R} + \mathbf{V_C} = \mathbf{V}$

Since $\mathbf{V_C}$ and $\mathbf{V_L}$ are always along the same line and in opposite directions, they can be combined into a single phasor $(\mathbf{V_C} + \mathbf{V_L})$ which has a magnitude $|V_{cm} - V_{Lm}|$Since **V** is represented as the hypotenuse of a right-traingle whose sides are $\mathbf{V_R}$ and $(\mathbf{V_C} + \mathbf{V_L})$,

The Pythagorean Theorem gives

$$V_m^2 = V_{Rm}^2 + (V_{Cm} - V_{Lm})2$$

$$V_m^2 = (i_m R)^2 + (i_m X_C - i_m X_L)2$$

$$V_m^2 = i_m^2[(R)^2 + (X_C - X_L)2]$$

$i_m = V_m \,/\, \sqrt{R^2 + (Xc - X_L)^2}$

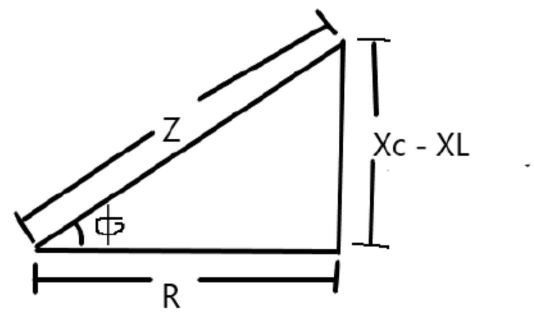
$i_m = V_m$ / Z

Z=$\sqrt{R^2 + (Xc - X_L)^2}$

Where Z is called impedance of the LCR series circuit which is opposition offered to the current in LCR series circuit.

And $\tan\varphi = \frac{V_{Cm} - V_{Lm}}{V_{Rm}} = \frac{X_C - X_L}{R}$

Impedance Triangle



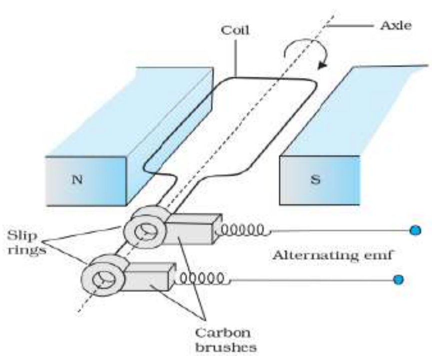
Instantaneous Current I = $\frac{V_m \, Sin\, wt + \varphi}{\sqrt{R^2 + (Xc - X_L)^2}}$

At resonance $X_C = X_L$

$$\frac{1}{\omega C} = \omega L$$

Resonance frequency $\omega_r = \frac{1}{\sqrt{LC}}$

16. Principle: Rotating coil kept in magnetic field produce ac current.



Construction: It consists of the four main parts:

Field Magnet: It produces the magnetic field.

Armature: It consists of a large number of turns of insulated wire in the soft iron drum or ring. It can revolve round an axle between the two poles of the field magnet. The drum or ring serves the two purposes: (a) It serves as a support to coils and (b) It increases the magnetic field due to air core being replaced by an iron core.

Slip Rings: The slip rings are the two metal rings to which the ends of armature coil are connected. These rings are fixed to the shaft which rotates the armature coil so that the rings also rotate along with the armature.

Brushes: These are two flexible metal plates or carbon rods) which are fixed and constantly touch the revolving rings. The output current in external load R_L is taken through these brushes.

Expression for induced emf

When the coil is rotated with a constant angular speed ω, the angle θ between the magnetic field vector B and the area vector A of the coil at any instant t is θ = ωt (assuming θ = 0º at t = 0). As a result, the effective area of the coil exposed to the magnetic field lines changes with time, the flux at any time t is $\Phi_B = BA \cos\theta = BA \cos\omega t$

From Faraday's law, the induced emf for the rotating coil of N turns is then,

$$E = -N\frac{d\phi_B}{dt} = -NBA\frac{d\,cos\omega t}{dt}$$

Thus, the instantaneous value of the emf is

$\varepsilon = NBA\,\omega \sin\omega t$

where NBAω is the maximum value of the emf, which occurs when sin ωt = ±1.

If we denote NBAω as ε_0,

then $\varepsilon = \varepsilon_0 \sin\omega t$

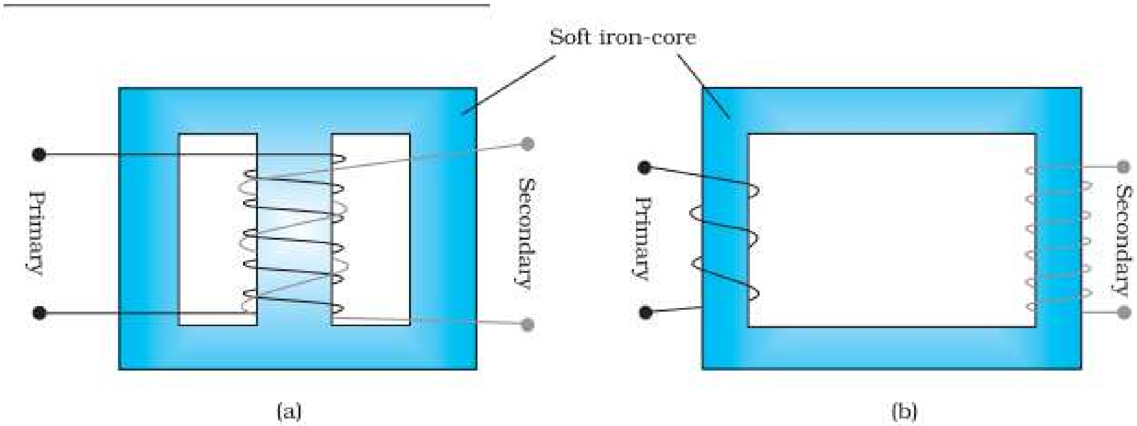
Obviously, the emf produced is alternating and hence the current is also alternating. Current produced by an ac generator cannot be measured by moving coil ammeter; because the average value of ac over full cycle is zero

17. Same as question no 2

18. Same as question no 2

The source of energy generation is the mechanical energy of rotation of armature coil.

19.



Principle : Based on Mutual inductance.

Construction : A transformer consists of two sets of coils, insulated from each other. They are wound on a soft-iron core, either one on top of the other or on separate limbs of the core. One of the coils called the primary coil has N p turns. The other coil is called the secondary coil; it has Ns turns. Often the primary coil is the input coil and the secondary coil is the output coil of the transformer

Working : When an alternating voltage is applied to the primary, the resulting current produces an alternating magnetic flux which links the secondary and induces an emf in it. The value of this emf depends on the number of turns in the secondary. We consider an ideal transformer in which the primary has negligible resistance and all the flux in the core links both primary and secondary windings.

Let φ be the flux in each turn in the core at time t due to current in the primary when a voltage v_p is applied to it.

Induced emf E_S or voltage in secondary coil of Ns turns will be

$$\varepsilon_{s} = -N_s \frac{d\phi}{dt}$$

The alternate flux φ induced back emf in the primary coil is

$$\varepsilon_{p} = -N_p \frac{d\phi}{dt}$$

But $\varepsilon_p = v_p$. If this were not so, the primary current would be infinite since the primary has zero resistance (as assumed). If the secondary is an open circuit or the current taken from it is small, then to a good approximation $\varepsilon_s = v_s$

$v_{s=-\ N_s}\ \frac{d\phi}{dt}$ and $v_{p=-\ N_p}\ \frac{d\phi}{dt}$

Thus

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

If the transformer is assumed to be 100% efficient (no energy losses), the power input is equal to the power output, and since p = i v,

$$V_{\ p}\, i_p\ = V_s i_s$$

Thus $\frac{i_p}{i_c}\ = \frac{V_s}{V_p}\ = \frac{N_s}{N_p}$

(b)Transformer Losses

Flux Leakage: There is always some flux leakage; that is, not all of the flux due to primary passes through the secondary due to poor design of the core or the air gaps in the core. It can be reduced by winding the primary and secondary coils one over the other.

Resistance of the windings: The wire used for the windings has some resistance and so, energy is lost due to heat produced in the wire (I^2R). In high current, low voltage windings, these are minimised by using thick wire.

Eddy currents: The alternating magnetic flux induces eddy currents in the iron core and causes heating. The effect is reduced by having a laminated core.

Hysteresis: The magnetisation of the core is repeatedly reversed by the alternating magnetic field. The resulting expenditure of energy in the core appears as heat and is kept to a minimum by using a magnetic material which has a low hysteresis loss.

(b) When output voltage increases, the output current automatically decreases to keep the power same. Thus, there is no violation of conservation of energy in a step up / step down transformer.

CASE STUDY TYPE (4 MARKS EACH)

20. Ans 1. Copper loss, Eddy current loss, Hysteresis loss, flux loss

Ans2. Eddy current losses are reduced by using a laminated core.

Ans3. Choosing a material having small Hysteresis loop area

Ans 4. Step down transformer.

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SECTION B

MULTIPLE CHOICE QUESTION

Q1. In LCR circuit, the capacitance is changed from C to 4C. For the same resonant frequency, the inductance should be changed from L to

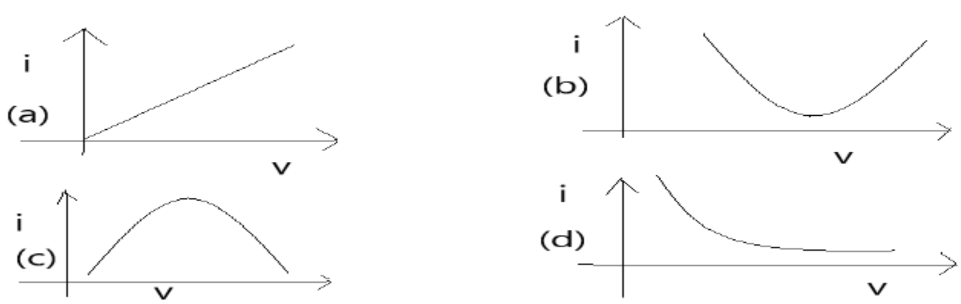
(a) 2L (b) L / 2 (c) L / 4 (d) 4 L

Q2. A bulb and a capacitor are connected in series to a source of alternating current. If its frequency is increased, while keeping the voltage of the source constant, then

(a) Bulb will give more intense light (b) Bulb will give less intense light

(c) Bulb will give light of same intensity as before (d) Bulb will stop radiating light

Q3. The i - ν curve for anti-resonant circuit is



Assertion-Reasoning Question:

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c) If assertion is true but reason is false.

(d) If the assertion and reason both are false

Q4. **Assertion**: When capacitive reactance is smaller than the inductive reactance in LCR current, e.m.f. leads the current.

Reason: The phase angle is the angle between the alternating e.m.f and alternating current of the circuit.

Q5. **Assertion**: A capacitor of suitable capacitance can be used in an ac circuit in place of the choke coil.

Reason: A capacitor blocks dc and allows ac only.

Q6. If rotational velocity of an a.c. generator armature is doubled, then induced e.m.f will become

(a) Half (b) Two times (c) Four times (d) Unchanged

Q7. In a step-up transformer, the turn ratio is 1: 2. A Leclanche cell (e.m.f. 1.5V) is connected across the primary. The voltage developed in the secondary would be

(a) 3.0 V (b) 0.75 V (c) 1.5 V (d) Zero

Q8. In a step-up transformer the turn ratio is 1:10. A resistance of 200 ohm connected across the secondary is drawing a current of 0.5 A. What is the primary voltage and current?

(a) 50 V, 1 amp (b) 10 V, 5 amp (c) 25 V, 4 amp (d) 20 V, 2 amp

Q9. **Assertion**: A given transformer can be used to step-up or step-down the voltage.

Reason: The output voltage depends upon the ratio of the number of turns of the two coils of the transformer.

SHORT ANSWER TYPE I (2MARKS EACH)

Q10.Define power factor. State the conditions under which it is (i) maximum and (ii) minimum.

Q11.In a series LCR circuit with an ac source of effective voltage 50 V, frequency $\nu = 50/\pi$ Hz, R = 300 Ω, C = 20 μF and L = 1.0 H. Find the rms current in the circuit.

Q12.An output voltage of an ideal transformer connected to 240 V ac mains is 24V. When the transformer used to light a bulb 24V, 24W Calculate the current in the primary of the circuit.

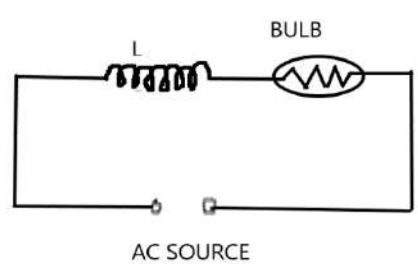
SHORT ANSWER TYPE II (3MARKS EACH)

Q13.A series LCR circuit is connected to an ac source (200 V, 50 Hz). The voltages across the resistor, capacitor and inductor are respectively 200 V, 250 V and 250 V.

(i)The algebraic sum of the voltages across the three elements is greater than the voltage of the source. How is this paradox resolved?

(ii)Given the value of the resistance of R is 40 W, calculate the current in the circuit.

Q14.An inductor L of reactance X_L is connected in series with a bulb B to an ac source as shown in figure. Explain briefly how does the brightness of the bulb change when (i) number of turns of the inductor is reduced (ii) an iron rod is inserted in the inductor and (iii) a capacitor of reactance $X_C = X_L$ is included in the circuit.



LONG ANSWER TYPE (5MARKS EACH)

Q15. (a) An ac source of voltage $V = V_0 \sin \omega t$ is connected to a series combination of L, C and R. Use the phasor diagram to obtain expressions for impedance of the circuit and phase angle between voltage and current. Find the condition when current will be in phase with the voltage. What is the circuit in this condition called?

(b) In a series L R circuit $X_L = R$ and power factor of the circuit is P_1. When capacitor with capacitance C such that $X_L = X_C$ is put in series, the power factor becomes P_2. Calculate $P_{1/} P_2$.

Q16. (a) An alternating voltage $V = V_m \sin \omega$ applied to a series LCR circuit drives a current given by $i = i_m \sin (\omega t + \varphi)$. Deduce an expression for the average power dissipated over a cycle.

(b) For circuits used for transporting electric power, a low power factor implies large power loss in transmission. Explain.

Q17. Draw a schematic diagram of a step-up transformer. Explain its working principle. Deduce the expression for the secondary to primary voltage in terms of the number of turns in the two coils. In an ideal transformer, how is this ratio related to the currents in the two coils? How is the transformer used in large scale transmission and distribution of electrical energy over long distances?

CASE STUDY TYPE (4 MARKS EACH)

Q18. An airport metal is essentially a resonant circuit. The portal you step through is an inductor (a large loop of conducting wire) that is part of the circuit. The frequency of the circuit is tuned to the resonant frequency of the circuit when there is no metal in the inductor. Any metal on your body increases the effective inductance of the loop and changes the current in it. When you pass through a metal detector, you become part of a resonant circuit. As you step through the detector, the inductance of the circuit changes, and thus the current in the circuit changes.

1. What is resonance?
2. On what factors does resonance frequency depends?
3. For the metal detector to detect a small metal object the sharpness of the current versus frequency graph be more or less? Justify your answer.
4. What is impedance of the circuit at resonance?

****

ANSWERS-SECTION B

Question Types Includes 1) MCQ 2) VSA 3) SA-I 4) SA-II 5) LA 6) Assertion and reason 7) Case study.

MULTIPLE CHOICE QUESTION

1. Ans. (c) L / 4

2. Ans. (a) Bulb will give more intense light

3. Ans. (b)

4. Ans. (b) If both assertion and reason are true but reason is not the correct explanation of the assertion.

5. Ans. (b) If both assertion and reason are true but reason is not the correct explanation of the assertion.

6. Ans. (b) Two times

7. Ans. (d) Zero

8. Ans. (b) 10 V, 5 amp

9. Ans. (a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

SHORT ANSWER TYPE I (2MARKS EACH)

10. The power factor (cos φ) is the ratio of resistance and impedance of an ac circuit i.e., Power factor, cos φ= R/ Z   Maximum power factor is 1 when Z = R i.e., when circuit is purely resistive. Minimum power factor is 0 when R = 0 i.e., when circuit is purely inductive or capacitive

11. Irms = Vrms/ Z

Here $Z=\sqrt{R^2+(Xc-XL)^2}$ $X_L = \omega L = 100\Omega$ and $Xc = 1/\omega C = 500\Omega$

Z= 500Ω Irms = 0.1A

12. $I_2=P_2/E_2 = 1A$

SHORT ANSWER TYPE II (3MARKS EACH)

13. Ans.(i) $V_{eff} = V_R + V_L + V_C = 200\text{ V} + 250\text{ V} + 250\text{ V} = 700\text{V}$ which is greater than 200V . This is due to V_R, V_L and V_C are vectors and cannot add like a numbers

Thus Veff = $\sqrt{{V_R}^2+(V_L-V_C)^2}$ Veff = $\sqrt{(200)^2+(250-250)^2}$

Veff= 200V.

14. (i) When the number of turns in the inductor is reduced, the self-inductance of the coil decreases; so impedance of circuit reduces and so current in the circuit increases. Thus, the brightness of the bulb increases. (ii) When iron (being a ferromagnetic substance) rod is inserted in the coil, its inductance increases and in turn, impedance of the circuit increases. As a result, a larger fraction of the applied ac voltage appears across the inductor, leaving less voltage across the bulb. Hence, brightness of the bulb decreases. (iii) When capacitor of reactance $X_C = X_L$ is introduced, the net reactance of circuit becomes zero, so impedance of circuit decreases; it becomes Z = R; so current in circuit increases; hence brightness of bulb increases. Thus brightness of bulb in both cases increases

LONG ANSWER TYPE (5MARKS EACH)

15. (a) Refer Answer Section A1

(b) Case1. When X_L = R then Z= $\sqrt{2}$R thus power factor P1 = $\frac{R}{Z}$ becomes P1 = 1/$\sqrt{2}$

Case 2. When $X_L = X_C$ then power factor $P_2 = 1$

Thus $P_1/ P_2 = 1/\sqrt{2}$

16. In LCR series circuit

V= Vm sinωt and i = i_m sin (ωt+φ)

Thus instantaneous power P= Vi = (VmSinωt) (i_m Sin (ωt+φ))

= ($V_m i_m$ Sinωt)[Sinωt cosφ + cos ωt sinφ] = $V_m i_m$ [Sin^2ωt cosφ+ $\cos^2$ ωt sinφ]

Thus Average power over a complete cycle

Pav = $\frac{1}{T}\int_0^T Pdt = \frac{1}{T}\int_0^T$ Vmim [Sin2ωt cosφ + cos2 ωt sinφ]dt

Solving

$\int_0^T sin^2\omega t cos\phi dt$ = T/2 cosφ and $\int_0^T cos^2\omega t sin\phi dt$=0

Thus Pav = $V_m i_m$ cosφ /2 = $V_{rms} I_{rms}$ cosφ

(b) Pav = $V_{rms} I_{rms}$ cosφ

For small power factor cosφ, I_{rms} increases for constant V_{rms} and power loss is = $I^2_{rms}R$ increases.

17. Derivation is same as answer of Section A5.

The large scale transmission and distribution of electrical energy over long distances is done with the use of transformers. The voltage output of the generator is stepped-up (so that current is reduced and consequently, the I^2R loss is cut down). It is then transmitted over long distances to an area sub-station near the consumers. There the voltage is stepped down. It is further stepped down at distributing sub-stations and utility poles before a power supply of 240 V reaches our homes.

CASE STUDY TYPE (4 MARKS EACH)

18. Ans1. In LCR series circuit when inductive reactance become equal to capacitive reactance then the current in a circuit become maximum called resonance.

Ans2. Resonance frequency depends on value of inductor L and capacitor C

Ans3. Graph should be sharper for unique resonance frequency.

Ans4. At resonance impedance is minimum i.e. Z= R

****

SECTION C

MULTIPLE CHOICE QUESTION

Q1. An inductance of 1 mH a condenser of 10 μF and a resistance of 50 Ω are connected in series. The reactance of inductor and condensers are same. The reactance of either of them will be

(a) 100 Ω (b) 30 Ω (c) 3.2 Ω (d) 10 Ω

Q2. An ac circuit consists of an inductor of inductance 0.5 H and a capacitor of capacitance 8 μF in series. The current in the circuit is maximum when the angular frequency of ac source is

a) 500 rad/sec (b) 2×10^5 rad/sec (c) 4000 rad/sec (d) 5000 rad/sec

Q3. An inductive circuit contains a resistance of 10 ohm and an inductance of 2.0 henry. If an ac voltage of 120 volt and frequency of 60 Hz is applied to this circuit, the current in the circuit would be nearly

(a) 0.32 amp (b) 0.16 amp (c) 0.48 amp (d) 0.80 amp

Q4. The power factor of an ac circuit having resistance (R) and inductance (L) connected in series and an angular velocity ω is

(a) $R/\omega L$ (b) $R/(R^2+\omega^2 L^2)^{\frac{1}{2}}$ (c) $\omega L / R$ (d) $R/(R^2 - \omega^2 L^2)^{\frac{1}{2}}$

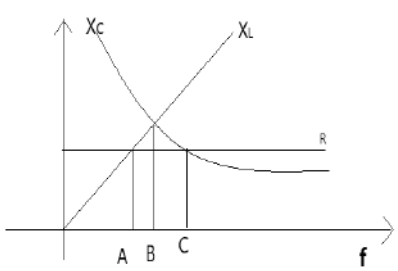
Q5. A telephone wire of length 200 km has a capacitance of 0.014 μF per km. If it carries an ac of frequency 5 kHz, what should be the value of an inductor required to be connected in series so that the impedance of the circuit is minimum

(a) 0.35 mH (b) 35 mH (c) 3.5 mH (d) Zero

Q6. An LCR series circuit with a resistance of 100 ohm is connected to an ac source of 200 V (r.m.s.) and angular frequency 300 rad/s. When only the capacitor is removed, the current lags behind the voltage by 60 ^{o}. When only the inductor is removed the current leads the voltage by 60 ^{o}. The average power dissipated is

(a) 50 W (b) 100 W (c) 200 W (d)400W

Q7. The figure shows variation of R, X_L and X_C with frequency f in a series L, C, R circuit. Then for what frequency point, the circuit is inductive

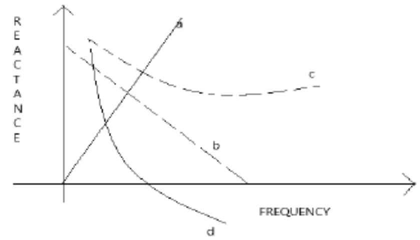


(a) A (b) B (c) C

(d) All points

Q8. Which of the following plots may represent the reactance of a series LC combination

(a) a (b) b (c) c (d) d



Q9. A loss free transformer has 500 turns on its primary winding and 2500 in secondary. The meters of the secondary indicate 200 volts at 8 amperes under these conditions. The voltage and current in the primary is

(a) 100 V, 16 A (b) 40 V, 40 A (c) 160 V, 10 A (d) 80 V, 20 A

Q10. A power transformer is used to step up an alternating e.m.f. of 220 V to 11 kV to transmit 4.4 kW of power. If the primary coil has 1000 turns, what is the current rating of the secondary? Assume 100% efficiency for the transformer

(a) 4 A (b) 0.4 A (c) 0.04 A (d) 0.2 A

SHORT ANSWER TYPE I (2MARKS EACH)

Q11.An alternating voltage $E = E_0 \sin \omega t$ is applied to a circuit containing a resistor R connected in series with a unknown box. The current in the circuit is found to be $I = I_o \sin (\omega t + \pi/4)$.

(i) State whether the element in the unknown box is a capacitor or inductor.

(ii) Draw the corresponding phasor diagram and find the impedance in terms of R.

Q12.A 60 W load is connected to the secondary of a transformer whose primary draws line voltage. If a current of 0.54 A flows in the load, what is the current in the primary coil? Comment on the type of transformer being used.

Q13. A radio wave of wavelength 300m can be transmitted by a transmission centre. A condenser of capacity 2.4 μF is available. Calculate the inductance of required coil for resonance.

Q14.How much current is drawn by the primary of a transformer which step down 220V to 22V to operate a device with an impedance of 220Ω?

SHORT ANSWER TYPE II (3MARKS EACH)

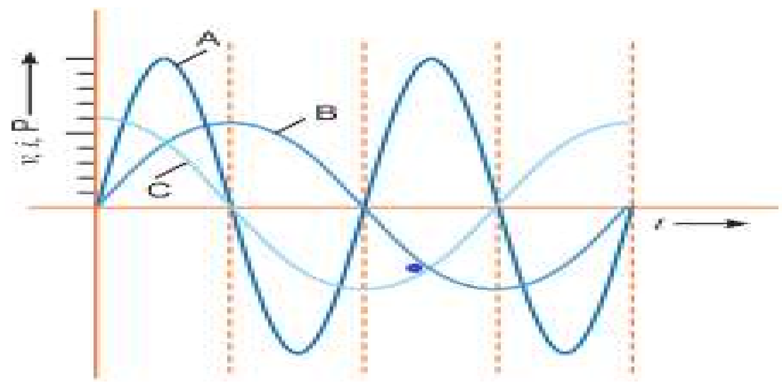
Q15.A capacitor (C) and resistor (R) are connected in series with an ac source of voltage of frequency 50 Hz. The potential difference across C and R is 120 V, 90 V respectively, and the current in the circuit is 3 A. Calculate (i) the impedance of the circuit (ii) the value of the inductance, which when connected in series with C and R will make the power factor of the circuit unity.

Q16.A device 'X' is connected to an ac source. The variation of voltage, current and power in one complete cycle is shown in the figure.

(a) Which curve shows power consumption over a full cycle?

(b) What is the average power consumption over a cycle?

(c) Identify the device 'X'.



Long Questions (Each carry 5 marks)

Q17. A voltage $V = V_0 \sin \omega t$ is applied to a series LCR circuit. Derive the expression for the average power dissipated over a cycle. Under what condition is (i) no power dissipated even though the current flows through the circuit, (ii) maximum power dissipated in the circuit?

Q18. (a) Draw the diagram of a device which is used to decrease high ac voltage into a low ac voltage and state its working principle. Write four sources of energy loss in this device.

(b) A small town with a demand of 1200 kW of electric power at 220 V is situated 20 km away from an electric plant generating power at 440 V. The resistance of the two wire line carrying power is 0.5 Ω per km. The town gets the power from the line through a 4000-220 V step-down transformer at a sub-station in the town. Estimate the line power loss in the form of heat.

Q19. A 2 μF capacitor, 100 Ω resistor and 8 H inductor are connected in series with an ac source.

(i) What should be the frequency of the source such that current drawn in the circuit is maximum? What is this frequency called?

(ii) If the peak value of emf of the source is 200 V, find the maximum current.

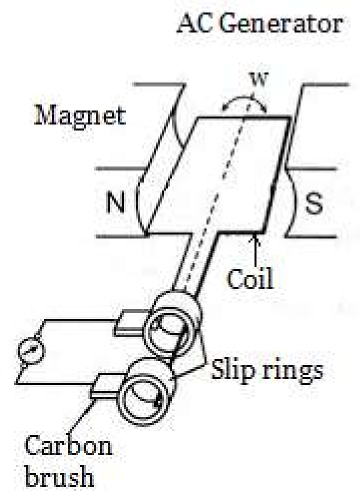
(iii)Draw a graph showing variation of amplitude of circuit current with changing frequency of applied voltage in a series LRC circuit for two different values of resistance R_1 and R_2 ($R_1 > R_2$).

Q20. (i) Draw a labelled diagram of a step-up transformer. Obtain the ratio of secondary to primary voltage in terms of number of turns and currents in the two coils.

(ii) A power transmission line feeds input power at 2200 V to a step-down transformer with its primary windings having 3000 turns. Find the number of turns in the secondary to get the power output at 220 V.

CASE STUDY TYPE QUESTIONS (4 MARKS EACH)

Q21. Electric generators are used to produce electrical energy. To understand how they work, let us consider the alternating current (ac) generator, a device that converts mechanical energy to electrical energy. In its simplest form, it consists of a loop of wire rotated by some external means in a magnetic field In commercial power plants, the energy required to rotate the loop can be derived from a variety of sources. For example, in a hydroelectric plant, falling water directed against the blades of a turbine produces the rotary motion; in a coal-fired plant, the energy released by burning coal is used to convert water to steam, and this steam is directed against the turbine blades. As a loop rotates in a magnetic field, the magnetic flux through the area enclosed by the loop changes with time; this induces an emf and a current in the loop according to Faraday's law. The ends of the loop are connected to slip rings that rotate with the loop. Connections from these slip rings, which act as output terminals of the generator, to the external circuit are made by stationary brushes in contact with the slip rings.



1. Name the principle on which ac generator based.

2. What is the condition for maximum induced emf in a Coil?

3. An ac generator consists of 8 turns of wire, each of area A = 0.090 0 m^2, and the total resistance of the wire is 12.0 Ω. The loop rotates in a 0.500-T magnetic field at a constant frequency of 60.0 Hz. Find the maximum induced emf.

4. In above case what is the maximum induced current when the output terminals are connected to a low-resistance conductor?

****

ANSWER-KEY

Question Types Includes 1) MCQ 2) VSA 3) SA-I 4) SA-II 5) LA 6) Assertion and reason 7) Case study.

SECTION C

MULTIPLE CHOICE QUESTION

1. (d) 10 Ω

2. (a) 500 rad/sec

3. (b) 0.16 amp

4. (b) $R/ (R^2 + \omega^2 L^2)^{\frac{1}{2}}$

5. (a) 0.35 mH

6. (d) 400 W

7. (c) C

8. (d) d

9. (b) 40 V, 40 A

10. (b) 0.4 A

SHORT ANSWER TYPE I (2MARKS EACH)

11(i) As the current leads the voltage by π/4, the element used in black box is a capacitor.

ii) $\tan(\pi/4) = V_C/V_R$ $1 = V_C/V_R$ gives $X_C = R$

Impedance $Z = \sqrt{R^2 + Xc^2}$ Gives $Z = \sqrt{2}\,R$

12. Here $P_L = 60$ W, $I_L = 0.54$ A . $V_L = 60/0.54 = 111.1$ V

The transformer is step-down and have ½ input voltage.
Hence $I_P = 1/2$ $I_L = 0.27$ A

13. Frequency $\nu = C/\lambda = 10^6$ Hz.

$\upsilon^2 = 1/ 4\pi^2 LC$ Gives $L = 1.055 \times 10^8$ H

14. $I_2 = E_2/ Z_2 = 0.1A$

$I_1 = E_2\, I_2/E_1 = 0.01A.$
$I_1 = E_2 I_2/E_1 = 0.1A$

SHORT ANSWER TYPE II (3MARKS EACH)

15. (i)$R = V_R/I = 30\Omega$ $X_c = V_c/I = 40\Omega$ $Z = \sqrt{R^2 + Xc^2} = 50\Omega$

(ii) $X_L = X_c$ $\omega L = 40$ $L = 40/2\pi f = 2/5\pi$ H.

16.Ans. (a) A

(b) Zero

(c) L or C or LC Series combination of L and C

Long Questions (Each carry 5 marks)

17. Derivation same as Question B2

(i)Condition for No power loss is $P_{av} = V_{rms} I_{rms} \cos\varphi$

$\cos\varphi = 0$ i.e. $\varphi = 90^0$ No resistor used in circuit.

(ii)For Maximum power loss $X_C = X_L$ i.e. at resonance. $\cos\varphi = 1$ and power lost is maximum.

18.(b) Demand of electric power = 1200 kW

Distance of town from power station = 20 km

Two wire = 20 × 2 = 40 km

Total resistance of line = 40 × 0.5 = 20 Ω

The town gets a power of 4000 volts Power = voltage × current

$$I = \frac{1200\text{x}10^4}{4000} = 1200/4 = 300 \text{ A}$$

The line power loss in the form of heat = $I^2 \times R$

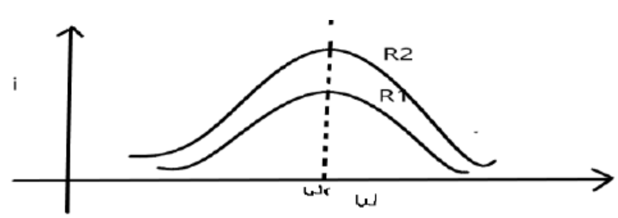
= (300)2 × 20 = 9000 × 20 = 1800 kW

19.

$\omega L = \frac{1}{\omega C}$ $\omega^2 = \frac{1}{LC}$ $2\pi v^2 = \frac{1}{LC}$ $v = 39.80\, Hz$ the frequency is called resonance frequency.

ii.Maximum current at resonance $I_m^{max} = \frac{V_m}{R} = \frac{200}{100} = 2A$

iii.



R_1 is greater than R_2

20. Ans $N_s = \frac{V_s}{V_p} N_p = 300\ turns$

CASE STUDY TYPE QUESTIONS (4 MARKS EACH)

21. Answer1. Electromagnetic induction

Answer2. Plane of coil become parallel to magnetic field so $\theta = 90,\ \ sin\theta = 1$

Answer3.$\varepsilon_{max}\ = NBA\ \omega = 136V$

Answer4. $I_{max} =\ \frac{\varepsilon_{max}}{R}$ = 11.3

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QUESTION BANK

CHAPTER 8-ELECTROMAGNETIC WAVES

SECTION A

1 MARK QUESTIONS

Q1. What is displacement current?

Q2. What are electromagnetic waves?

Q3. State the Maxwell's law of induction.

Q4. Which of the following is false for electromagnetic waves:

(a) transverse (b) non-mechanical waves

(c) longitudinal (d) produced by accelerating charges

Q5. If the magnetic monopole exists, then which of the Maxwell's equation to be modified?

(a) $\oint \mathbf{E}.\boldsymbol{dS} = q/\epsilon_o$ (b) $\oint \boldsymbol{B}.\boldsymbol{dS} = 0$

(c) $\oint \boldsymbol{E}.\mathbf{dl} = -\,d\phi_B/dt$ (d) $\oint \boldsymbol{E}.\boldsymbol{d}\mathbf{l} = \mu_o(I_c+I_d)$

Q6. Which of the following is NOT true for electromagnetic waves?

(a) They transport energy

(b) They have momentum

(c) They travel at different speeds in air depending on their frequency

(d)They travel at different speeds in medium depending on their frequency

Q7. Why can light travel in vacuum, whereas sound cannot do so?

Q8. Is displacement current, like conduction current, a source of magnetic field?

Q9. Expand the acronym LASER and RADAR.

Q10. Which of the following statement is **NOT true** about the properties of electromagnetic waves?

(a) These waves do not require any material medium for their propagation

(b) Both electric and magnetic field vectors attain the maxima and minima at the same time

(c) The energy in electromagnetic wave is divided equally between electric and magnetic fields

(d) Both electric and magnetic field vectors are parallel to each other.

Q11. Do Electromagnetic waves carry energy and momentum? **(CBSE2017)**

Q12. Identify the EM waves whose wavelength vary as

(a)10^{-12}m<1<10^{-8}m

(b)10^{-3}m<1<10^{-1}m

Write one use for each. **(CBSE2017)**

Q13. Name the Electromagnetic radiations used for

(i)Water purification (ii) Eye surgery **(CBSE 2018)**

Q14**.**How is displacement current produced between plates of parallel plates during charging? (**CBSE 2020)**

ASSERTION REASON TYPE QUESTIONS

Directions: In each of the following questions, a statement of Assertion (A) is given followed by a corresponding statement of Reason (R) just below it. Of the statements, mark the correct answer as:

(A) If both assertion and reason are true and reason is the correct explanation of assertion.

(B) If both assertion and reason are true but reason is not the correct explanation of assertion.

(C) If the assertion is true and the reason is false.

(D) If both assertion and reason are false.

Q15.**Assertion**: Electromagnetic waves are transverse in nature.

Reason: The electric and magnetic fields are perpendicular to each other and perpendicular to the direction of propagation.

Q16. **Assertion**: The electromagnetic wave is transverse in nature.

Reason: Electromagnetic waves propagate parallel to the direction of electric and magnetic fields.

Q17**.Assertion**: The velocity of electromagnetic waves depends on electric and magnetic properties of the medium.

Reason: Velocity of electromagnetic waves in free space is constant.

CASE STUDY BASED QUESTIONS

Q18. LASER

Electromagnetic radiation is a natural phenomenon found in almost all areas of daily life, from radio waves to sunlight to x-rays. Laser radiation – like all light – is also a form of electromagnetic radiation. Electromagnetic radiation that has a wavelength between 380 nm and 780 nm is visible to the human eye and is commonly referred to as light. At wavelengths longer than 780 nm, optical radiation is termed infrared (IR) and is invisible to the eye. At wavelengths shorter than 380 nm, optical radiation is termed ultraviolet (UV) and is also invisible to the eye. The term "laser light" refers to a much broader range of the electromagnetic spectrum than just the visible spectrum, anything between 150 nm up to 11000 nm (i.e. from the UV up to the far IR). The term laser is an acronym which stands for "light amplification by stimulated emission of radiation".

Einstein explained the stimulated emission. In an atom, an electron may move to a higher energy level by absorbing a photon. When the electron comes back to the lower energy level it releases the same photon. This is called spontaneous emission. This may also so happen that the excited electron absorbs another photon, releases two photons and returns to the lower energy state. This is known as stimulated emission.

Laser emission is therefore a light emission whose energy is used, in lithotripsy, for targeting and ablating the stone inside the human body organ.

Apart from medical usage, lasers are used for optical disk drives, printers, barcode readers etc.

(I) What is the full form of LASER?

(a) Light amplified by stimulated emission of radiation

(b) Light amplification by stimulated emission of radiation

(c) Light amplification by simultaneous emission of radiation

(d) Light amplified by synchronous emission of radiation

(II) The "stimulated emission" is the process of:

(a) release of a photon when an electron comes back from higher to lower energy level.

(b) release of two photons by absorbing one photon when the electron comes back from higher to lower energy level.

(c) absorption of a photon when an electron moves from lower to higher energy level.

(d) None of the above

(III) What is the range of amplitude of LASER?

(a) 150 nm – 400 nm (b) 700 nm – 11000 nm (c) Both the above (d) None of the above

(IV) Lithotripsy is:

(a) an industrial application. (b) a medical application.

(c) laboratory application. (d) process control application.

(V) LASER is used in:

(a) optical disk drive. (b) transmitting satellite signal.

(c) radio communication. (d) ionization.

2 MARKS QUESTIONS

Q19. Suggest reasons, why

(a) food in metal containers cannot be cooked in a microwave oven.

(b) an empty glass container does not get hot in a microwave oven.

Q20. Electromagnetic waves with wavelength

(i) λ_1 is suitable for radar systems used in aircraft navigation.

(ii) λ_2 is used to kill germs in water purifiers.

(iii) λ_3 is used to improve visibility in runways during fog and mist conditions.

Identify and name the part of the electromagnetic spectrum to which these radiations belong. Also arrange these wavelengths in ascending order of their magnitude.

3 MARKS QUESTIONS

Q21. Give two uses of 1) IR radiation 2) Microwaves 3) UV radiation

Q22. Write down the properties of electromagnetic waves.

Q23. Write short notes on 1) Microwave 2) X-ray 3) Radio waves

****

SECTION A-ANSWER KEY

1 MARK QUESTIONS

1.The current which comes into play in the region in which the electric field (or electric flux) is changing with time is called displacement current.

$$I_d = \epsilon_0 \, d\phi_E / dt$$

2.The accelerated charge produces the electromagnetic waves. They have the transverse nature. The electromagnetic waves are a non-mechanical wave which moves with speed equals to the speed of light.

3. Whenever changing the electric flux (Φ_E) in the region encircled by loop, then magnetic field is induced.

4(c)

5. (b)

6 (c)

7.Light waves are electromagnetic in nature. They do not require a material medium for propagation. So, the light can travel in vacuum. On the other hand, sound waves require a material medium for propagation. They are mechanical waves and cannot travel in vacuum.

8. Yes, displacement current is also a source of magnetic field like the conduction current .

9. LASER-Light amplification by stimulated emission of radiation
   RADAR-Radio detection and ranging.

10. (iv) Both electric and magnetic field vectors are parallel to each other.

11. Yes, EM waves carry both energy and momentum.

12. (a)X rays - used in in detection of fractures in bones.
    (b)Gamma rays- used in radio therapy for treatment of cancer.

13. UV rays

14. Refer Ncert

ASSERTION REASON BASED QUESTIONS

15. (a)

16. (c)

17.(b)

CASE STUDY BASED QUESTIONS

18. (I)B (II)B (III) C (IV) B (V) A

2 MARKS QUESTIONS

19.In a microwave oven, the frequency of microwaves is selected to match the resonance frequency of water molecules, so that the energy from the waves is transferred efficiently to the kinetic energy of the molecules. This raises the temperature of any food containing water. (a) The atoms of the metallic container are set into forced vibrations by the microwaves. Due to this, energy of the microwaves is not efficiently transferred to the metallic container. Owing to this, food in metallic containers cannot be cooked in a microwave oven.

(b) The molecules of the glass container do not respond to the frequency of microwaves. Due to this, energy from the microwaves is not transferred to the glass container and hence it does not get hot in a microwave oven.

20. $\lambda 1$ -Microwave

$\lambda 2$ - ultraviolet

$\lambda 3$- infrared

Ascending order - $\lambda 2<\lambda 3<\lambda 1$

3 MARKS QUESTIONS

21. IR radiation • It is used in infrared photography •TV remote as a signal carrier •Heat therapy for muscular pain or sprain.

Microwaves • It is used in Radio and Television communication system • It is used in cellular phones (Voice communication)

UV radiation • It is used to destroy bacteria in sterilizing the surgical instruments. • It is used in Burglar alarm • It is used to detect the invisible writing, finger prints.

22.Refer notes of study material/Ncert

23.(i) Microwaves are suitable for RADAR systems that are used in aircraft navigation. These rays are produced by special vacuum tubes, namely klystrons and magnetrons diodes. (ii) Infrared rays are used to treat muscular strain. These rays are produced by hot bodies and molecules.

(iii) X-rays are used as a diagnostic tool in medicine. These rays are produced, when high energy electrons are stopped suddenly on a metal of high atomic number.

SECTION B

1 MARK QUESTIONS

Q1.If the amplitude of the magnetic field is 3×10^{-6} $tesla$, then the amplitude of the electric field for a electromagnetic waves is

(a) 100 V/m (b) 300 V/m (c) 600 V/m (d) 900 V/m

Q2.In an electromagnetic wave travelling in free space the rms value of the electric field is 3 V/m. The peak value of the magnetic field is,

(a) 1.414 x10^{-8}T (b) 1.0×10^{-8}T (c) 2.828×10^{-8}T (d) 2.0×10^{-8}T

Q3.The direction of propagation of electromagnetic waves is along

(a) $\boldsymbol{E}$ (b) $\boldsymbol{B}$ (c) $\boldsymbol{E}.\boldsymbol{B}$ $(d)$$\mathbf{E} \times \boldsymbol{B}$

Q4.In an electromagnetic wave:

(a) power is transmitted along the magnetic field

(b) power is transmitted along the electric field

(c) power is equally transferred along the electric and magnetic field

(d) power is transmitted in a direction perpendicular to both the fields.

Q5.Why are infrared waves called heat waves. Explain. What do you understand by the statement "Electromagnetic waves transport momentum"? **(CBSE 2018)**

ASSERTION REASON TYPE QUESTIONS

Q6.**Assertion**: Infrared radiation plays an important role in maintaining the average temperature of earth.

Reason: Infrared radiations are sometimes referred to as heat waves

Q7. **Assertion**: When a charged particle moves in a circular path, it produces electromagnetic waves.

Reason: Charged particle has acceleration.

Q8. **Assertion**: Sound waves cannot travel in vacuum but light can travel in vacuum

Reason : Sound waves are longitudinal waves and they cannot be polarised but electromagnetic waves are transverse and they can be polarised.

CASE STUDY BASED QUESTIONS

Q9. The electromagnetic spectrum consists of visible light, x- rays, gamma rays, microwaves, ultraviolet rays, radio waves and infrared waves. The waves used in radio and television communication are the radio waves having frequency range 500 kHz to 1000MHz. In the ultrahigh frequency bands cellular phones use the radio waves to transmit the voice. Microwaves are the waves having short wavelengths. In aircraft navigation, for the radar system microwaves are used due to their short wavelength. Infrared waves are also called heat waves. Infrared radiation has the most importance in maintaining earth's surface temperature through the greenhouse effect. The infrared waves have vast applications in real life such as infrared detectors that are used for military purposes and also to see the growth of crops. The waves which are visible to the human eye are the visible rays. Visible rays are having frequency range as $4\text{x}10^{14}$Hz to $7\text{x}10^{14}$ Hz. The huge source of ultraviolet light is the sun. Ultraviolet rays have wavelength range from $4\text{x}10^{-7}$m to $6\text{x}10^{-10}$m. X-rays are the rays having most importance in medical applications which have a wavelength range 10nm to10^{-4} nm. X-rays are used to destroy the living tissue and organisms in the medical field. Then gamma rays are the rays having wavelength range as 10^{-10}m to 10^{-14}m which are the high frequency radiations mostly produced in nuclear reactions. Gamma rays are also used to destroy cancer cells in the medical field.

(I) The TV waves range from _____ which are the radio waves.

(a) 54Hz to 890Hz (b) 54 MHz to 890 MHz

(c) 500 kHz to 1000 MHz (d) 1000 Hz to 1000 KHz

(II) The domestic application of microwaves used is____

(a) electric induction (b) water heater (c) TV (d) microwave oven

(III) The part of the electromagnetic spectrum which is detected by human eye is having wavelength range as

a) 900 – 400 nm b) 200 – 400 mm c) 700 – 400 mm d) 700 – 400 nm

(IV) Why are infrared waves also called heat waves?

(V) How does the ozone layer in the atmosphere play a protective role?

2 MARKS QUESTIONS

Q10.Why are infrared radiations also referred as heat waves? Write the name of radiations which lie next to infrared radiations in the electromagnetic spectrum. **(CBSE2020)**

Q11.A plane electromagnetic wave travels in vacuum along z-direction. What can you say about the directions of its electric and magnetic field vectors? If the frequency of the wave is 30 MHz, what is its wavelength?

Q12. (a)Identify the part of EM spectrum used in (i)RADAR (ii)Eye surgery. Write the frequency range. **(CBSE 2019)**

(b)Prove that the average energy density of oscillating Electric field is equal to that of oscillating magnetic field?

3 MARKS QUESTIONS

Q13.Answer the following questions.

(i) Show, by giving a simple example, how EM waves carry energy and momentum.

(ii) How are microwaves produced? Why is it necessary in microwaves ovens to select the frequency of microwaves to match the resonant frequency of water molecules?

(iii) Write two important uses of infrared waves.

Q14.Name the parts of the electromagnetic spectrum which is

(i) suitable for RADAR systems in aircraft navigations.

(ii) used to treat muscular strain.

(iii) used as a diagnostic tool in medicine. Write in brief, how these waves can be produced?

Q15.(i) Arrange the following electromagnetic waves in the descending order of their wavelengths.

(a) Microwaves (b) Infrared rays (c) Ultraviolet radiation (d) g-rays

(ii) Write one use each of any two of them

Q16.Explain the Maxwell's modification of Ampere's circuital law.

Q17.Discuss the source and propagation of electromagnetic waves.

****

ANSWERS (SECTION B)

1 MARK QUESTIONS

1. (d) 2. (a) 3. (d) 4. (d)

5.Infrared waves are known as heat waves because they produce heat.

When Electromagnetic waves hit body the mass is lost by the momentum is conserved that is transferred from Electromagnetic waves to the body.

ASSERTION REASON BASED QUESTIONS

6.B 7.B 8.B

CASE STUDY BASED QUESTIONS

9.(I)(b) 54MHz to 890 MHz

(II)(d) microwave oven

(III)(d) 700 – 400 nm

(IV)refer study material/Ncert

(V)The very harmful ultraviolet rays coming from the sun are absorbed by the ozone layer in the atmosphere which is at an altitude of 40 – 50 km from the earth's surface. And due to which very less ultraviolet light rays from the sun reach the earth. Ultraviolet rays are very harmful to humans which may cause skin cancer. In this way, the ozone layer in the atmosphere plays a very protective role.

2 MARKS QUESTIONS

10.Infrared red waves are the waves which are having frequency lower than the frequency of visible light range. This infrared wave causes the electrons, whole atoms or molecules also of that material. Due to such increased vibrations the internal energy of the material gets increased and thereby increases in the temperature of the material and heat is generated. Because of this reason infrared waves are also called the heat waves.

Visible rays come next to infrared radiation in electromagnetic spectrum having shorter wavelength.

The radiations next to infrared radiations, having longer wavelengths will be microwaves

11. As we know that, the direction of electromagnetic wave is perpendicular to both electric and magnetic fields. Here, electromagnetic wave is travelling in z-direction, then electric and magnetic fields are in xy-direction and are perpendicular to each other. Frequency of waves, n = 30 MHz = 30 X 10^6 Hz Speed, c = 3X10^8 m/s Using the formula, c = n.λ Wavelength of electromagnetic

waves, $\lambda = c/n = (3x10^8)/(30\ x10^6) = 10$ m Thus, the wavelength of electromagnetic waves is 10 m.

12.(a)(i)Microwaves range-1GHz-2GHz (ii)UV rays-range 10^{15}-10^{17} Hz

(b) $U_E = \mathbf{1/2}\in_o \boldsymbol{E}^2$ $U_B = B^2/2$;**c=** $1/\sqrt{\mu_o \in_o}$

E=BC ; Thus ,$U_E = \mathbf{1/2}\in_o (BC)^2 = B^2/2\ \mu_o$

3 MARKS QUESTIONS

13.(i) Consider a plane perpendicular to the direction of propagation of the wave. An electric charge, on the plane will be set in motion by the electric and magnetic fields of EM wave, incident on this plane. This is only possible, if EM wave constitutes momentum and energy. Thus, this illustrates that EM waves carry energy and momentum.

(ii) Microwaves are produced by special vacuum tube like the klystron, magnetron and Gunn diode. The frequency of microwaves is selected to match the resonant frequency of water molecules, so that energy is transformed efficiently to increase the kinetic energy of the molecules. Thus, facilitating the food to cook properly.

(iii) Uses of infrared rays (a) In knowing the molecular structure and therapy to heal muscular pain. (b) In remote control of TV, VCR, etc.

14. **Microwave** It is produced by special vacuum tubes such as klystron, magnetron and gun diode. The frequency range of microwaves is 10^9 Hz to 10^{11}Hz. These waves undergoes reflection can be polarized. It is used in radar system for aircraft navigation, speed of the vehicle, microwave over for cooking and very long distance wireless communication through satellite.

֍ **X-Ray** It is produced when there is sudden stopping of high-speed electrons at high atomic number target, and also by electronic transitions among the innermost orbits of atoms. The frequency range of X-rays is from 10^{17} Hz to 10^{19} Hz. X-rays have more penetrating power than ultraviolet radiation. X-rays are used extensively in studying structures of inner atomic electron shells and crystal structures. It is used in detecting fractures, diseased organs, formation of bones and stones, observing the progress of healing bones. Further, in a finished metal product, it is used to detect faults, cracks, flaws and holes.

֍ **Radio Waves** They are produced by accelerated motion of charges in conducting wires. The frequency range is from a few Hz to 109 Hz. They show reflection and diffraction

15.(i) The decreasing order of wavelengths of electromagnetic waves is Microwaves > Infrared > Ultraviolet radiation > γ -rays (ii) Microwaves -They are used in RADAR devices. γ -rays- It is used in radio therapy.

16.Refer study material

17.Refer study material

****

SECTION C

1 MARK QUESTIONS

Q1.The relative magnetic permeability of the medium is 2.5 and the relative electrical permittivity of the medium is 2.25. Compute the refractive index of the medium.

(a) 2.37 (b) 4.75 (c) 0.25 (d) 1.05

Q2. Compute the speed of the electromagnetic wave in a medium if the amplitude of electric and magnetic fields are 3×10^4 and 2×10^{-4}tesla, respectively

(a)3 $\times 10^8$m/s (b) 1.5 $\times$ 10^8m/s (c) 6 $\times$ 10^8 m/s (d) 5 $\times 10^8$ m/s

Q3.The charging current for a capacitor is 0.25 A. What is the displacement current across its plates?

Q4.If the Earth did not have an atmosphere, would its average surface temperature be higher or lower than what it is now?

ASSERTION REASON TYPE QUESTIONS

Q5.**Assertion**: The frequencies of incident, reflected and refracted beams of monochromatic light incident from one medium to another are the same.

Reason: The incident, reflected and refracted rays are coplanar.

Q6.**Assertion**: The earth without its atmosphere will be inhospitably cold.

Reason: All heat would escape in the absence of atmosphere.

Q7.**Assertion**: Microwaves are better carriers of signal than optical waves.

Reason: Microwaves move faster than optical waves.

Q8.**Assertion**: Gamma rays are more energetic than x rays.

Reason: Gamma rays are of nuclear origin but x rays are produced due to sudden deceleration of high energy electrons while falling in the metal of high atomic number.

CASE STUDY BASED QUESTION

Q9.According to Maxwell's electromagnetic equations it has been proved that electric and magnetic field vectors are perpendicular to each other and also perpendicular to the direction of propagation as shown in the figure below. If Ex is the electric field along X axis, then By will be the direction of magnetic field along y axis and both which are perpendicular to the z axis showing direction of propagation. The light waves are also electromagnetic waves and may travel through vacuum also. So, we can find the velocity of a light traveling through the material medium having permittivity € and magnetic permeability u as $V = 1/\sqrt{\varepsilon\mu}$

In this way, we proved that velocity of light also depends on the electrical and magnetic properties of that medium through which it is traveling. The velocity of light which is constant everywhere is having value as $3X10^8$m/s. The most technological importance of electromagnetic waves is that they have a strong capacity to take energy from one place to another place. The best examples are radio waves, TV signals which also carry energy from their broadcasting stations. Also, life is possible on the earth only because of the sunlight coming from the sun to the earth which also carries energy and it is nothing but the electromagnetic waves. Due to which electromagnetic waves are considered as the transverse waves.

(i)The ratio of relative permittivity of the medium to the permittivity of vacuum is called as**______**.

(a)permeability (b) permittivity of free space

(c) dielectric constant of the medium (d) electric intensity

(II) Who showed that electromagnetic waves can be polarised?

(a) Maxwell (b) Hertz (c) Ampere (d) Michelson and Morley

(III) The pressure exerted by the electromagnetic waves is called as

(a) light pressure (b) electric pressure (c) magnetic pressure (d) radiation pressure

(IV) What is the relationship between magnitude of magnetic field and electric field in case of electromagnetic waves from Maxwell's equations?

(V) What is meant by the permittivity and permeability of the medium?

2 MARKS QUESTIONS

Q10.The electric field of an electromagnetic wave is given by $E= 50 \sin\boldsymbol{\omega}(t- \boldsymbol{x} /\boldsymbol{c})$ N/C. Find the energy contained in a cylinder of cross-section $10cm^2$ and length 50 cm along the X-axis.

Q11.A variable-frequency a.c. source is connected to a capacitor. Will the displacement current increase or decrease with increase in frequency?

3 MARKS QUESTIONS

Q12.The magnetic field in a plane electromagnetic wave is given by $B_y = 2 \times 10^{-7} \sin [0.5 \times 10^3 x + 1.5 \times 10^{11} t]$ (in T)

(a) What is the wavelength and frequency of the wave?

(b) Write an expression for the electric field.

Q13. Answer the following questions-

(i) Name the EM waves which are used for the treatment of certain forms of cancer. Write their frequency range.

(ii) Thin ozone layer on top of stratosphere is crucial for human survival. Why?

(iii) Why is the amount of the momentum transferred by the EM waves incident on the surface so small?

****

ANSWERS (SECTION C)

1 MARK QUESTIONS

1(a)

2(b)

3.Displacement current is always equal to conduction current and hence equals to 0.25 A

4.The infrared radiation emitted by earth are retained by the earth's atmosphere due to the green house effect and this keeps the earth warm. If the Earth did not have atmosphere, its average temperature would have been low.

ASSERTION REASON TYPE QUESTIONS

5. B 6. A 7. D 8.B

CASE STUDY BASED QUESTIONS

9. (I) (c) dielectric constant of the medium

(I) (b) Hertz

(II) (d) radiation pressure

(III) From Maxwell's equations, the relationship between magnitude of magnetic field and electric field is given as Bo = (Eo/c)

(IV) Permittivity of the medium is nothing but the ability of that medium to store electric potential energy in that medium.

While permeability of the medium is also the ability of the medium to allow the number of magnetic field lines through it.

2 MARKS QUESTIONS

10.The average value of energy density (energy / volume) is given by

Uav = $\mathbf{1/2}\in\boldsymbol{oEo}^{\mathbf{2}}$ /Total volume of the cylinder V = A l ;

Total energy contained in the cylinder, U = (Uav) /V= (1/2 $\in\boldsymbol{oEo}$)/Al

= $\mathbf{1/2}[(\mathbf{8.86}\ \boldsymbol{X}\ \mathbf{10^{-12}})(\mathbf{50})^{\mathbf{2}}]/[(10 \text{ X } 10^{-4})(50 \text{ X } 10^{-2})] = 5.5 \text{ X } 10^{-12}$ J

11. If we increase the frequency, the reactance of the capacitor will decrease and consequently conduction current will increase. Since displacement current is equal to conduction current, the displacement current will increase with increase in frequency of a.c. source.

3 MARKS QUESTIONS

12. Here, By =2 x 10^{-7} sin [0.5 x 10^{3} x+1.5 x 10^{11}t]

(a) The Y-component of the magnetic field is given by By = B_O sin2 π ($/\boldsymbol{\lambda}$ + $\boldsymbol{t}/\boldsymbol{T}$)

Comparing the given equation with the above equation:

$2\pi/\lambda$ = 1/ (0.5 x 10^3 λ) =1.257 x 10^{-2} m

Also $2\pi/T$ = 1.5 x 10^{11} Or ν = 2.387 x 10^{10} Hz

(b) Since the argument of sine in the expression for the magnetic field is of the type (kx + ωt), the direction of propagation of the e. m. wave is along negative X-axis and the magnetic field is along negative Y-axis.

Hence, the electric field is along negative Z-axis and expression for it is given by

$E_y = E_O \sin 2\boldsymbol{\pi} (x/\boldsymbol{\lambda} + \boldsymbol{t}/\boldsymbol{T})$

Here, $E_O = B_O c$ = 2 x 10^{-7} x 3 x 10^8 = 60 V/m;

Ez = 60sin [0.5 x 10^3 x+1.5 x 10^{11} t] (in V/m)

13. i) γ-rays are used for the treatment of certain forms of cancer. Its frequency range is 3x10^{19} Hz to 5 x10^{22} Hz.

(ii) The thin ozone layer on top of stratosphere absorbs most of the harmful ultraviolet rays coming from the sun towards the earth. They include UVA, UVB and UVC radiations, which can destroy the life system on the earth. Hence, this layer is crucial for human survival.

(iii) An electromagnetic wave transports linear momentum as it travels through space. If an electromagnetic wave transfers a total energy U to a totally absorbing surface in time t, then total linear momentum delivered to the at surface. This means, the momentum range of EM waves is 10^{-19} to 10^{-41}. Thus, the amount of momentum transferred by the EM waves incident on the surface is very small.

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QUESTION BANK
RAY OPTICS

SECTION A
1-Mark Questions

Q1. Which of the following does not change during the refraction of light?
frequency, velocity or wavelength of light

Q2. State Snell's law of refraction?

Q3. Define refractive index of the material?

Q4. Which mirror is used as driver's mirror?

Q5. Define principal focus of a mirror?

Q6. Show the variation of u and v in the case of a concave mirror?

Q7. Write the relation between the object distance (u), image distance (v) and focal length (f) of a concave mirror?

Q8. If the wavelength (colour) of incident light on a concave mirror is changed, how will the focal length of the mirror change?

Q9. State the laws of reflection of light?

Q10. Light travelling in a medium with the velocity 3×10^8m/s is refracted into a second medium in which it travels with a velocity 2×10^8m/s. What is a refractive index of the second medium?

Q11. Light a wavelength 5000 $°A$ in air enters a medium of refractive index 1.4 what will be its frequency in the medium?

Q12. What is the ratio of velocity of two light waves travelling in vacuum and having wavelength $4000°A$ and $8000°A$?

Q13. Can absolute refractive index of any material be less than one. Why?

Q14. State the principle of an optical fibre?

Q15. What do you mean by critical angle?

Q16. Write the relation between critical angle and refractive index?

Q17. What is the main use of optical fibres?

Q18. Calculate the speed of light in a medium whose critical angle is 30 °?

Q19. State the thin lens formula?

Q20. Define power of a lens and write its SI unit?

MULTIPLE CHOICE QUESTIONS

Q21. Which of the following is not due to total internal reflection?

a) Brilliance of diamond
b) Working of optical fibre
c) Difference between apparent and real depth of a pond
d) Mirage on hot summer days

Q22. An object is placed at the focus of the convex mirror. If its focal length is 20cm, the distance of image from the mirror is

a) 10cm
b) 20cm
c) 40cm
d) None of the above

Q23. An object is placed at the focus of a concave mirror. If the focal length of the mirror is 20cm, then the distance of image from the pole is

a) 10cm
b) 20cm
c) 40cm
d) Infinity

Q24. The relation between angle of incidence i , angle of prism A and angle of minimum deviation d_m for a triangular prism is

a) A+d_m = i
b) A+d_m = 2i
c) $A + \frac{d_m}{2}$ =i
d) 2A+d_m = i

Q25. The critical angle for total internal reflection from a medium to vacuum is 30°. The velocity of light in the medium is

a) 3×10^8m/s
b) 1.5×10^8m/s
c) 6×10^8m/s
d) $\sqrt{3} \times 10^8$m/s

Q26. A beam of light passes from air to glass. How does the speed of light vary

a) decreases
b) increases
c) remains unchanged
d) it may decrease or increase, depending on the colour

Q27. A convex length of focal length is put in contact with a concave lens of same focal length. The equivalent focal length of the combination is

a) zero
b) f
c) 2f
d) Infinity

Q28. Half of the lens is wrapped in black paper. How will it change the image

a) Size of image is halved

b) Intensity of image is halved
c) There is no change in the size of image or intensity
d) Both size and intensity of the image are changed.

Q29. Which of the following produces virtual as well as real image.
a) Concave lens and Convex mirror
b) Convex Mirror and Convex lens
c) Convex lens and Concave mirror
d) Concave mirror and Concave lens

Q30. What is the nature of the graph between $\frac{1}{u}$ and $\frac{1}{v}$ for a convex lens where u is the distance of the object and v is that of the image?
a) Straight line b) Parabola c) Ellipse d) Hyperbola

Q31. A ray of light passes through a plane glass slab of thickness t and refractive index $\mu = 1.5$, The angle between the incident ray and the emergent ray will be
a) 0º b) 30º c) 45º d) 60º

Q32. A convex lens of power 4D and a concave lens of power 3D are placed in contact. What is the equivalent power of the combination?
a) 7D b) $\frac{4}{3}$D c) 1D d) $\frac{3}{4}$D

Q33. A lens behaves as a diverging lens in air (n=1) and a converging lens in water (n=1.3). The refractive index μ of the material of the lens is
a) $1 < n < 1.3$
b) $n > 1.3$
c) $n < 1.0$
b) $n = \frac{1+1.3}{2}$

Q34. For using a convex lens as a magnifying glass, where should we place the object?
a) At the principal focus
b) Nearer to the lens
c) At $\frac{f}{2}$, where f = focal length
d) Anywhere

Q35. A lens of power 3.5D is placed is contact with a lens of power -2.5D. The combination will behave like
a) A convergent lens of focal length 100cm
b) A divergent lens of focal length 100cm
c) A convergent lens of focal length 200cm
d) A divergent lens of focal length 200cm

ASSERTION AND REASON

Directions: These questions consist of two statements, each printed as Assertion and Reason. While answering these questions, you are required to choose any one of the following four responses.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

Q36. Assertion: Plane mirror may form real image

Reason: Plane mirror forms virtual image, if object is real.

Q37. Assertion: The focal length of the convex mirror will increase, if the mirror is placed in water.

Reason: The focal length of a convex mirror of radius R is equal to f = R/2.

Q38. Assertion: The image formed by a concave mirror is certainly real if the object is virtual.

Reason: The image formed by a concave mirror is certainly virtual if the object is real.

Q39.**Assertion:** If the rays are diverging after emerging from a lens; the lens must be concave.

Reason: The convex lens can give diverging rays.

Q40. **Assertion:** The optical instruments are used to increase the size of the image of the object.

Reason: The optical instruments are used to increase the visual angle.

Q41. **Assertion:** The resolving power of a telescope is more if the diameter of the objective lens is more.

Reason: Objective lens of large diameter collects more light.

Q42. **Assertion:** The focal length of an equiconvex lens of radius of curvature R made of material of refractive index n = 1.5, is R.

Reason: The focal length of the lens will be R/2.

Q43. **Assertion (A):** The maximum intensity in interference pattern is four times the intensity due to each slit.

Reason (R): Intensity is directly proportional to square of amplitude.

Q44. **Assertion (A):** Diffraction is common in sound but not common in light waves.

Reason (R): Wavelength of light is more than the wavelength of sound.

Q45. **Assertion (A):** Interference obeys the law of conservation of energy.

Reason (R): The energy is redistributed in case of interference.

2 MARKS QUESTIONS

Q46. A concave mirror is placed in water. Will there be any change in its focal length? Give reason?

Q47. An object under water appears to be at a lesser depth than in reality, why?

Q48. The refractive index of the material of a concave lens is n. It is immersed in a medium of refractive index n_1. A parallel beam of light is incident on the lens. Trace the path of emergent rays in each of the following cases:

i) $n_1 > n$ ii) $n_1 < n$ iii) $n_1 = n$

Q49. An air bubble is formed inside water. Does it act as a converging lens or a diverging lens? Explain.

Q50. An equi-convex lens of radius of curvature R is cut into two equal parts by a vertical plane, so it becomes a Plano convex lens. If f is the focal length of the equi-convex lens, then what will be focal length of Plano convex lens?

Q51. An object is kept in front of a concave mirror as shown in figure. Complete the ray diagram showing the image formation of the object.

How will the position and intensity of the image be affected if the lower half of the mirrors reflecting surface is painted black?

Q52. A spherical convex surface of radius of curvature 20cm made of glass of refractive index 1.5 is placed in air. Find the position of the image formed if a point object is placed 30cm in front of a convex surface on the principal axis?

Q53. The radii of curvature of the faces of a double convex lens are 10cm and 15cm. If the focal length of the lens is 12cm, find the refractive index of the material of the lens?

Q54. An object is kept in front of a concave mirror of focal length 15cm. Calculate the refractive index of the material of the lens?

Q55. State the condition under which a large magnification can be achieved in an astronomical telescope?

THREE MARKS QUESTIONS

Q56. State the condition for total internal reflection of light to take place at an interface separating two transparent media. Hence derive the expression for the critical angle in terms of the speeds of light in two media. (CBSE D 2000)

Q57. (i) What is total internal reflection? Under what conditions does it occur?

(ii) Find a relation between critical angle and refractive index.

(iii) Name one phenomenon which is based on total internal reflection.

Q58. (i) Name the phenomenon on which the working of an optical fiber is based.

(ii) What are the necessary conditions for this phenomenon to occur?

(iii) Draw a labelled diagram of an optical fiber and show how light propagates through the optical fiber using this phenomenon.

Q59.What are optical fibers? Mention their one practical application.

Q60.Write the basic assumptions in the derivation of lens maker's formula. Hence derive this expression. (CBSE OD 20)

Q61. Using the ray diagram for a system of two lenses of focal lengths f1 and f2 in contact with each other, show that two lens system can be regarded as equivalent to a single lens of focal length f, where $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$. Also write the relation for the equivalent power of the lens combination.

(CBSE 17, 19, 20)

Q62. Draw a graph to show the variation of the angle of deviation δ with that of the angle of incidence i for a monochromatic ray of light passing through a glass prism of refracting angle A. Hence deduce the relation:

$$n = \frac{sin\left(\frac{\delta_m + A}{2}\right)}{sin\left(\frac{A}{2}\right)}$$ (CBSE D 17C)

Q63. A concave lens made of material of refractive index 'n_2'is held in a reference medium of refractive index 'n_1'. Trace the path of parallel beam of light passing through the lens when:

(i) $n_1 = n_2$ (ii) $n_1 < n_2$ (iii) $n_1 > n_2$ (CBSE OD 2000, 03C)

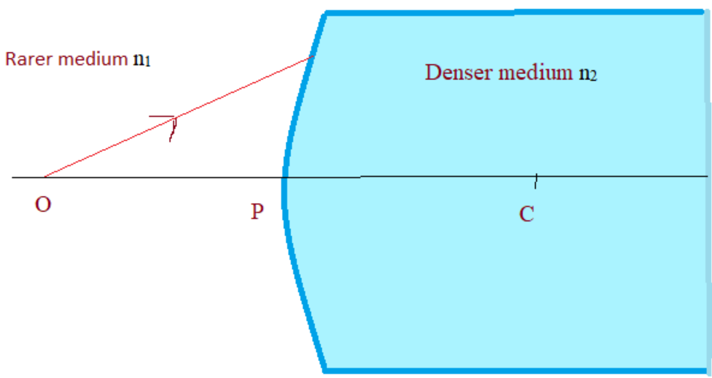
5 MARKS QUESTIONS

Q64. (a) Draw a ray diagram to show image formation when the concave mirror produces a real, inverted and magnified image of the object.

(b) Obtain the mirror formula and write the expression for the linear magnification.

(c) Explain two advantages of a reflecting telescope over a refracting telescope. (CBSE 18)

Q65. (a)A spherical surface of radius of curvature, separates a rarer and a denser medium as shown in figure. Complete the path of the incident ray of light, showing the formation of a real image. Hence derive the relation connecting object distance 'u', image distance 'v', radius of curvature R and the refractive indices n_1 and n_2 of the two media.



(b)Briefly explain, how the focal length of a convex lens changes, with increase in wavelength of incident light. (CBSEOD 04; D 16C)

Q66.Derive expression for the Lens Maker's formula $\frac{1}{f} = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$ where the symbols have usual meanings. State the assumptions used and the convention of signs.

Q67. Trace the path of a monochromatic ray of light through a prism of refracting angle 'A'. Draw a graph to show the variation of angle of deviation 'δ' with the variation of angle of incidence 'i'.Deduce the relation $n = \frac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin\left(A/2\right)}$ (CBSE F 08; D 16)

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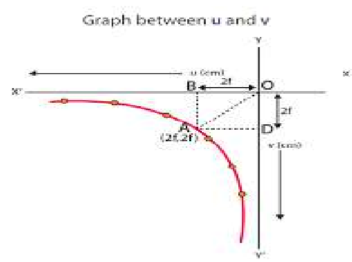
SECTION A –ANSWER KEY

1. Frequency
2. The ratio of sine of the angle of incidence to sine of the angle of refraction is a constant ,called the refractive index of second medium with respect to first medium
3. Refractive index n=$\frac{speed\ of\ light\ in\ vaccum}{speed\ of\ light\ in\ medium} = \frac{c}{v}$
4. Convex mirror
5. Rays parallel and close to the principal axis (paraxial rays) after reflection at a concave mirror actually converge to a fixed point on the principal axis. This fixed point is called as the principal focus.
6. $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$



7. The relation connecting image distance (v), object distance (u) and focal length (f) of a mirror is $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$
8. For a mirror f= $\frac{R}{2}$, the focal length is independent of the wavelength or colour of incident light.
9. Angle of incidence= angle of reflection

   The incident ray, reflected ray and the normal at the point of incidence all lie on the same plane.
10. Refractive index of second medium w r to first medium (air)=$\frac{\text{speed of light in medium 1}}{\text{speed of light in medium 2}}$=$\frac{3\times 10^8}{2\times10^8}$ =1.5
11. Frequency $f = \frac{c}{\lambda}$ =$\frac{3\times 10^8}{5\times10^{-7}}$ =6×10^{14}Hz
12. In vacuum, velocity of every wavelength is same. Hence ratio is 1:1
13. $n = \frac{c}{v}$, since $v < c$,n cannot be less than one.
14. Total internal reflection
15. The angle of incidence in the denser medium for which the angle of refraction becomes 90°.

16. Critical angle C=$\sin^{-1}(\frac{1}{n})$,n is the absolute refractive index of denser medium

17. To transmit light signals from one place to another without any loss of intensity.

18. Critical angle C=$\sin^{-1}(\frac{1}{n})$ or $n = \frac{1}{\sin C}$ =$\frac{1}{\sin 30}$ =2

also $n = \frac{c}{v}$,$v = \frac{c}{n}$ =$\frac{3\times 10^8}{2}$ =1.5×10^8m/s

19. The relation connecting image distance (v), object distance (u) and focal length (f) of a lens is $\frac{1}{\mathrm{v}} - \frac{1}{\mathrm{u}} = \frac{1}{\mathrm{f}}$

20. It is the reciprocal of focal length of the lens in metres.$P = \frac{1}{f}$

S I unit is dioptre

ANSWERS TO MCQ

21. a) Difference between apparent and real depth of a pond

22.a) 10cm

23. d) Infinity

24.a)A+d_m = 2i

25.1.5×10^8m/s

26.a)Decreases

27.d)Infinity

28.b) Intensity of image is halved

29.c) Convex lens and Concave mirror

30.a) Straight line

31.a) 0°

32.c) 1D

33. 1< n<1.3

34. b) Nearer to the lens

35.a) convergent lens of focal length 100cm

ASSERTION AND REASON

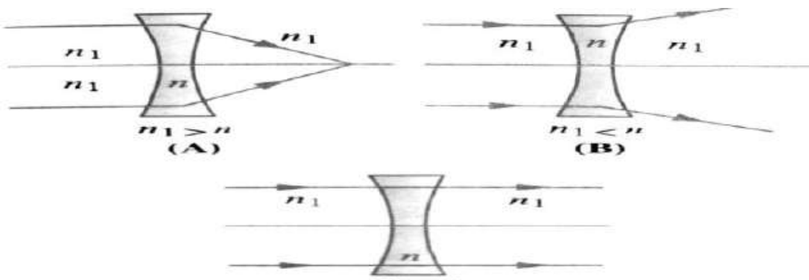
36. b 37. D 38. C 39. D 40. D 41. A 42. C 43. B 44. C 45. a

ANSWERS TO QUESTIONS OF 2 MARKS

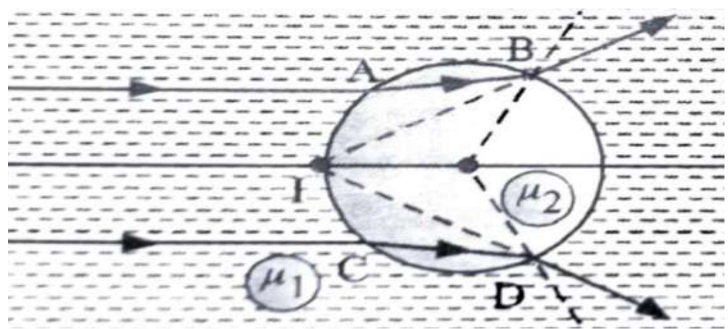
46. Focal length of a mirror f=$\frac{R}{2}$ where R is the radius of curvature of the mirror. Hence focal length doesn't depends on the medium in which it is immersed. So focal length remains the same.

47. This is due to refraction of light. Refractive index n = $\frac{\text{real depth}}{\text{apparent depth}}$. Since n>1, apparent depth is less than the real depth.

48.



49. A ray of light parallel to the principal axis, incident on the air bubble, bends away from the normal as it goes from denser to rarer medium. The refracted ray AB, suffers refraction at B and it bends toward the normal. The refracted rays at B and D when produced backwards, meets the principal axis at I, giving a virtual image. The air bubble diverges the rays of light, so it behaves like a diverging lens.



50.$\frac{1}{f}$=(n−1)$(\frac{1}{R_1}-\frac{1}{R_2})$

For equi-convex lens R_1 = +R and R_2=-R

$\frac{1}{f}$=$(n-1)(\frac{1}{R}+\frac{1}{R})$

=2 $\frac{(n-1)}{R}$

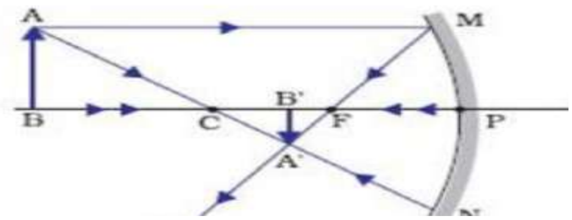
For plano convex lens R_1 = +R and R_2= ∞

$\frac{1}{f^1}$=$(n-1)(\frac{1}{R})$

=$(n-1)R = 2f$

Focal length become two times.

51. Image formed will be real, inverted and diminished between C and F



There will be no change in the position of the image, but its intensity will be reduced.

52.R=20cm,$n1$=1,$n2$=1.5 ,u= -30cm

$$\frac{n2}{v} - \frac{n_1}{u} = \frac{n_2 - n\mu_1}{R}$$

$$\frac{1.5}{v} - \frac{1}{-30} = \frac{1.5 - 1}{20}$$

$$\frac{1.5}{v} = \frac{-1}{120} v = -180cm$$

53.Given m=3 and f=-15cm m=$\frac{v}{u} v = 3u$

$$\frac{1}{\mathrm{v}} + \frac{1}{\mathrm{u}} = \frac{1}{\mathrm{f}}$$

u=-20cm

54. $R_1 = +10cm \quad R_2 = -15cm ,f = 12cm$

$\frac{1}{f}$ =$(n-1)(\frac{1}{R_1} - \frac{1}{R_2})$

$\frac{1}{12}$ =$(n-1)(\frac{1}{10} - \frac{1}{-15})$

$(n-1) = 0.5$

$n = 1 + 0.5 = 1.5$

55. Angular magnification M=$-\frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$ when the final image is formed at least distance of distinct vision

M $= -\frac{f_o}{f_e}$ in normal adjustment

ANSWERS OF THREE MARKS QUESTIONS

56. Conditions for total internal reflection:

(a) Light must travel from denser medium to rarer medium
(b) Angle of incidence in denser medium must be greater than critical angle

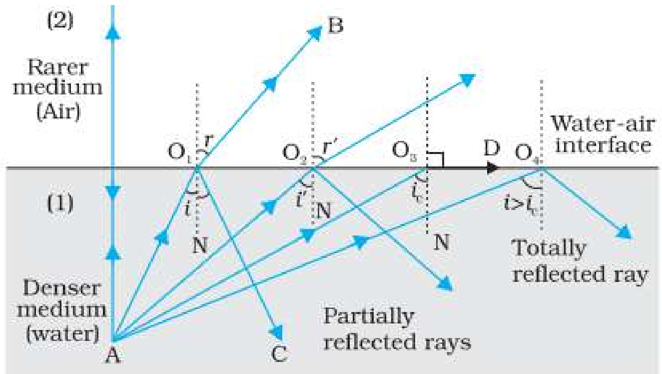


FIGURE Refraction and internal reflection of rays from a point A in the denser medium (water) incident at different angles at the interface with a rarer medium (air).

CREDIT : NCERT TEXTBOOK CLASS 12 PHYSICS PART-2 PG:320

$n_{21} = \frac{\sin i}{\sin r}$ (as per the figure above)

for total internal reflection to occur $i \geq i_c$;

at critical angle i_c; angle of refraction, $r = 90^0$

hence $n_{21} = \frac{\sin i_c}{\sin 90^0} = \sin i_c$

$$n_{21} = \frac{1}{n_{12}}$$

$$\frac{1}{n_{12}} = \sin i_c$$

$$n_{12} = \frac{1}{\sin i_c}$$

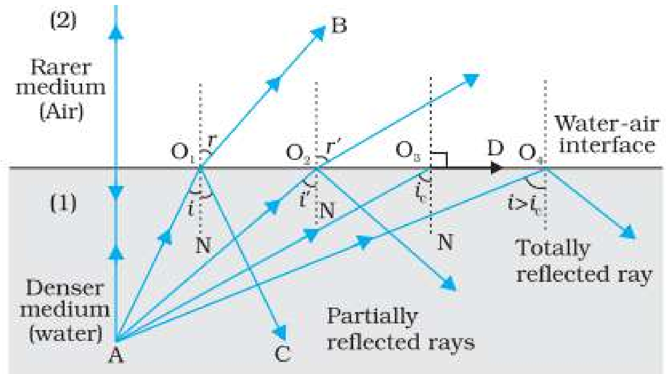
Thus, refractive index of denser medium with respect to the rarer medium is equal to $^1/_{\sin i_c}$

57. (i) When a ray of light travels from an optically denser medium into rarer medium at an angle greater than the critical angle, it reflects back into the denser medium. This phenomenon I called total internal reflection.

Conditions for total internal reflection:

(a) Light must travel from denser medium to rarer medium

(b) Angle of incidence in denser medium must be greater than critical angle



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$$n_{21} = \frac{1}{n_{12}}$$

$$\frac{1}{n_{12}} = \sin i_c$$

$$n_{12} = \frac{1}{\sin i_c}$$

Thus, refractive index of denser medium with respect to the rarer medium is equal to $^1/_{\sin i_c}$

(iii) (a) Mirage (b) Optical fibre (c) Sparkling of diamond (d) Shinning of air bubbles in water (e) Totally reflecting prism

58. (i) Working of an optical fibre is based on total internal reflection.

(ii) (a) Rays of light have to travel from optically denser medium to optically rarer medium

(b) Angle of incidence in the denser medium should be greater than critical angle

(iii)

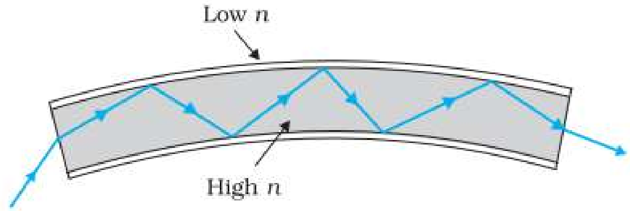

FIGURE Light undergoes successive total internal reflections as it moves through an optical fibre.

CREDIT: NCERT TEXTBOOK CLASS 12 PHYSICS PART-2 PG: 322

59. An optical fibre is a device based on total internal reflection by which a light signal may be transmitted from one place to another with a negligible loss of energy. It is a very long and thin pipe of quartz $(n = 1.7)$ of thickness nearly $\approx 10^{-4}$ m coated all around with a material of refractive index 1.5. A large number of such fibres held together from a light pipe and are used for communication of light signals. When a light ray is incident on one at a small angle of incidence, it suffers refraction from air to quartz and strikes the quartz-coating interface at an angle more than the critical angle and so suffers total internal reflection and strikes the opposite face again at an angle greater than critical angle and so again suffers total reflection. Thus, the ray within the fibre suffers multiple total internal reflections and finally strikes the other end at an angle less than critical angle for quartz-air interface and emerges in air.

As there is no loss of energy in total internal reflection, the light signal is transmitted by this device without any appreciable loss of energy.

Application: Optical fibre is used (i)to transmit light signal to distant places (ii) in endoscopy.

60. Refer question 3 of section A 5 marks questions.

61.

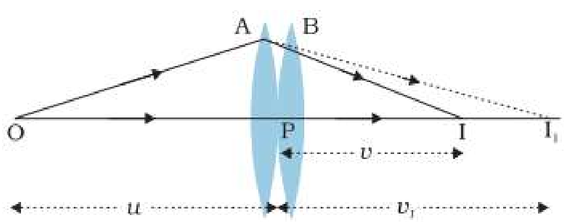

FIGURE Image formation by a combination of two thin lenses in contact.

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Consider two lenses A and B of focal length f_1 and f_2 placed in contact with each other. Let the object be placed at a point O beyond the focus of the first lens A. The first lens produces an image at I_1. Since image I_1 is real, it serves as a virtual object for the second lens B, producing the final image at I.

For the image formed by the first lens A, we get

$$\frac{1}{v_1} - \frac{1}{u} = \frac{1}{f_1} \dots \dots (1)$$

For the image formed by the second lens B, we get

$$\frac{1}{v} - \frac{1}{v_1} = \frac{1}{f_2} \dots \dots (2)$$

Adding Eqs. (1) and (2), we get

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f_1} + \frac{1}{f_2} \dots \dots (3)$$

If the two lens-system is regarded as equivalent to a single lens of focal length f we get

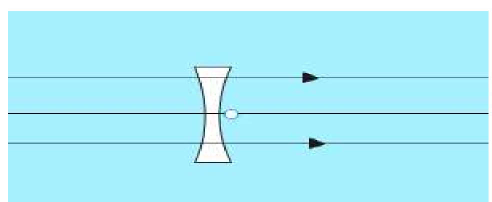
$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \dots \dots (4)$$

From (3) and (4)

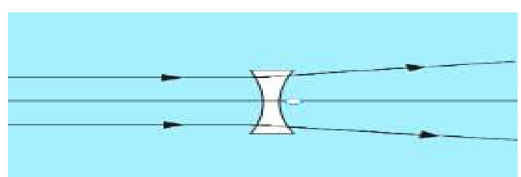
$$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{f}$$

62. Refer question 4 of section A 5 marks questions.

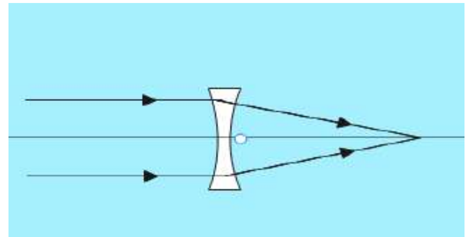
63. (i) $n_1 = n_2$



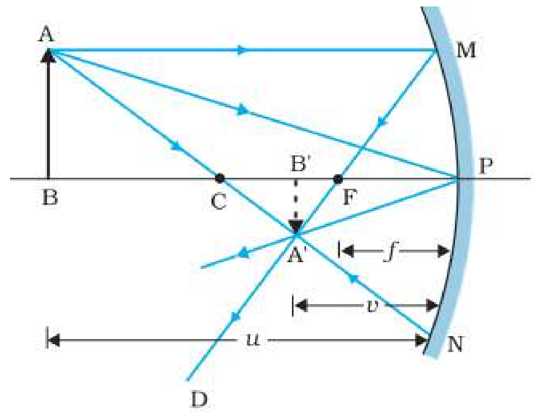
(ii) $n_1 < n_2$



(iii) $n_1 > n_2$



SOLUTION OF 5 MARKS QUESTIONS



Ray diagram for image formation by concave mirror

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64. (a) Ray diagram:

(b) The two right- angled triangles $A'B'F$ and MPF are similar.

$$\frac{B'A'}{PM} = \frac{B'F}{FP}$$

$$\frac{B'A'}{BA} = \frac{B'F}{FP} (\because PM = BA) \dots \dots \dots (1)$$

$$\angle APB = \angle A'PB'$$

The right triangles $A'B'P$ and ABP are also similar

$$\frac{B'A'}{BA} = \frac{B'P}{BP} \dots \dots (2)$$

Comparing eqs. (1) and (2)

$$\frac{B'F}{FP} = \frac{B'P}{BP}$$

$$\frac{B'P - FP}{FP} = \frac{B'P}{BP} \dots \dots . (3)$$

Taking the sign conventions, $B'P = -v, \quad FP = -f, \quad BP = -u$

Using these in equation (3)

$$\frac{-v+f}{-f} = \frac{-v}{-u}$$

$$\frac{v-f}{f} = \frac{v}{u} \quad \Rightarrow \quad \frac{v}{f} - 1 = \frac{v}{u} \quad \Rightarrow \quad \frac{1}{f} - \frac{1}{v} = \frac{1}{u} \dots \dots (dividing\ by\ v)$$

$$\therefore \frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

The above equation is mirror formula.

Linear magnification: $m = \frac{h'}{h}$

From eqn (2)

$$\frac{B'A'}{BA} = \frac{B'P}{BP} \qquad \therefore \frac{-h'}{h} = \frac{-v}{-u}$$

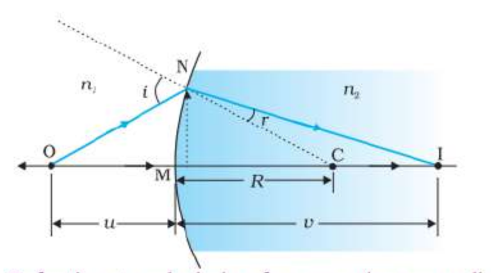
$$m = \frac{h'}{h} = -\frac{v}{u}$$

(c) The two advantages of reflecting telescope:

(i)There is no chromatic aberration in case of reflecting telescope as the objective is a mirror.

(ii) Spherical aberration is reduced in case of reflecting telescope by using mirror objective in the form of paraboloidal mirror.

65. The figure shows the geometry of image formation of image I of an object O on the principal axis of a spherical surface with centre of curvature C, and radius of curvature R.



Refraction at a spherical surface separating two media.
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Consider the aperture of surface to be small compared to other distances involved, so that the angle approximation can be made.

$$tan\angle NOM \approx \angle NOM = \frac{MN}{OM}$$

$$tan\angle NCM \approx \angle NCM = \frac{MN}{MC}$$

$$tan\angle NIM \approx \angle NIM = \frac{MN}{MI}$$

$For\ \Delta NOC, 'i'\ is\ the\ exterior\ angle.$

$$\therefore i = \angle NOM + \angle NCM$$

$$\therefore i = \frac{MN}{OM} + \frac{MN}{MC} \ldots\ldots (1)$$

$For\ \Delta NCI, \angle NCM\ is\ the\ exterior\ angle.$

$$\therefore r = \angle NCM - \angle NIM$$

$$\therefore r = \frac{MN}{MC} - \frac{MN}{MI} \ldots\ldots (2)$$

By Snell's law

$$n_1 \sin i = n_2 \sin r$$

$n_1 i = n_2 r \dots\dots \quad (for\ small\ angles)$

$$n_1\left(\frac{MN}{OM}+\frac{MN}{MC}\right) = n_2\left(\frac{MN}{MC}-\frac{MN}{MI}\right) \quad \dots\dots(from\ (1)\&(2))$$

$$\frac{n_1}{OM}+\frac{n_1}{MC}=\frac{n_2}{MC}-\frac{n_2}{MI}\dots\dots\dots(dividing\ by\ MN)$$

$$\frac{n_1}{OM}+\frac{n_2}{MI}=\frac{n_2-n_1}{MC}$$

Applying the sign convention, $OM = -u, \quad MI = +v, \quad MC = +R$

$$\frac{n_1}{-u}+\frac{n_2}{v}=\frac{n_2-n_1}{R}$$

$$\frac{n_2}{v}-\frac{n_1}{u}=\frac{n_2-n_1}{R}\dots\dots(3)$$

Equation (3) is the required equation.

(b) $n_{21}=\frac{\lambda_1}{\lambda_2}=\frac{n_2}{n_1}$

$for\ \lambda_2 > \lambda_1,\ n_2 < n_1$

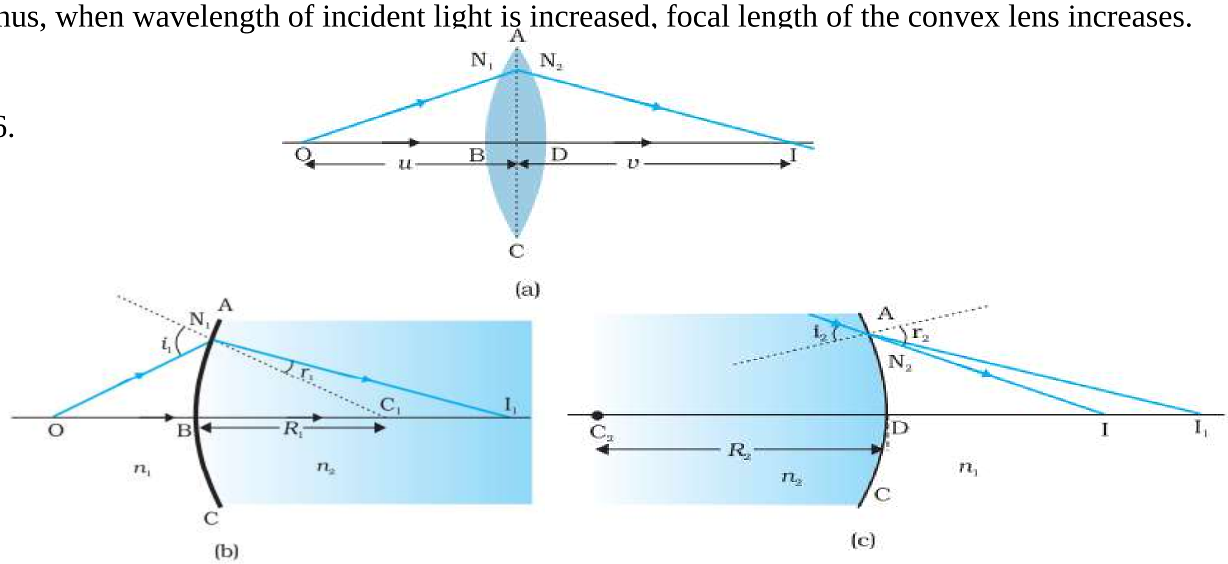
$According\ to\ Lens\ maker's\ equation \frac{1}{f}=(n-1)\left[\frac{1}{R_1}-\frac{1}{R_2}\right]$

$$\therefore f \propto \frac{1}{(n-1)}$$

$\therefore for\ \lambda_2 > \lambda_1,\ n_2 < n_1\ and\ f_2 > f_1$

Thus, when wavelength of incident light is increased, focal length of the convex lens increases.

66.



Fig(a) shows the geometry of image formation by a double convex lens. The image formation can be seen in terms of two steps:

(i) The first refracting surface forms the image I_1 of the object O (fig b)

(ii) The image I_1 acts as a virtual object for the second surface that forms the image at I (fig c)

Applying equation for refraction at a spherical surface to the first surface ABC,

$$\frac{n_1}{OB}+\frac{n_2}{BI_1}=\frac{n_2-n_1}{BC_1} \dots \dots (1)$$

Applying equation for refraction at a spherical surface to the second surface ADC,

$$\frac{n_2}{-DI_1}+\frac{n_1}{DI}=\frac{n_1-n_2}{-DC_2} \dots \dots (2)$$

For this case the refractive index of the medium on the right side of ADC is n_1 while on its left it is n_2. Further DI_1 is negative as the distance is measured against the direction of incident light.

Also for thin lens, $BI_1 = DI_1$

Equation (2) becomes

$$-\frac{n_2}{BI_1}+\frac{n_1}{DI}=\frac{n_2-n_1}{DC_2} \dots \dots (3)$$

Adding eqs (1) and (3)

$$\frac{n_1}{OB}+\frac{n_1}{DI}=(n_2-n_1)\left(\frac{1}{BC_1}+\frac{1}{DC_2}\right) \dots \dots (4)$$

Suppose the object is at infinity, $OB \to \infty \; and \; DI = f$

$$\frac{n_1}{f}=(n_2-n_1)\left(\frac{1}{BC_1}+\frac{1}{DC_2}\right) \dots \dots (5)$$

By the sign conventions, $BC_1 = +R_1 DC_2 = -R_2$

$$\frac{n_1}{f}=(n_2-n_1)\left(\frac{1}{R_1}+\frac{1}{-R_2}\right)$$

$$\frac{1}{f}=\left(\frac{n_2}{n_1}-\frac{n_1}{n_1}\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \dots \dots \dots (dividing\ by\ n_1)$$

$$\frac{1}{f}=\left(\frac{n_2}{n_1}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\frac{1}{f}=(n_{21}-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \dots \dots (6) \left(\because n_{21}=\frac{n_2}{n_1}\right)$$

Eqn (6) is Lens Maker's formula.

Assumptions made in the derivation of Lens Maker's formula

1. The lens used is thin so that the distances measured from its surfaces may be taken equal to those measured from its optical centre.
2. The object is a point object placed on the principal axis.
3. The aperture of the lens is small.
4. All the rays are paraxial.

New Cartesian sign convention for spherical lenses:

1. All distances are measured from the optical centre of the lens.
2. The distances measured in the direction of incident light are positive.
3. The distances measured in the opposite direction of incident light are negative.

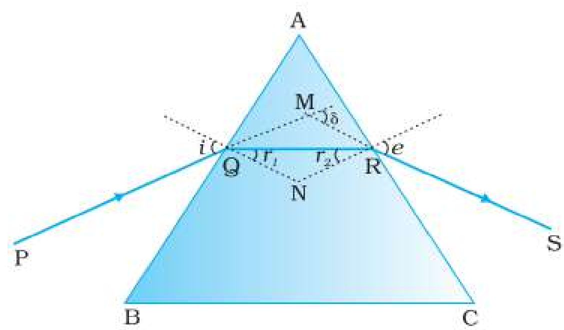


FIG: Light passing through the triangular prism
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67. Figure shows the passage of light through a triangular prism ABC. Ray PQ is incident on the face AB. The angle of incidence and angle of refraction are i and $r_1$respectively. The ray QR emerges from the face AC. The angle of incidence on this face is r_2 and angle of refraction or emergence is e.

The angle between the emergent ray RS and the direction of the incident ray is called the angle of deviation, δ

In □ AQNR, $\angle AQN + \angle ARN = 90^O + 90^O = 180^O$

$\angle A + \angle QNR = 180^O \ldots..(1)$

In ΔQNR, $r_1 + r_2 + \angle QNR = 180^O \ldots\ldots(2)$

Comparing (1) and (2) $r_1 + r_2 = A \ldots\ldots..(3)$

In ΔMQR, $\delta = \angle MQR + \angle MRQ \ldots..(\delta\ is\ exterior\ angle)$

$\delta = (i - r_1) + (e - r_2)$

$\delta = i + e - A \ldots\ldots\ldots(4)$

Plot of angle of deviation (δ) versus angle of incidence (i) for a triangular prism:

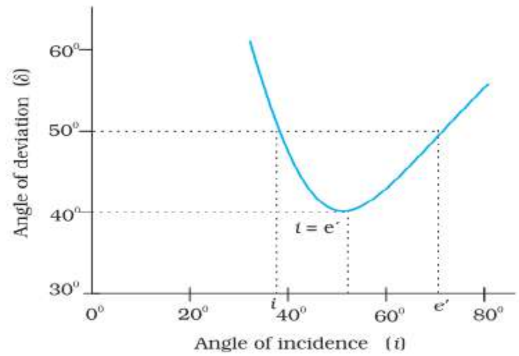
At $\delta = \delta_m i = e \therefore r_1 = r_2$

$\therefore eqn\ (3) becomes\ 2r = A \quad \therefore r = \dfrac{A}{2}$

$Eqn\ (4)\ becomes\ \delta_m = 2i - A \quad \therefore i = \dfrac{A + \delta_m}{2\delta}$

According to Snell's law

$$n_{21} = \frac{\sin i}{\sin r}$$



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Substituting i and r in the above equation $\quad n_{21} = \dfrac{\sin\left(\frac{A+\delta m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

****

SECTION B

1 MARK QUESTIONS

Q1. What happens to the focal length of a lens when it is immersed in water?

Q2. What happens to the power of a lens immersed in water?

Q3. How can a convex lens behave like a diverging lens?

Q4. An object is placed at the focus of a concave lens, where will be the image formed?

Q5. Two lenses having focal lengths $f_1 and\ f_2$ are placed in contact. what is the focal length of the combination?

Q6. A converging and the diverging lens of equal focal lengths are placed co-axially in contact. Find the focal length and power of the combination?

Q7. A double convex lens made from a material of refractive index $n_2$is immersed in a liquid of refractive index$\mu_1 (n_2 > n_1\ )$ what change if any would occur in the nature of the lens?

Q8. A glass lens of refractive index 1.45 is placed in a liquid, what must be the refractive index of the liquid in order to make the lens disappear?

Q9. For the same value of angle of incidence, the angles of refraction in three media are 15°, 25° and 35° respectively. In which medium would the velocity of light be minimum?

Q10. A biconvex lens made of a transparent medium of refractive index 1.5 is immersed in water of refractive index 1.33. Will the lens behave as a converging or diverging lens. Give reason?

Q11. Draw the path of ray of light suffering minimum deviation while passing through a prism?

Q12. Plot a graph to show the variation of angle of deviation as a function of angle of incidence for light rays passing through a prism?

Q13. Write down the relation between the refractive index of the material of the prism, angle of prism and angle of minimum deviation?

Q14. What do you mean by angle of minimum deviation?

Q15. What is the relation between refractive index and wavelength of light?

Q16. Write down the expression for magnifying power of a compound microscope?

MCQ

Q17. A convex lens of focal length 10 cm is placed in contact with a concave lens of focal length 20cm. What is the nature and focal length of the combination?

a) Concave,10cm
b) Convex, 10cm
c) Concave, 20cm
d) Convex, 20cm

Q18. A convex lens of focal length 16cm forms a virtual image of double the size of the object. What is the distance of the object from the lens?

a) 8cm b) 16cm c) 24cm d) 32cm

Q19. The angle of prism is 30^o and ray incident at 60^o on one refracting surface suffers a deviation of $30\ ^o$. What is the angle of emergence?

a) $0\ ^o$ b) 15 c) $30\ ^o$ d) $45\ ^o$

Q20. A ray of light passes through an equilateral prism such that the angle of incidence is equal to angle of emergence and the later is equal $3/4^{th}$ the angle of prism. The angle of deviation is

a) $45\ ^o$ b) $39\ ^o$ c) $20\ ^o$ d) $30\ ^o$

Q21. A convex length of focal length 15cm is made of material having refractive index 1.2. When placed in water of refractive index 1.3 it will behave as

a) Converging lens of focal length 15cm
b) Converging lens of focal length different than 15 cm
c) Diverging lens of focal length 15cm
d) Diverging lens of focal length different than 15 cm

ASSERTION AND REASON

Q22. **Assertion (A):** We cannot get diffraction pattern from a wide slit illuminated by monochromatic light.

Reason (R): In diffraction pattern, all the bright bands are not of the same intensity.

Q23. **Assertion (A):** When a light wave travels from a rarer to a denser medium, it loses speed. The reduction in speed imply a reduction in energy carried by the light wave.
Reason (R): The energy of a wave is proportional to velocity of wave.

Q24. **Assertion (A):** The film which appears bright in reflected system will appear dark in the transmitted light and vice-versa.

Reason (R): The conditions for film to appear bright or dark in reflected light are just reverse to those in the transmitted light.

Q25. **Assertion (A):** In Young's double slit experiment, the fringes become indistinct if one of the slits is covered with cellophane paper.

Reason (R): The cellophane paper decrease the wavelength of light.

Q26. **Assertion (A):** One of the conditions for interference is that the two sources should be very narrow.

Reason (R): One broad source is equal to large number of narrow sources.

2 MARKS QUESTION

Q27. Give reasons to explain why a reflecting telescope is preferred over a refracting telescope?

Q28 Draw a ray diagram to show as to how a right isosceles prism made of crown glass can be used to obtain an inverted image?

Q29 A ray of light incident on a equilateral prism propagates parallel to the baseline of the prism inside it. Find the angle of incidence of this ray, given the refractive index of the material of the prism is $\sqrt{3}$?

Q30. What is total internal reflection and what are the conditions under which it occurs?

Q31. The objective of a telescope is of larger focal length and of larger aperture compared to the eyepiece. Give reasons?

3 MARKS QUESTION

Q32.(a) With the help of a ray diagram, show how a concave mirror is used to obtain an erect and magnified image of an object.

(b) Using the above ray diagram, obtain the mirror formula and the expression for linear magnification. (CBSE 18C, 19C)

Q33. Draw the ray diagram showing refraction of light through a glass prism and hence obtain the relation between the refractive index n of the prism, angle of prism and angle of minimum deviation. (CBSE F 17) **OR**

(i)Trace the path of a ray of light PQ which is incident at an angle i on one face of a glass prism of angle A. It then emerges out from the other face at an angle e. Use the ray diagram to prove that the angle through which the ray is deviated is given by $\angle\delta = \angle i + \angle e - \angle A$

(ii) What will be the minimum value of δ if the ray passes symmetrically? (CBSE F 2022)

Q34. (a) Draw a ray diagram showing the image formation by a compound microscope.

(b) Derive an expression for total magnification when the image is formed at infinity.

(c) Write the considerations that you keep in mind, while choosing lenses to be used as eyepiece and objective in a compound microscope. (CBSE 19C)

Q35. (a) Draw a labelled diagram of refraction type telescope in normal adjustment.

(b) Give its two shortcomings over reflecting type telescope.

(c) Why is eyepiece of a telescope of short focal length, while objective is of large focal length? Explain. (CBSE 17; SP 19)

Q36. (a) Draw a labelled diagram of a reflecting type telescope.

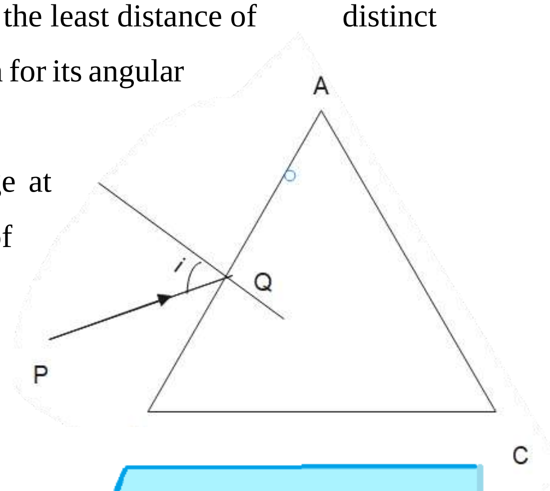
(b) Write two important advantages justifying why reflecting type telescopes are preferred over refracting telescopes. (CBSE F 17)

(c) The objective of a telescope is of larger focal length and of larger aperture (compared to the eye-piece). Why? Give reasons. (CBSE F 13; OD 17)

Q37. Draw a ray diagram to show the formation of an image at the least distance of distinct vision, by a compound microscope. Hence, obtain an expression for its angular magnification. (CBSE COMPT 2022)

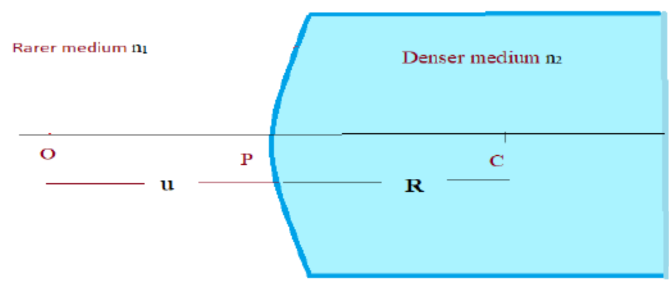
Q38. Draw a ray diagram to show the formation of an image at infinity, by a compound microscope. Explain the working of compound microscope.

Q39. Draw a ray diagram to show the formation of an image at infinity, by an astronomical telescope. Explain the working of an astronomical telescope.



5 MARKS QUESTION

Q40. (a) A point object 'O' is kept in a medium of refractive index n_1 in front of a convex spherical surface of radius of curvature R which separates the second medium of refractive index n_2 from the first one, as shown in figure.



Draw the ray diagram showing the image formation and deduce the relationship between the object distance and the image distance in terms of n_1, n_2 and R (CBSE F 17)

(b) When the image formed above acts as a virtual object for a concave spherical surface separating the medium n_2 from n_1 ($n_2 > n_1$), draw this ray diagram and write the similar relation. Hence obtain the expression for the Lens Maker's formula. (CBSE D 15)

Q41. (a) A ray 'PQ' of light is incident on the face AB of a glass prism ABC and emerges out of the face AC. Trace the path of the ray. Show that $\angle i + \angle e = \angle A + \angle \delta$ where δ and e denote the angle of deviation and angle of emergence respectively.

Plot a graph showing the variation of the angle of deviation as a function of angle of incidence. State the condition under which $\angle\delta$ is minimum.

(b) Find out the relation between the refractive index (n) of the glass prism and A for the case when the angle of prism(A) is equal to the angle of minimum deviation (δ_m). Hence obtain the value of the refractive index for angle of prism A = 60° (CBSE OD 15)

Q42.Draw a ray diagram for the formation of image by a compound microscope. Define its magnifying power. Deduce the expression for the magnifying power of the microscope. Explain,

(i)Why must both the object and the eyepiece of a compound microscope have short focal lengths?

(ii)While viewing through a compound microscope, why should our eyes be positioned not on the eyepiece but a short distance away from it for best viewing? [Foreign 2008]

Q43. Draw a ray diagram showing the image formation of a distant object by a refracting telescope. Define its magnifying power and write the two important factors considered to increase the magnifying power. Describe briefly the two main limitations and explain how far these can be minimized in a reflecting telescope. (CBSE F 15, 16)

Q44. Draw a ray diagram for the formation of image of a distant object by an astronomical telescope in normal adjustment position. Deduce the expression for its magnifying power. Write two basic features which can distinguish between a telescope and compound microscope.

Q45. Draw a labelled ray diagram showing the image formation of a distant object by refracting telescope. Deduce the expression for its magnifying power when the final image is formed at infinity.

(ii)The sum of focal lengths of the two lenses of a refracting telescope is 105 cm. The focal length of one lens is 20 times that of the other. Determine the total magnification of the telescope when the final image is formed at infinity. [All India 2014]

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SECTION B-ANSWER KEY

1. $\frac{1}{f} = (n-1)(\frac{1}{R_1} - \frac{1}{R_2})$ when the lens is immersed in water, $\frac{1}{f_w} = (\frac{n_g}{n_w} - 1)(\frac{1}{R_1} - \frac{1}{R_2})$.

   The focal length increases.

2. Power of the lens immersed in water decreases as the focal length increases.

3. Convex lens behaves like a diverging lens when it is placed in a medium of refractive index greater than the refractive index of the lens material.

4. $\frac{1}{\mathrm{v}} - \frac{1}{\mathrm{u}} = \frac{1}{\mathrm{f}}$ for a concave lens $u = -f$, $v = \infty$ the image is formed at infinity.

5. $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$ where, f is the focal length of the combination.

6. $\frac{1}{f} = \frac{1}{f_1} - \frac{1}{f_1} = 0$, $f = \frac{1}{0} = \infty$ power $P = \frac{1}{f} = 0$

7. $\frac{1}{f} = (n-1)(\frac{1}{R_1} - \frac{1}{R_2}) = \left(\frac{n_2}{n1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

   Since, $n_2 > n1$, f is positive nature of lens is the same.

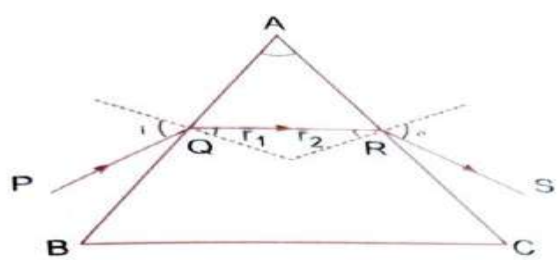
8. Refractive index of liquid should be same as that of glass.

9. $n = \frac{\sin i}{\sin r}$ when r increases, μ decreases

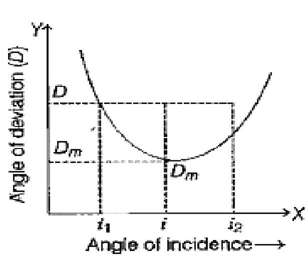
   $v = \frac{c}{n}$ when n decreases, v increases. Velocity is minimum in medium A

10. $\frac{1}{f} = (\frac{n_g}{n_w} - 1)(\frac{1}{R_1} - \frac{1}{R_2})$ since $n_g > n_w$ focal length is positive and will behave as a converging lens.

11.



12.



13. Refractive index $n = \frac{\sin\frac{A+d_m}{2}}{\sin\frac{A}{2}}$ where A= angle of prism and d_m is the minimum deviation.

14. The exterior angle formed between the directions of the incident ray produced forwards and the emergent ray drawn backwards is called angle of deviation.

15. Refractive index $n = A + \frac{B}{\lambda^2}$ where A, B are constants

16. M=$-\frac{L}{f_0}(1 + \frac{D}{f_e})$

MCQ

17. d) Convex, 20cm

18. a) 8cm

19. a) 0 °

20. d) 30°

21. d) Diverging lens of focal length different than 15 cm

A and R

22. (b) Both A and R are true but R is not the correct explanation of A.

23. (d) A is false and R is also false.

24. (a) Both A and R are true and R is the correct explanation of A.

25. (c) A is true but R is false.

26. (a) Both A and R are true and R is the correct explanation of A.

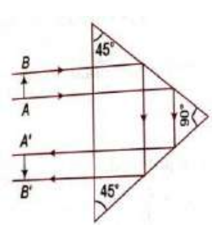
2 MARKS

27.i) No chromatic aberration because mirrors are used.

i) Spherical aberration can be minimised using parabolic mirrors.

ii) Image formed is bright.

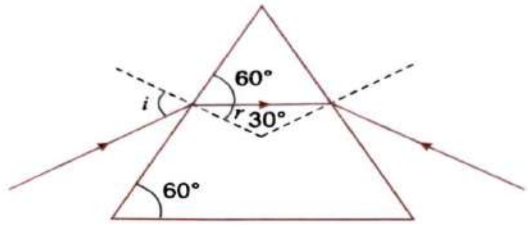
28.



29.

From figure r=30°, $n = \sqrt{3} n = \frac{\sin i}{\sin r}$

$$\sin i \ = \sqrt{3} \sin 30$$
$$i = 60$$



30. The phenomenon by which rays of light proceeding from an object in the denser medium returns back to the same medium when incident an angle greater than the critical angle for the pair of media is called total internal reflection.

Conditions for TIR

1. Object should be placed in the denser medium.
2. Angle of incidence in the denser medium should be greater than the critical angle for the pair of media.

31. Telescopes should have large light gathering power and a large magnifying power.

3-MARKS

32.

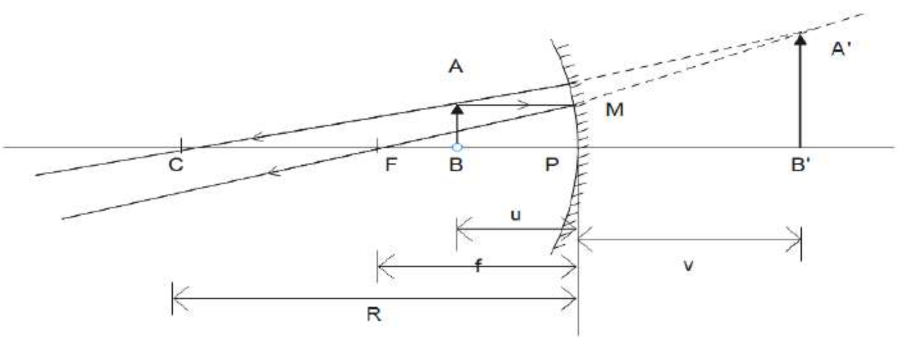


Fig : Image formed by a concave mirror when the object lies between F and P
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1.

$\Delta MPF \sim \Delta A'B'F'$

$$\frac{A'B'}{MP} = \frac{FB'}{FP}$$

$$\frac{A'B'}{AP} = \frac{FP + PB'}{FP}$$

Applying the new Cartesian sign convention,

$A'B' = +h_2, \quad AB = +h_1, \quad FP = -f, \quad PB' = v$

$$\frac{h_2}{h_1} = \frac{-f+v}{-f} = -\frac{v}{u} \ldots\ldots\ldots (using\ mirror\ formula)$$

$$m = \frac{h_2}{h_1} = -\frac{v}{u}$$

2. Refer question 4 of section A 5 marks questions & Refer question 2 of section B 5 marks questions.

(ii) $\delta = \delta_{min}$ $i = e$ $r_1 = r_2$

$$i + e = A + \delta$$

$$i + i = A + \delta_{min}$$

$$\delta_{min} = 2i - A$$

34. (a)

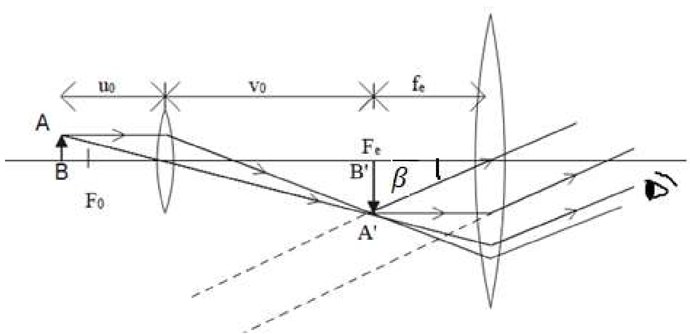

IMAGE FORMATION BY COMPOUND MICROSCOPE
(FINAL IMAGE AT INFINITY)
(CREDIT: IMAGE CREATED USING EDRAW)

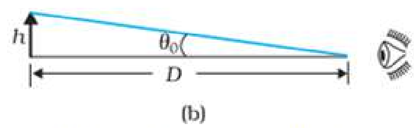

FIG: Angle subtended by the object at LDDV on eye.
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$$m = \frac{\beta}{\theta_0} = \frac{\tan\beta}{\tan\theta_0} = \frac{AB'/B'E}{h/D} = \frac{h'/u_e}{h/D} = \frac{h'}{h}.\frac{D}{u_e} = m_o m_e \ldots\ldots (1)$$

$$m_o = \frac{h'}{h} = \frac{L}{-f_0}$$

$$m_e = \frac{D}{f_e}$$

$$m = m_o m_e = \frac{L}{-f_0}\frac{D}{f_e}$$

<u>Consideration while choosing objective and eyepiece:</u>

(i) Both the lenses should have short focal lengths.

(ii) The focal length of the objective should be smaller than the eyepiece.

35. (a)

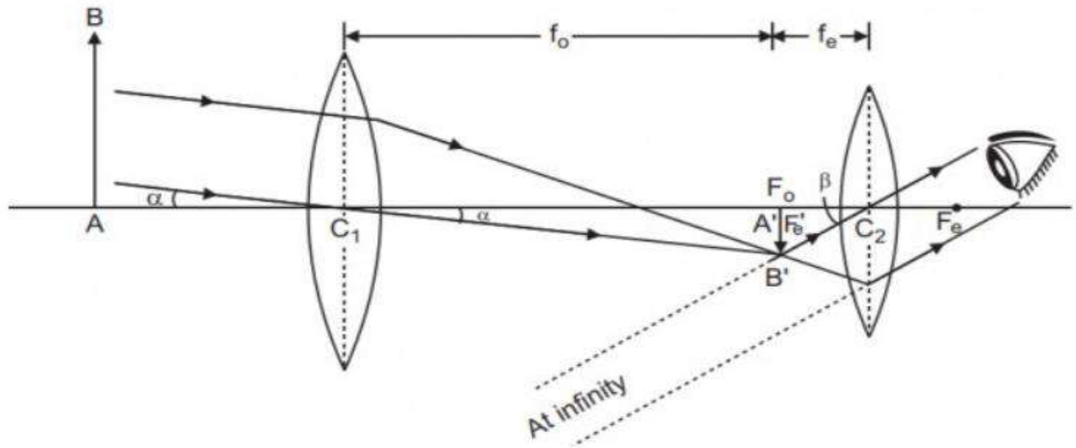

FIG: RAY DIAGRAM FOR ASTRONOMICAL TELESCOPE (FINAL IMAGE AT INFINITY/ NORMAL ADJUSTMENT)
CREDIT: HAREN.IN

(b)Limitations of a refracting telescope:

(i) Suffers from chromatic aberration
(ii) Suffers from spherical aberration
(iii) Small magnifying power
(iv) Small resolving power

$$(c)\ m = -\frac{f_0}{f_e}$$

When $f_o >> f_e$, the telescope will have large magnifying power.

36. (a)

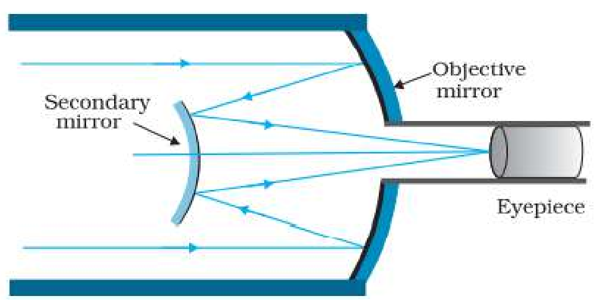

FIGURE Schematic diagram of a reflecting telescope (Cassegrain).

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(b)Advantages of a reflecting telescope:

(i) No chromatic aberration, because mirror objective is used.
(ii) Spherical aberration can be removed by paraboloidal mirror.
(iii) Image is bright because there is no loss of energy due to refraction.

(iv) Large mirror provides an easier mechanical support over its entire back surface.

(c) The objective of larger focal length produces high angular magnification while that of larger aperture has a high resolving power.

37. Refer question (3) of Section B 5 marks questions.

38. Refer question (3) of Section B 3 marks questions for diagram.

Working:

(a) <u>When the final image is formed at the least distance of distinct vision:</u>

The object AB to be viewed is placed at distance slightly larger than the focal length of the objective O. The objective forms a real, inverted and magnified image on the other side of the lens. The separation between the objective and eyepiece is so adjusted that the image lies within the focal length of the eyepiece. The image formed by the objective acts as an object for the eyepiece. The eyepiece forms a virtual and magnified final image which is inverted with respect to the object.

(b) <u>When the final image is formed at infinity:</u>

When the image formed by the objective lies at the focus of the eyepiece, the final image is formed at infinity.

39. Refer question (4a) of Section B, 3 marks questions for diagram.

Working:

(a) <u>When the final image is formed at the least distance of distinct vision:</u>

The parallel beam of light coming from the distant object falls on the objective at some angle α. The objective focusses the beam in its focal plane and forms a real, inverted and diminished image on the other side of the lens. This image acts as an object for the eyepiece. The separation between the objective and eyepiece is so adjusted that the image lies within the focal length of the eyepiece. The eyepiece magnifies this image so that final image is magnified and inverted with respect to the object.

(b) <u>When the final image is formed at infinity:</u>

When the image formed by the objective lies at the focus of the eyepiece, the final image is formed at infinity.

5 MARKS QUESTIONS:

40. (a)Refer Section A Question (2a)

(b) Refer Section A Question (3)

41.(a)Refer Section A Question (4). Derive up to equation (4)

For graph Section A Question (4).

Condition under which δ is minimum: At $\delta = \delta_m i = e \;\therefore r_1 = r_2$

(b) $A = \delta_m$

$$n_{21} = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

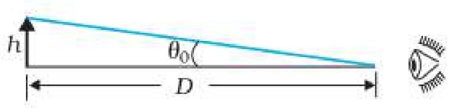
$$\boxed{n_{21} = \frac{\sin\left(\frac{A+A}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin A}{\sin\left(\frac{A}{2}\right)} = \frac{2\sin\left(\frac{A}{2}\right)\cos\left(\frac{A}{2}\right)}{\sin\left(\frac{A}{2}\right)} = 2\cos\left(\frac{A}{2}\right)}$$

$$n_{21} = \frac{\sin\left(\frac{120}{2}\right)}{\sin\left(\frac{60}{2}\right)} \dots\dots.(A = 60^0)$$

$$n_{21} = \frac{\sin 60}{\sin 30}$$

$$n_{21} = \frac{\sqrt{3}/2}{1/2} = \sqrt{3}$$

42..



(b)

FIG: Angle subtended by the object at LDDV on eye.
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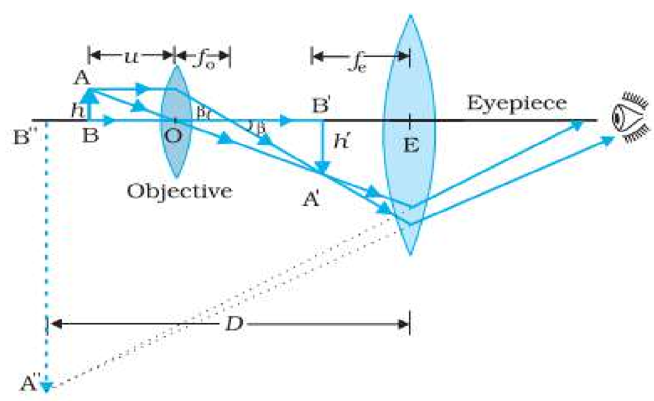

Fig: Formation of image by a compound microscope (Final image at LDDV)
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Magnifying power: The magnifying power of a compound microscope is defined as the ratio of the angle subtended at the eye by the final virtual image to the angle subtended at the eye by the object, when both are at the least distance of distinct vision from the eye.

$$m = \frac{\beta}{\theta_0} = \frac{\tan\beta}{\tan\theta_0} = \frac{AB'/B'E}{h/D} = \frac{h'/u_e}{h/D} = \frac{h'}{h}.\frac{D}{u_e} = m_o m_e \ldots\ldots\ldots\ldots\ldots..(B'E = u_e)$$

$$m_o = \frac{h'}{h} = \frac{v_0}{u_0}$$

As the eyepiece acts as a simple microscope, $m_e = \frac{D}{u_e} = \left(1 + \frac{D}{f_e}\right)$

$$m = m_o m_e = \frac{v_0}{u_0}\left(1 + \frac{D}{f_e}\right)$$

As the object AB is placed close to the focus F_0 of the objective, $u_0 \approx -f_0$

As the object $A'B'$ is formed close to the eyelens whose focal length is short,

$\therefore v_0 \approx L$

$(L \text{ is the length of the microscope tube or the distance between the two lenses.})$

$$m = -\frac{L}{f_0}\left(1 + \frac{D}{f_e}\right)$$

(Note: The above equation is derived for the final object at LDDV. The derivation can also be done for the case of final image formed at infinity as it is not specified in the question)

(i) The magnifying power of a compound microscope is given by:

$$m = m_o m_e = \frac{v_0}{u_0}\left(1 + \frac{D}{f_e}\right)$$

$$m = \frac{f_0}{u_0 - f_0}\left(1 + \frac{D}{f_e}\right)$$

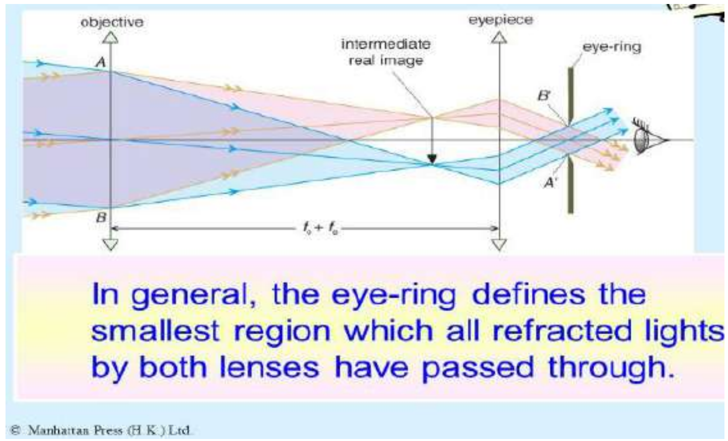
Angular magnification (m_0) of objective will be large when u_0 is slightly greater than f_0. Since microscope is used for viewing very close objects, so u0 is small. Consequently, f_o has to be small.

$$m_e = \frac{D}{u_e} = \left(1 + \frac{D}{f_e}\right)$$

The angular magnification (m_e) of the eyepiece will be large if f_e is small.

(ii)

All the rays from the object refracted by the objective go through the eyering. Therefore, it is an ideal position for our eyes for viewing. If we place our eyes too close to the eye-piece, we shall not collect much of the light and also reduce our field of view. If we position our eyes on the eyering and the area of the pupil of our eye is greater or equal to the area of the eyering, our eyes will collect all the light refracted by the objective. The exact location of the eyering depends on the separation between the objective and the eyepiece and the focal length of the eyepiece.



43.

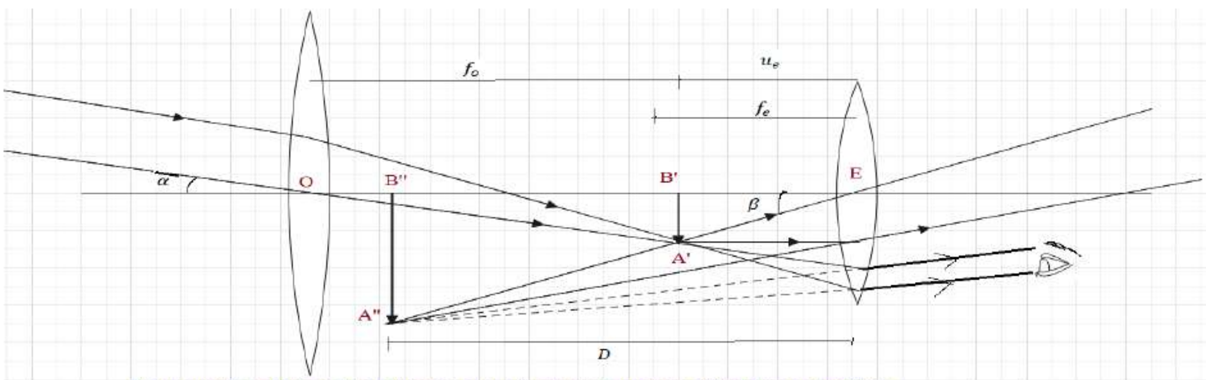


Fig: Formation of image by a refracting type astronomical telescope (final image at LDDV)
CREDIT: Image created using EDRAW.

Magnifying power: The magnifying power of a telescope is defined as the ratio of the angle subtended at the eye by the final image formed at the least distance of distinct vision to the angle subtented at the eye by the object at infinity, when seen directly.

Factors for increasing the magnifying power:

(i) Increasing focal length of the objective
(ii) Decreasing focal length of the eyepiece.

Limitations of a refracting telescope:

(v) Suffers from chromatic aberration
(vi) Suffers from spherical aberration
(vii) Small magnifying power
(viii) Small resolving power

Advantages of a reflecting telescope:

(v) No chromatic aberration, because mirror objective is used.
(vi) Spherical aberration can be removed by paraboloidal mirror.
(vii) Image is bright because there is no loss of energy due to refraction.
(viii) Large mirror provides an easier mechanical support over its entire back surface.

44.

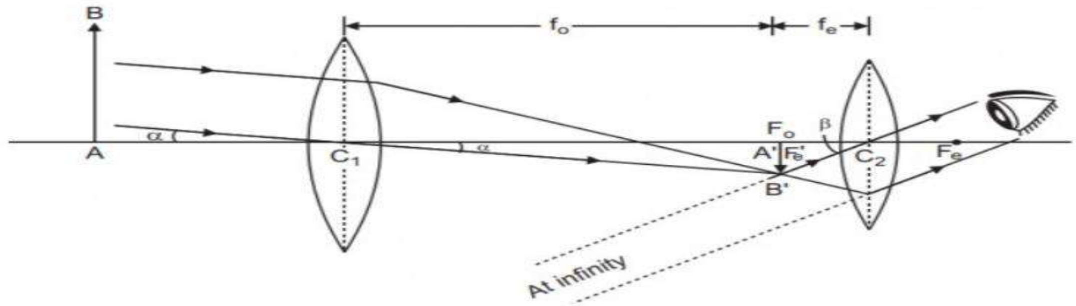


FIG: RAY DIAGRAM FOR ASTRONOMICAL TELESCOPE (FINAL IMAGE AT INFINITY/ NORMAL ADJUSTMENT)
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Magnifying power, $m \ = \frac{\beta}{\alpha} = \frac{\tan\beta}{\tan\alpha} = \frac{A'B'/A'C_2}{A'B'/A'C_1}$

$$m = \frac{A'C_1}{A'C_2}$$

$$m = -\frac{f_0}{f_e} where, A'C_1 = -f_0 \ , \qquad A'C_2 = f_e$$

Construction difference:

Microscope	Telescope
1. Objective is of very short focal length and of short aperture.	1. Objective is of large focal length and of large aperture.
2.Eyepiece is of short focal length (but $f_e > f_o$) and large aperture.	2. Eyepiece is of short focal length and short aperture.

Working difference:

Microscope	Telescope
1. Objective forms real and magnified image of an object kept just beyond the focus.	1. Objective forms image of the distant object at, or within, the focus of its eyepiece.
2. It produces linear magnification, i.e., size of the image is larger than that of the object.	2. It produces angular magnification i.e, the image is nearer to the eye but the size does not increase.

45. (i) Refer 5 marks question, section B, question (5)

(ii) $f_0 = 20f_e \quad \therefore \frac{f_0}{f_e} = 20 \qquad \therefore m = 20$

SECTION-C

1MARK

Q1. On what factors does the magnifying power of a compound microscope depend?

Q2. What is the nature of final image formed in a compound microscope?

Q3. What do you mean by normal adjustment of a telescope?

Q4. The focal length of the objective and eyepiece of a telescope are f_o and $f_e$respectively what is the magnifying power of the telescope in normal adjustment?

Q5. Name the two types of reflecting telescopes?

Q6. Write the important features of a good telescope?

Q7. Define the term magnifying power of a compound microscope?

Q8. Write the expression for magnifying power of a telescope when the final image is formed at the least distance of distinct vision

Q9. In a telescope objective lens is of large focal length while eyepiece is of small focal length. Why

Q10. Out of blue and red light which is deviated more by a prism? Give reason?

MCQ

Q11. To increase the magnifying power of a telescope, we should increase

a) Focal length of the objective
b) Focal length of the eyepiece
c) Aperture of the objective.
d) Aperture of the eyepiece.

Q12. In a compound microscope, the objective produces a magnification of 10, while the eyepiece produces a magnification of 5, then the overall magnification achieved by a compound microscope is

a) 2 b) 50 c) 0.5 d) 25

Q13. If $f_o$and f_e are the focal lengths of the objective and eyepiece of an astronomical telescope, the length of the tube is

a) $f_o + f_e$
b) $f_o - f_e$

c) $\sqrt{f_o \times f_e}$

d) $\frac{f_o f_e}{f_o + f_e}$

Q14. An astronomical telescope is set for normal adjustment and the distance between the objective and eyepiece is 1.05 metre. The magnifying power of the telescope is 20. What is the focal length of the objective?

a) 2m b) 1m c) .5m d) .25m

Q15. When a telescope is in normal adjustment, the distance of the objective from the eyepiece is 100cm. if the magnifying power of the telescope in normal adjustment is 24, the focal length of the lenses are

a) 96cm, 4cm b) 90cm, 10cm c) 80cm, 20cm d) 50cm, 50cm

2MARKS

Q16. Draw a ray diagram to show the image formation by a concave mirror when the object is placed between its focus and pole. Using this diagram, derive the magnification produced in the image.

Q17. Draw a labelled diagram for the formation of image by a compound microscope when the final image is formed at the near point or the least distance of distinct vision?

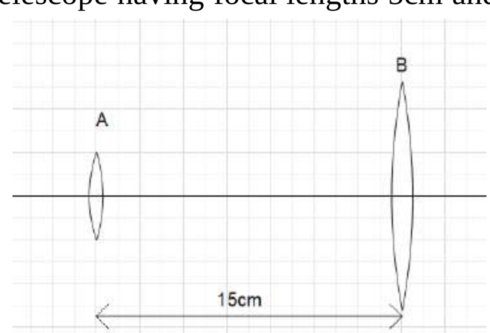
Q18. Draw a ray diagram to obtain the image at the least distance of distinct vision using an astronomical telescope?

Q19 Draw a schematic ray diagram of a reflecting type telescope (Cassegrain)?

Q20. Draw a ray diagram to obtain the image by an astronomical telescope in normal adjustment position?

3MARKS

Q21. Two convex lenses A and B of an astronomical telescope having focal lengths 5cm and 20 cm respectively, are arranged as shown in the figure:



(i) Which one of the two lenses you will select to use as the objective lens and why?

(ii) What should be the change in the distance between the lenses to have the telescope in its normal adjustment position?

(iii) Calculate the magnifying power of the telescope in the normal adjustment position. (CBSE SAMPLE PAPER 2003)

Q22. Which two of the following lenses L_1, L_2 and L_3 will you select as objective and eyepiece for constructing best possible (i) telescope (ii) microscope? Give reason to support your answer. (CBSE D 09, 15C; OD 17)

Lenses	Power (P)	Aperture(A)
L_1	3 D	8cm
L_2	6 D	1 cm
L_3	10 D	1 cm

Q23. Four double convex lenses, with the following specifications are available:

Lenses	Focal length	Aperture(A)
A	100 cm	10 cm
B	100 cm	5 cm
C	10 cm	2cm
D	5 cm	2 cm

Which two of the given four lenses, should be selected as the objective and eyepiece to construct an astronomical telescope and why? What will be the magnifying power and normal length of the telescope tube so constructed?

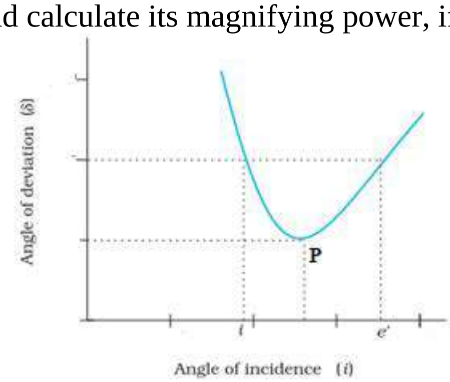
Write the advantages of reflecting type telescope over such a telescope.

Or

Which two of the above four lenses should be selected as objective and eyepiece of a compound microscope and why? How can the magnifying power of such a microscope be increased? Draw a labelled ray diagram for the image formation in such a microscope. (CBSE SAMPLE PAPER 2005)

Q24. An optical instrument uses eye-lens of power 12.5 D and object lens of power 50D and has a tube length of 20 cm. Name the optical instrument and calculate its magnifying power, if it forms the final image at infinity. (CBSE D 17)

Q25. A plot, between the angle of deviation (δ) and angle of incidence (i), for a triangular prism is shown in figure:



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Explain why any given value of 'δ' corresponds to two values of angle of incidence. State the significance of point P on the graph. (CBSE SAMPLE PAPER 2011)

Q26. Define power of the lens. Why is the power of a lens measured as the reciprocal of its focal length? Give its SI unit and define it. Sun glasses have curved surfaces but they do not have any power. Why?

5MARKS

Q27. (a) Derive mirror equation for a convex mirror.

(b) Using it, show that a convex mirror always produces a virtual image, independent of the location of the object. (CBSE SP 20)

Q28.Draw a ray diagram showing the formation of the image by a point object on the principal axis of a spherical convex surface separating two media of refractive indices n_1 and n_2, when a point source is kept in the rarer medium of refractive index n_1. Derive the relation between object and image distance in terms of refractive index of the medium and radius of curvature of the surface. Hence obtain the expression for Lens Maker's formula in the case of thin convex lens.

(CBSE D 09, 14, 14C, OD 16)

Q29. Draw a ray diagram to show the working of a compound microscope. Deduce an expression for the total magnification when the final image is formed at the near point.

In a compound microscope, an object is placed at a distance of 1.5 cm from the objective of focal length 1.25 cm. If the eye piece has a focal length of 5 cm and the final image is formed at the near point, estimate the magnifying power of the microscope. (CBSE D10)

Q30.(a) Draw a ray diagram for final image formed at distance of distinct vision (D) by a compound microscope and write an expression for its magnifying power.

(b) An angular magnification of 30X is desired for a compound microscope using an objective of focal length 1.25 cm and eyepiece of focal length 5cm. How will you set up the compound microscope? (CBSE SP 20)

Q31.(i) What is meant by 'normal adjustment' in case of an astronomical telescope? Trace the paths of three rays from a distant object through an astronomical telescope in normal adjustment.

(ii)A small telescope has an objective lens of focal length 140 cm and an eye-piece of focal length 5.0 cm.What is the(a) magnifying power of telescope for viewing distant objects when the telescope is in normal adjustment (i.e., when the final image is at infinity)?

(b) the final image is formed at the least distance of distinct vision (D = 25cm)? (CBSE OD13)

(c) What is the separation between the objective and eye lens when final image is formed at infinity?

(d) If this telescope is used to view a 100m tall tower 3km away, what is the height of the image of the tower formed by the objective lens?

(e) what is the height of the final image of the tower if it is formed at the least distance of distinct vision D = 25 cm.

SECTION C-ANSWERS OF 1 MARK QUESTIONS

1. M depends on the focal length of objective and eyepiece.
2. Real, inverted and magnified with respect to object.
3. Adjustment in which final image is formed at infinity.
4. Magnifying power M= $-\frac{f_o}{f_e}$
5. Newtonian type and Cassegrain type
6. High magnifying power, large light gathering power and high resolving power.
7. Magnifying power M=$\frac{angle\ subtended\ by\ the\ image\ at\ the\ eye}{ngle\ subtended\ by\ the\ object\ at\ the\ eye}$ when both are at the least distance of distinct vision.
8. Magnifying power M= $-\frac{f_o}{f_e}(1+\frac{f_e}{D})$
9. For larger angular magnification
10. Deviation produced by a prism is $d = (n-1)A$ and refractive index n$\propto \frac{1}{\lambda^2}$.

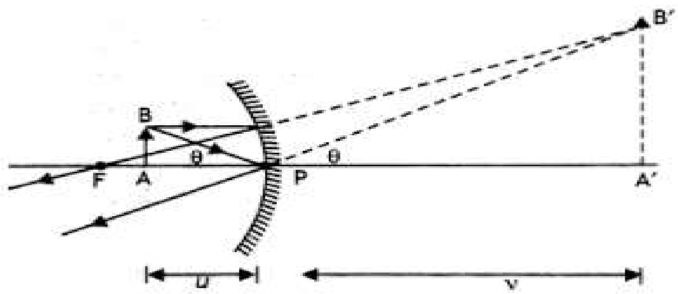
    Since violet has lesser wavelength its refractive index is more, hence deviation is more for violet.

ANSWERS TO MCQ

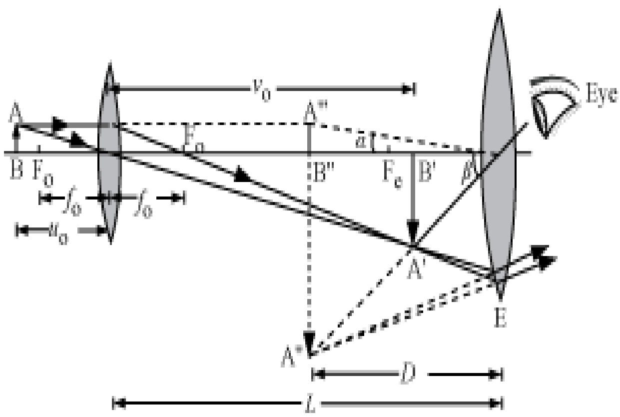
11. a) Focal length of the objective
12. a) 50
13. a) $f_o + f_e$
14. b) 1m
15. a) 96cm, 4cm

ANSWERS TO QUESTIONS OF 2 MARKS

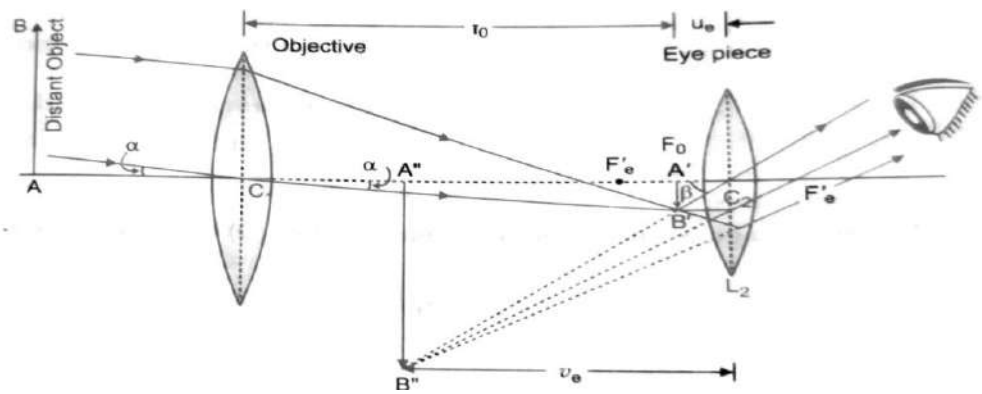
16.



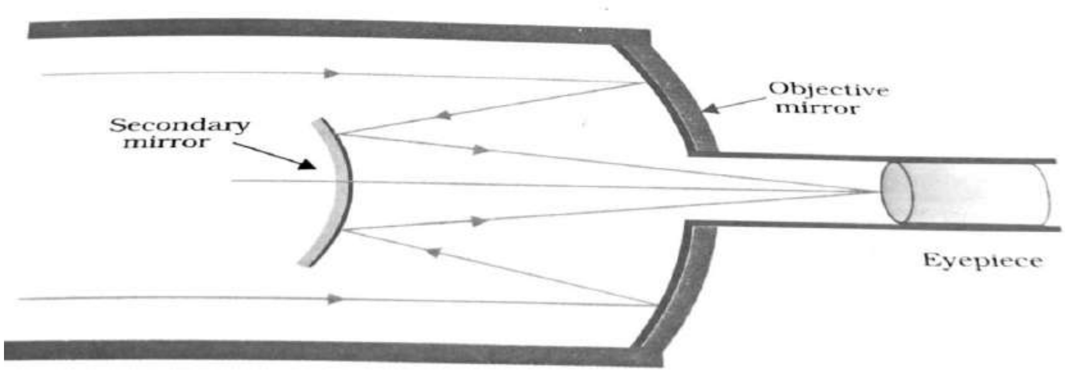
17.



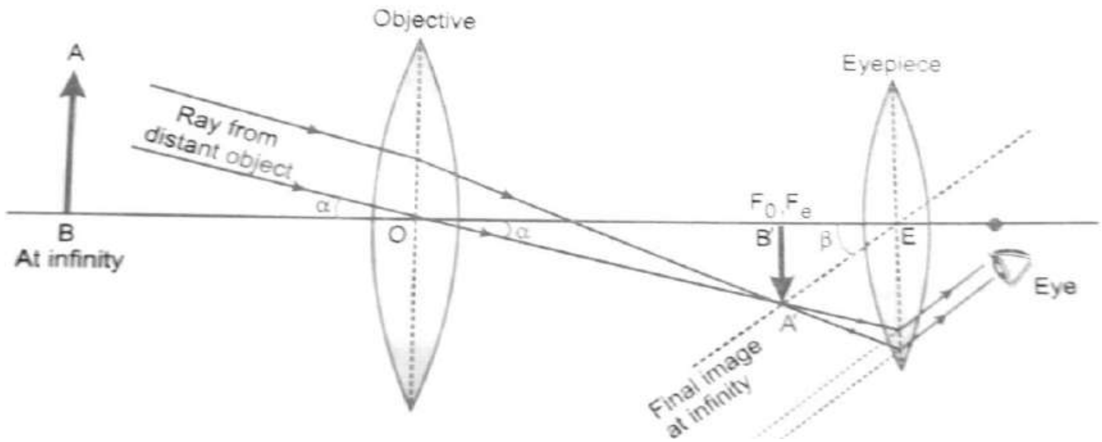
18.



19.



20.



3 MARKS QUESTION

21. (i) The lens B should be used as objective because it has larger focal length and larger radius.

(ii) In normal adjustment, the distance between objective and eyepiece

= fo + fe = 20+5=25cm

Distance required to be increased between the two lenses = 25-15 = 10 cm

(iii) Magnifying power of the telescope in normal adjustment,

$$m = \frac{f_0}{f_e} = \frac{20}{5} = 4$$

22.(i) **Telescope:** L_1 as objective and L_2 as eyepiece

Reason: The objective should have large aperture and large focal length while the eyepiece should have small aperture and small focal length. Then the light gathering power and magnifying power will be larger.

(ii) **Microscope:** L_3 as objective and L_2 as eyepiece

Reason: Both the lenses of the microscope should have short focal lengths and the focal length of the objective should be smaller than that of the eyepiece. Magnifying power will be larger for short focal lengths of objective and eyepiece.

23. For constructing astronomical telescope, lens A should be used as objective because of its large focal length and large aperture. Lens D should be used as its eyepiece because of its small focal length and small aperture.

$$m = \frac{f_0}{f_e} = \frac{100}{5} = 20$$

Normal length = 100+5 =105 cm

(b)Advantages of a reflecting telescope:

(a) No chromatic aberration, because mirror objective is used.
(b) Spherical aberration can be removed by paraboloidal mirror.

OR

For constructing compound microscope, the lens D should be used as objective and C as the eyepiece because the lenses should have small focal length and the focal length of the objective should be smaller than that of the eyepiece.

$$m = -\frac{v_0}{f_0}\left(1 + \frac{D}{f_e}\right)$$

The magnifying power of a compound microscope can be increased by taking both f_0 and f_e small.

For ray diagram refer question 3 of 5marks questions, Section B

24. The optical instrument is compound microscope.

$$f_e = \frac{1}{P_e} = \frac{100}{12.5} = 8$$

$$f_0 = \frac{1}{P_0} = \frac{100}{50} = 2$$

$$m = \frac{L}{f_0} \times \frac{D}{f_e} = \frac{20}{2} \times \frac{25}{8} = 31.25$$

25. In general, any given value of deviation δ, (except for i = e) corresponds to two values i and e. This is expected from the symmetry of i and e as

δ= i + e – A, i.e., δ remains the same if i and e are interchanged.

Point P is the point of minimum deviation. This is related to the fact that the path of the ray as shown in Figure can be traced back resulting in the same angle of deviation. At the minimum deviation δ_m, the refracted ray inside the prism becomes parallel to the base.

26.The power P of a lens is defined as the tangent of the angle by which it converges or diverges a beam of light falling at unit distant from the optical centre

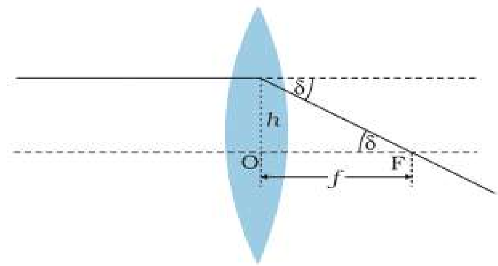


FIGURE Power of a lens.

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$$\tan\delta = \frac{h}{f}$$

$$If\ h = 1, \tan\delta = \frac{1}{f}$$

$$P = \frac{1}{f}$$

Power of a lens is a measure of the convergence or divergence, which a lens introduces in the light falling on it. Clearly, a lens of shorter focal length bends the incident light more. So, the power of a lens is measured as the reciprocal of its focal length.

SI unit of power is dioptre .One dioptre is the power of the lens whose focal length is 1m.

Both the surfaces of sun glasses are equally curved i.e., $R_1 = R_2$

$$P = (n_{21} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = 0$$

5 MARKS QUESTIONS:

<u>SECTION-C</u>

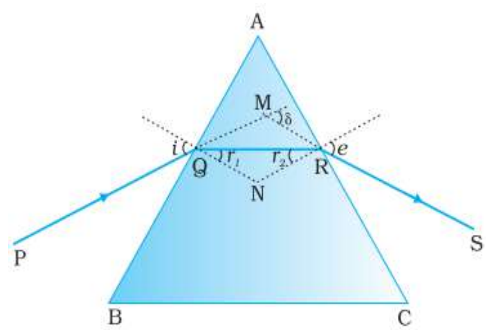

FIG: Light passing through the triangular prism
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27. (a) Refer 5 marks questions section A question (1)

(b) For a convex mirror, $f > 0$ and for an object on left, $u < 0$

From mirror formula,

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

As $f\ is + ve\ and\quad u\ is - ve,\quad so\ \frac{1}{v} > 0\qquad \therefore v > 0$

Thus, a convex mirror always produces a virtual image, independent of the location of the object.

28. Refer Section A of 5 marks questions, Qn(2) and Qn(3)

29. Refer qn 3 of Section B of 5 marks questions

$f_0 = 1 \cdot 25cm$

$f_e = 5\ cm$

$u_0 = -1.5\ cm$

$v_0 = -D = -25\ cm$

$$\frac{1}{f_0} = \frac{1}{v_0} - \frac{1}{u_0}$$

$$\frac{1}{v_0} = \frac{1}{f_0} + \frac{1}{u_0} = \frac{1}{1.25} - \frac{1}{1.5} = \frac{100}{125} - \frac{10}{15} = \frac{50}{375}$$

$$v_0 = \frac{375}{50} = 7.5\ cm$$

Magnifying power,

$$m = \frac{v_0}{u_0}\left(1 + \frac{D}{f_e}\right) = \frac{7.5}{-1.5}\left(1 + \frac{25}{5}\right) = -30$$

30. (a) Refer qn 3 of Section B of 5 marks questions

(b) $f_0 = 1.25\ cm\ \ f_e = 5cm\quad D = 25\ cm$

Angular magnification of the compound microscope = 30X

Total magnifying power of the compound microscope, m = 30

The angular magnification of the eyepiece is given by the relation

$$m_e = \left(1 + \frac{D}{f_e}\right)$$

$$m_e = \left(1 + \frac{25}{5}\right) = 6$$

The angular magnification of the objective lens (m_0)

$$m = m_o m_e$$

$$m_0 = \frac{m}{m_e} = \frac{30}{6} = 5$$

$$m_0 = \frac{image\ distance\ for\ the\ objective\ lens}{object\ distance\ for\ the\ objective\ lens}$$

$$5 = \frac{v_0}{-u_0}$$

$v_0 = -5u_0 \ldots\ldots (1)$

Applying the lens formula for the objective lens:

$$\frac{1}{f_0} = \frac{1}{v_0} - \frac{1}{u_0}$$

$$\frac{1}{1.25} = \frac{1}{-5u_0} - \frac{1}{u_0} = \frac{-6}{5u_0}$$

$$u_0 = \frac{-6}{5} \times 1.25 = -1.5\ cm$$

$$v_0 = -5u_0 = -5\ \times (-1.5) = 7.5\ cm$$

The object should be placed 1.5 cm away from the objective lens to obtain the desired magnification.

Applying the lens formula for the eyepiece:

$$\frac{1}{f_e} = \frac{1}{v_e} - \frac{1}{u_e}$$

$$\frac{1}{u_e} = \frac{1}{v_e} - \frac{1}{f_e}$$

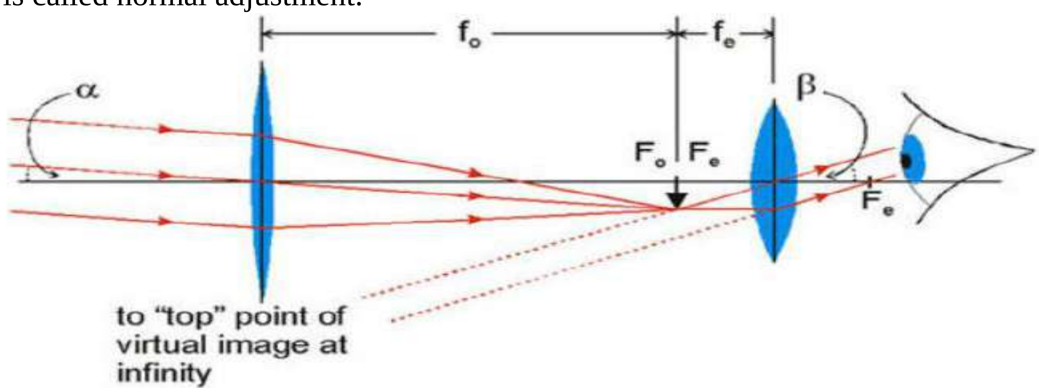
$$\frac{1}{u_e} = \frac{-1}{25} - \frac{1}{5} = -\frac{6}{25}$$

$$\therefore u_e = -4.17\ cm$$

Separation between the objective lens and the eyepiece = $|u_e| + |v_0| = 4.17 + 7.5 = 11.67cm$

Therefore, the separation between the objective lens and the eyepiece should be 11.67 for the required magnification.

31. (a) **Normal adjustment for the telescope:** When the astronomical telescope is adjusted in such a way that the final image is at infinity so that the eye is completely relaxed when viewing it. This is called normal adjustment.



(ii)

f_0 =

f_e = Fig: Image formation by an astronomical telescope (for Normal adjustment)

When the final image is at infinity, $m = -\frac{f_0}{f_e} = -\frac{140}{5} = -28$

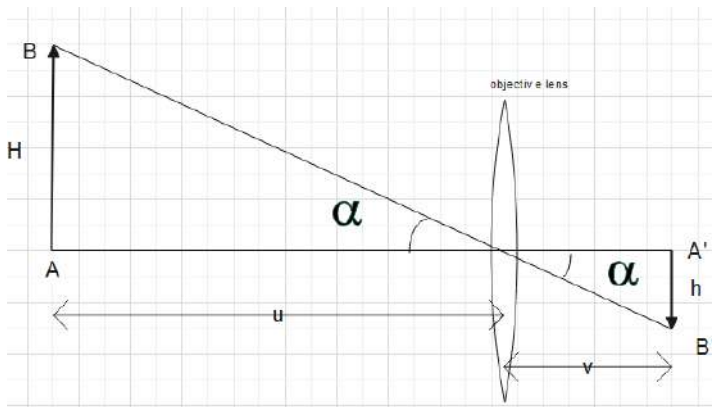
(b) When the final image is at the least distance of distinct vision,

$$m = -\frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right) = -\frac{140}{5}\left(1 + \frac{5}{25}\right) = -33.6$$

(c) Seperation between objective and eye lens when final image is formed at infinity

$$L = f_0 + f_e = 140 + 5 = 145cm$$

(d) Let AB be tower and $A'B'$ its image then



$$\frac{H}{u} = \frac{h}{v}$$

For distance object $v = f_0$

$$h = \frac{H}{u} f_0 = \frac{100}{3000} \times 1.4$$

$$h = 4.7 \times 10^{-2} m = 4.7\ cm$$

(e) Magnification produced by eyepiece :

$$m_e = \left(1 + \frac{D}{f_e}\right) = \left(1 + \frac{25}{5}\right) = 6$$

$$m_e = \frac{h_2}{h_1}$$

$$h_2 = m_e h_1 = 6 \times 4.7 = 28.2\ cm$$

****

QUESTION BANK
WAVE OPTICS

SECTION A

1 MARK QUESTIONS

Q1. Two plane monochromatic waves propagating in the same direction with amplitudes A and 2A and differing in phase by $\pi/3$ rad superpose. Calculate the amplitude of the resultant wave. [CBSE 03]

Q2. Two sources of intensity I and 4I are used in an interference experiment. Find the intensity at points where the waves from two sources superimpose with a phase difference is zero.

Q3. In a Young's double slit experiment, the intensity of light at a point on the screen where the path difference is λ, is k units. Find the intensity at a point where the path difference is $\lambda/4$. [CBSE 14,17,19]

Q4. The intensity at the central maxima in Young's double slit experiment is I_0. Find out the intensity at a point where the path difference is $\lambda/6$. [CBSE 12,14]

Q5. Find the ratio of intensities at two points in a screen in Young's double slit experiment, when waves from the two slits have path difference of 0 and $\lambda/4$ [CBSE2003]

Q6. Laser light of wavelength 630nm incident on a pair of slits produces an interference pattern in which the bright fringes are separated by 8.1mm. A second light produces an interference pattern in which the fringes are separated by 7.2mm. Calculate the wavelength of the second light. [CBSE2000,09]

Q7. In Young's experiment, the width of the fringes obtained with light of wavelength 6000Å is 2.0mm. Calculate the fringe width if the entire apparatus is immersed in a liquid medium of refractive index 1.33. [CBSE2003]

Q8. A beam of light consisting of two wavelengths 800nm and 600nm is used to obtain the interference fringes in a Young's double slit experiment on a screen placed 1.4m away. If the two slits are separated by 0.28mm, calculate the least distance from the central bright maximum where the bright fringes of the two wavelengths coincide. [CBSE12,09.]

Q9. In Young's double slit experiment, using light of wavelength 400nm interference fringes of width 'X' are obtained the wavelength of light is increased to 600nm and the separation between the slits is halved. If one wants the observed fringe width on the screen to be the same in the two cases, find the ratio of the distance between the screen and the plane of the interfering sources in the two arrangements.

Q10. A parallel beam of light of 600 nm falls on a narrow slit and the resulting diffraction pattern is observed on a screen 1.2 m away. It is observed that the first minimum is a distance of 3 mm from the centre of a screen. Calculate the width of the slit. [CBSE08]

Q11. A monochromatic light of wavelength 500 nm is incident normally on a single slit of width 0.2 mm to produce a diffraction pattern. Find the angular width of the central maxima obtained on the screen. [CBSE17]

Q12. A slit of width d is illuminated by red light of wavelength 6500Å. For what value of d will the first minimum fall at an angle of diffraction of 30˚. [CBSE09]

Q13. When the monochromatic light travels from one medium to another its wavelength changes but the frequency remains the same explain [CBSE 11]

Q14. State any two essential conditions for two light waves to be coherent.

Q15. How is the fringe width of an interference pattern in the young's double slit experiment affected if the two slits are brought close to each other? [CBSE 17]

Q16. How does the angular separation between the fringes in the single slit diffraction experiment changes when the distance of the separation between the slit and screen is doubled. [CBSE 12]

Q17. Name the shape of the wave front originating from a point source.

Q18. State the path difference between two waves of destructive interference.

Q19. What is the effect on the interference fringes in the Young's double slit experiment if the separation between two slits is increased?

MCQ

Q20. In a double slit experiment instead of taking slits of equal width, one slit is made twice as wide as other. Then the interference pattern

A) the intensity of both the maxima and the minima increase.

B) the intensity of the Maxima increases and the minimum has zero intensity.

C) the intensity of the maximum decreases and that of minima increases.

D) the intensity of Maxima decreases and the minimum has zero intensity.

Q21. To demonstrate the phenomenon of interference we require

A) two sources which emit radiation of the same frequency

B) two sources which emit radiation of nearly same frequency.

C) two sources which emit radiation of same frequency and have a constant phase difference

D) two sources which emit radiation of different wavelength.

Q22. A double slit experiment is performed with light of wavelength 500 mm a thin film of thickness to new m and refractive index 1.5 is introduced in the path of upper beam the location of the central maximum will

A) remain unshifted.

B) shift downward by 10 fringes.

C) shift downward by nearly two fringes.

D) shift upward by nearly two fringes.

Q23. A monochromatic beam of light is used for the formation of fringes on the screen by illuminating the two slits in the young's double slit interference experiment. When a thin film of mica is in interposed in the path of one of the interfering beams then

A) the fringe width increases.

B) the fringe width decreases.

C) the fringe width remains the same but pattern shifts.

D) the fringe pattern disappears.

Q24. In young's double slit experiment an electron beam is used to obtain the interference pattern if speed of electron is increased then

A) distance between two consecutive fringes will increase.

B) distance between two consecutive fringes will decrease.

C) no interference pattern will be observed.

D) distance between two consecutive fringes remain same.

Q25. Yellow light is used in a single slit diffraction experiment with slit width of 0.6 mm. lf yellow light is replaced by X-rays then the observed pattern will reveal

A) the central maximum is narrower.

B) more number of fringes.

C) less number of fringes.

D no diffraction pattern.

Q26. Maximum diffraction takes place in a given slit for

A) Gamma rays B) UV light C) infrared light D)radio waves

Q27. If I is the intensity of the principal maximum in the single slit diffraction pattern then what will be its intensity when the slit width is doubled?

A) I B) I/2 C) 2I D) 4I

Q28. What happens if one of the slits, say S_1 in Young's double, slit experiment-is covered with a glass plate which absorbs half the intensity of light from it?

A) The bright fringes become less-bright and the dark fringes have a finite light intensity

B) The bright fringes become brighter and the dark fringes become darker

C) The fringe width decreases

D) No fringes will be observed

Q29. What happens to the interference pattern the two slits S_1 and S_2 in Young's double experiment are illuminated by two independent but identical sources?

A) The intensity of the bright fringes doubled

B) The intensity of the bright fringes becomes four times

C) Two sets of interference fringes overlap

D) No interference pattern is observed

2 MARKS QUESTIONS

Q30. How does the width of interference fringes in young's double slit experiment change when?

i)The distance between the slit and the screen is decreased

ii)The frequency of the source is increased.

Q31. In young's double slit experiment, the two slits 0.15 mm apart are illuminated by a monochromatic light of wavelength 450 nm. The screen is 1m away from the slits.

a) Find the distance of the second (i) bright fringe(ii) dark fringe from the central maximum

b) How will the fringe pattern change if the screen is moved away from the slits? [CBSE 2010]

Q32. Why cannot two independent monochromatic sources produce sustained interference pattern? [CBSE 2015,19]

Q33. Does the appearance of bright and dark fringes in the interference pattern violate, in anyway, conservation of energy? Explain.

Q34. Why is no interference pattern observed when two coherent sources are

(i) infinitely closed to each other?

(ii) far apart from each other? [CBSE 2008]

Q35. What changes in the interference pattern in young's double slit experiment will be observed when?

(i) the apparatus is immersed in water?

(ii) light of smaller frequency is used? [CBSE 2004,09]

Q36. Laser light of wavelength 630 nm on appear of slits produces and interference pattern in which the bright fringes are separated by 8.1 mm. A second light produces and interference pattern in which fringes are separated by 7.2 mm. Calculate the wavelength of the second light

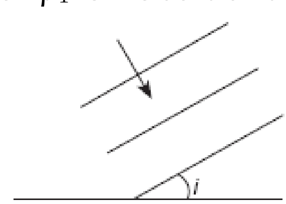
Q37. Yellow light of wavelength 6000A produces fringes of width 0.8 mm in young's double slit experiment. What will be the fringe width if the light source is replaced by another monochromatic source of wavelength 7500 A and the separation between the slits is doubled?

Q38. The light waves from two coherent sources have intensity in the ratio 4 : 9. Find the ratio of intensity of maxima and minima in the interference pattern. [CBSE 2017]

Q39. The ratio of intensity is at maxima and minima is 25:16. What will be the ratio of width of two slits in young's double slit experiment? [CBSE 2006]

3 MARKS QUESTIONS

Q40. A plane wavefront propagating in a medium of refractive index μ_1 is incident on a plane surface making the angle of incidence ***i*** as shown in the figure. It enters into a medium of refractive index μ_2 ($\mu_2 > \mu_1$). Use Huygens'



construction of secondary wavelets to trace the propagation of the refracted wavefront. Hence verify Snell's law of refraction.

Q41. How is a wavefront defined? Using Huygens's construction draw a figure showing the propagation of a plane wave reflecting at the interface of the two media. Show that the angle of incidence is equal to the angle of reflection.

Q42. Why cannot two independent monochromatic sources produce sustained interference patterns? Deduce, with the help of Young's arrangement to produce interference pattern, an expression for the fringe width.

Q43. The intensity at the central maxima (O) in a Young's double slit experiment is $\boldsymbol{I_o}$. If the distance OP equals one-third of the fringe width of the pattern, show that the intensity at point P would be $\frac{I_0}{4}$.

Q44. How is Huygens's principle used to obtain the diffraction pattern due to a single slit? Show the plot of variation of intensity with angle and state the reason for the reduction in intensity of secondary maxima compared to central maximum.

Q45. In a double slit interference experiment, the two coherent beams have slightly different intensities I and $I + \delta I$ ($\delta I << I$). Show that the resultant intensity at the maxima is nearly $4I$ while that at the minima is nearly $\frac{|\delta I|^2}{4I}$.

Q46. In a single slit diffraction pattern, how does the angular width of central maximum change, when (i) width of slit is decreased (ii)distance between slit and screen is increased (iii) light of smaller visible wavelength is used?

Q47. Light of wavelength 550 nm is incident as parallel beam on a slit of width 0.1 mm. Find the angular width and the linear width of the principal maxima in the resulting diffraction pattern on a screen kept at a distance of 1.1 m from the slit, which of these width would not change if the screen were moved to a distance of 2.2 m from the slit?

Q48. What is diffraction of light? Differentiate between diffraction and interference.

Q49. Yellow light (λ = 6000 Å) illuminates a single slit of width 1 x 10^{-4}m. Calculate the distance between two dark lines on either side of central maximum when the diffraction pattern is viewed on a screen kept 1.5 m away from the slit.

5 MARKS QUESTIONS

Q50. (a) State Huygens's principle. Using this principle draw a diagram to show how a plane wavefront incident at the interface of the two media gets refracted when it propagates from rarer to a denser medium. Hence verify Snell's law of refraction.

(b) When monochromatic light travels from a rarer to a denser medium, explain the following, giving reasons:
(i) Is the frequency of reflected and refracted light same as the frequency of incident light?
(ii) Does the decrease in speed imply a reduction in the energy carried by light wave?

Q51**.** (a) (i) 'Two independent monochromatic sources of light cannot produce a sustained interference pattern'. Give reason.
(ii) Light waves each of amplitude a and frequency *n*, emanating from two coherent light sources superpose at a point. If the displacements due to these waves is given by $y_1 = a$ cos t and $y_2 = a$ cos (ωt + ϕ), what is the phase difference between the two, obtain the expression for the resultant intensity at the point.
(b) In Young's double slit experiment, using monochromatic light of wavelength, the intensity of light at a point on the screen where path difference is, is *K* units. Find out the intensity of light at a point where path difference is $\frac{\lambda}{3}$.

Q52. (a) In Young's double slit experiment, describe briefly how bright and dark fringes are obtained on the screen kept in front of a double slit. Hence obtain the expression for the fringe width.
(b) The ratio of the intensities at minima to the maxima in the Young's double slit experiment is 9 : 25. Find the ratio of the widths of the two slits.

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SECTION A (ANSWER KEY)

1 MARK QUESTIONS

1 $A_R = \sqrt{[A_1^2 + A_2^2 + 2A_1 A_2 \cos\phi]}$

$= \sqrt{[A^2 + (2A)^2 + 2A \times 2A \cos \pi/3]}$

$= \sqrt{7}\, A$

2 The resultant intensity at a point where phase difference is ϕ is

$I_R = I_1 + I_2 + 2[\sqrt{I_1 I_2}]\cos\phi$

$I R = I + 4I + 2[\sqrt{I.4I}] \cos\phi = 5I + 4I \cos\phi$

When $\phi=0$, $I R = 5I+4I \cos 0 = 9I$.

3 When $p = \lambda/4$, $\phi = \pi/2$

Therefore, $I = 4I_0 \cos^2 \pi/4 = 4I_0 \times ½ = 2I_0 = k/2$.

4 When $p = \lambda/6$, $\phi = \pi/3$ so $I=I_0 \cos^2 \pi/6 = 3I_0/4$.

5 Intensity at any point of an interference pattern is given by $I=2 I_0 (1+\cos \phi)$

Where I_0 is the intensity of either wave.

Here $\phi_P = 0$,

$\Phi_Q = 2\pi\, p/\lambda = 2\pi\, (\lambda/4) / \lambda = 90^\circ$

Therefore, $I_P / I_Q = [1 + \cos \phi_P] / [1 + \cos \phi_Q]$

$= [1 + \cos 0] / [1 + \cos 90^\circ]$

$= [1 + 1] / [1 + 0] = 2/1 = 2:1$

6 Here $\lambda_1 = 630$ nm, $\beta_1 = 8.1$mm,

$\beta_2 = 7.2$mm, $\lambda_2 = ?$

Fringe width, $\beta = D\lambda/d$

$\beta_2 / \beta_1 = \lambda_2 / \lambda_1$

Therefore, $\lambda_2 = [\beta_2 / \beta_1] \times \lambda_1$

$= 7.2\text{mm} / 8.1\text{mm} \times 630\text{nm} = 560\text{nm}$.

7 Here, $\beta = 2.0$mm, $\mu = 1.33$

Refractive index of liquid,

μ = wavelength of light in vacuum/wavelength of light in liquid $= \lambda_v / \lambda_i$

$\lambda' = \lambda / \mu$

Fringe width in air,

$B = D\lambda/d$

Fringe width in liquid,

$\beta' = D\lambda'/d = D\lambda/d\mu = \beta/\mu = 2.0mm/1.33 = 1.5mm$

8 $X = n\lambda_1 D/d = (n+1)\lambda_2 D/d$

$n\lambda_1 = (n+1)\lambda_2$

$n = 3$

therefore, $x = 3D\lambda_1/d = 12mm$

9 In first case, $X = D_1\lambda_1/d$

In second case, $X = D_2\lambda_2 / d/2$

Therefore, $D_1\lambda_1/d = D_2\lambda_2 / d/2$

$D_1/D_2 = 2\cdot\lambda_2/\lambda_1 = 2 \times 600/400 = 3/1 = 3:1$

10 position of 1 st minimum $x_1 = D\lambda / d$

Slit width d= 0.24 mm

11 Angular width of central maximum

$2\theta = 2\lambda / d$

12 $d \sin\theta = \lambda$

$D = 1.3 \times 10^{-6}$ m

13 Frequency is the characteristics of the source while wavelength is the characteristics of medium when monochromatic light travels from one medium to another its speed changes so it's wavelength changes but frequency remain same.

14 1. The two rays must be continuous.

2. They should have a constant or zero phase difference.

15 $B = D\lambda / d$

As the separation D between the two slits decreases French width increases

16 When the distance between the slit and the screen is double the angular separation remains unchanged

17 spherical wave front

18 Path difference$\Delta = [2n+1]\lambda/2$

Where n = 0,1,2.....

19 Both the fringe width and angular separation decreases.

MCQ ANSWERS

20. A
21. C
22. D
23. C
24. B
25. D
26. D
27. D
28. A
29. D

ANSWERS OF 2 MARKS QUESTIONS

30. Fringe width = $D\lambda$ / d = Dc/dν

    i)When D decreases fringe width decreases.

    ii) When the frequency ν is increased fringe width increases.

31. (a)(i) Distance of nth bright fringe from central maximum = $nD\lambda$ / d = 6mm

    (ii) Distance of nth dark fringe from central maximum = $[2n-1]D\lambda$ /2 d = 4.5 mm

    (b) when D increases fringe width increases

32. (i)Light is emitted by the individual items and not by the bulk of matters acting as a whole.

    (ii)Even the tiniest source consists of millions of atoms and the emission of light by them takes place independently.

    (iii) Even an atom emits and unbroken wave of about 10^{-8} second due to its transition from higher energy state to lower energy state.

    The millions of atoms of a source cannot emit wave in the same phase. The face difference and hence the interference pattern changes 10 times in 1 second. Our eyes cannot see such rapid changes and a uniform illumination is seen on the screen. So independent light sources cannot produce a sustained interference.

33. In an interference pattern the average intensity is at the point of maxima and minimum are such that

I(average) α $a_1^2 + a_2^2$

If there is no interference between the light waves from the two sources then the intensity at every point would be same that is

$I = I_1 + I_2 \ \alpha \ a_1^2 + a_2^2$

Which is same as I (average) in the interference pattern. So, there is no violation of law of conservation of energy in the interference.

34. Fringe width is inversely proportional to distance between two slits.

(i) when the two coherent sources are placed in finitely close to each other the fringe width becomes very large. Even a single fringe may occupy the entire screen. The interference pattern is not observable.

(ii) as the distance between the sources is increased the French with goes on decreasing. At very large separation it becomes too small to be detected. The interference pattern cannot be observed.

35. Fringe width $\beta = D\lambda / d = Dc/d\nu$

(i) wave length of light in water decreases so fringe width decreases.

(ii)When light of small frequency is used, fringe width increases.

36. Fringe width $\beta = D\lambda / d$

$\lambda_1 / \lambda_2 = \beta_1 / \beta_2$

$\lambda_2 = \lambda_1\beta_2 / \beta_1 = 7.2 \times 630/8.1 = 560$nm

37. $\frac{\beta 2}{\beta 1} = \frac{D\lambda 2/2d}{D\lambda 1/d} = \lambda_2 / 2\lambda_1$

β_2 = [7500 x 0.8] / [2 x 6000] = 0.5 mm

38. Ratio $r = a_1 / a_2 = \sqrt{[I_1 / I_2]} = \sqrt{[4/9]} = 2/3$

$\frac{I_{max}}{I_{min}} = [\frac{r+1}{r-1}]^2 = 25:1$

39. Λ = 6000 Å , a = 1 x 10^{-4}m , D = 1.5m

The distance between two dark lines on either side of central maximum = width of central maximum= $2\lambda D/a$ = (2x6000 x 10^{-10}x 1.5) / (1 x 10^{-4})

=1.8 x 10^{-2}m= 1.8cm

3 MARKS QUESTIONS ANSWERS

40.

If v_1 and v_2 are the speeds of light in media 1 and 2 respectively, then distance travelled by light in a small time internal τ in two media will $BC = v_1\tau$ and $AE = v_2\tau$ respectively.

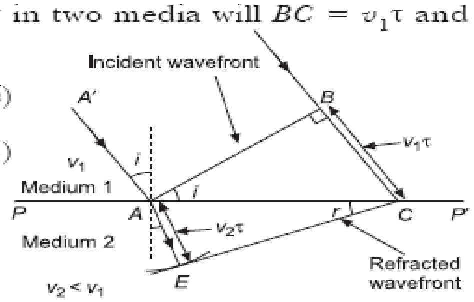
In ΔABC, $\quad \sin i \;=\; \dfrac{BC}{AC} = \dfrac{v_1\tau}{AC} \qquad \ldots(i)$

In ΔAEC, $\quad \sin r \;=\; \dfrac{AE}{AC} = \dfrac{v_2\tau}{AC} \qquad \ldots(ii)$

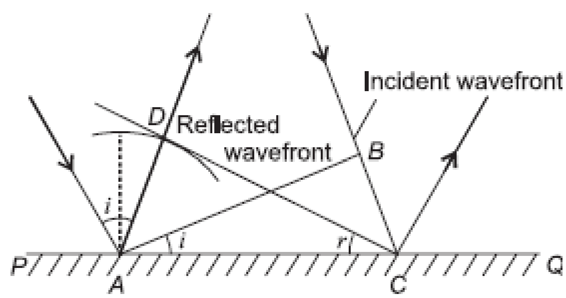
Combining equations (i) and (ii), we get

$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \mu_{21}$$

The above relation is known as Snell's law.



41. A wavefront is the locus of all points oscillating in same phase. A figure showing reflection of a plane wavefront using Huygen's construction is given below. In the figure AB is incident wavefront and *CD* is reflected wavefront. If *v* is speed of the wave in the medium and t is the time taken by the wavefront to cover distance *BC*, then



$$BC = vt$$

Obviously, $\quad AD = vt$

As ΔABC and ΔADC are congruent.

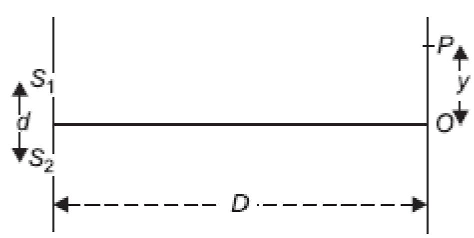
$\therefore \quad \angle i = \angle r$

42

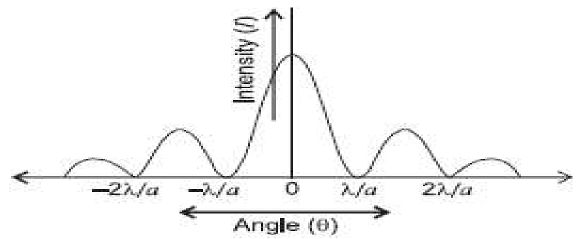
Given: $\quad y = \dfrac{\lambda D}{3d}$

As $\quad \Delta P = \dfrac{yd}{D} \;\Rightarrow\; \Delta P = \dfrac{\lambda}{3} \quad$ or $\quad \Delta\phi = \dfrac{2\pi}{3}$

$\therefore \quad I = I_0 \cos^2 \Delta\phi = I_0 \left(\cos\dfrac{2\pi}{3}\right)^2 = \dfrac{I_0}{4}$



44. When a plane wavefront is incident on a single slit, all the point sources of light constituting the wavefront are in same phase. The wavelets coming out from the wavefront might meet over the screen with some path difference, i.e., a phase difference is introduced between them.The brightness at a point on the screen depends on the phase difference between the wavelets meeting at the point. We imagine that the slit is divided into smaller parts and the wavelets coming out from these portions meet and superpose on the screen with proper phase difference.



The wavelets from different parts of the wavefront, incident on the slit, meet with zero phase difference to constitute a central maximum. In case of secondary maxima, there are some wavelets meeting the screen out of phase, thus, reducing intensity of secondary maxima.

45.

The resultant intensity is given by

$$I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\ \cos\phi,\ \text{where } I_1 = I,\ I_2 = I + \delta I$$

At maxima, $\cos\phi = 1$

$$\therefore \quad I_{max} = I + I + \delta I + 2\sqrt{I(I+\delta I)}$$

$$\therefore \quad I_{max} = 2I + 2I = 4I \qquad (\because\ \delta I << I)$$

At minima, $\cos\phi = -1$

$$I_{min} = I + I + \delta I - 2\sqrt{I(I+\delta I)}$$

$$I_{min} = 2I + \delta I - 2\left[I^2\left(1 + \frac{\delta I}{I}\right)\right]^{1/2} = 2I + \delta I - 2I\left[1 + \frac{1}{2}\frac{\delta I}{I} - \frac{1}{8}\left(\frac{\delta I}{I}\right)^2 + \ldots\right]$$

Neglecting the higher power, we get $I_{min} = \dfrac{2I}{8}\left(\dfrac{\delta I}{I}\right)^2 = \dfrac{1}{4}\dfrac{(\delta I)^2}{I}$

46. Linear width of central maximum β= 2Dλ/d

Angular width of central maximum β/D = 2λ/d

(i) When slit width d decreases, angular width increase.

(ii) When distance D between the slit and screen is increased, angular width does not change.

(iii) When light of smaller wavelength is used, angular width decreases.

47. λ=550 nm, d= 0.1 mm,D = 1.1m, ω = ?, β = ?

using ω = 2θ= 2λ/d, we get ω= .011 rad

using $\beta = 2\lambda D/d$,we get $\beta = 12.1$ mm

When the screen is moved to 2.2 m from the slit, the angular width will not change, linear width will increase.

48. Diffraction of light is the phenomenon of bending of light round the corners of an opaque obstacle and spreading into the regions of the geometrical shadow.

Diffraction	Interference
The phenomenon of interaction of light coming from different parts of the same wave front is called diffraction.	The phenomenon of non-uniform distribution of light energy (wave) due to the superposition of coherent sources of light is called interference.
In diffraction, the widths of fringes are not equal.	In interference, the width of fringes are equal.
Bands are very less in number.	Bands are very large in number.
Dark fringes in diffraction are not completely dark.	Dark fringes in interference are perfectly dark.

49. $\lambda = 6000$ Å , $a = 1 \times 10^{-4}$m , $D = 1.5$m

The distance between two dark lines on either side of central maximum = width of central maximum= $2\lambda D/a = (2 \times 6000 \times 10^{-10} \times 1.5) / (1 \times 10^{-4})$

$= 1.8 \times 10^{-2}$m= 1.8cm

i.e. $\sin\theta = \dfrac{\Delta P}{a}$

From $\Delta QOO'$, $\tan\theta = \dfrac{Y}{D}$

For a small angle, $\sin\theta \approx \tan\theta$ i.e. $\Delta P = \dfrac{Ya}{D}$

For bright fringes, $\Delta P = n\lambda$

Thus, $\dfrac{Y_n a}{D} = n\lambda \Rightarrow Y_n = \dfrac{n\lambda D}{a}$

For dark fringes, $\Delta P = (2n-1)\dfrac{\lambda}{2}$

Thus, $\dfrac{Y'_n a}{D} = (2n-1)\dfrac{\lambda}{2} \Rightarrow Y'_n = \dfrac{(2n-1)D\lambda}{2a}$

The separation between two consecutive dark or bright fringes is called fringe width.

i.e., $\beta = Y_n - Y_{n-1} = \dfrac{n\lambda D}{a} - \dfrac{(n-1)\lambda D}{a} = \dfrac{\lambda D}{a}$

Here β is the fringe width.

(b) Given: For an interference pattern, $\dfrac{I_{\min}}{I_{\max}} = \dfrac{9}{25}$, $\dfrac{I_1}{I_2} = ?$

Here $\dfrac{I_1}{I_2} = \dfrac{a_1^2}{a_2^2}$ and $\dfrac{I_{\min}}{I_{\max}} = \dfrac{\left(\dfrac{a_1}{a_2}-1\right)^2}{\left(\dfrac{a_1}{a_2}+1\right)^2}$

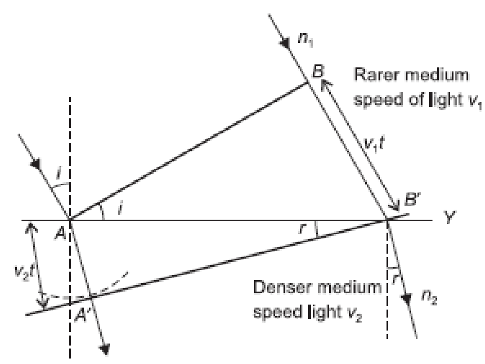
$$\therefore \quad \frac{\left(\dfrac{a_1}{a_2}-1\right)^2}{\left(\dfrac{a_1}{a_2}+1\right)^2} = \frac{9}{25} \Rightarrow \frac{\dfrac{a_1}{a_2}-1}{\dfrac{a_1}{a_2}+1} = \frac{3}{5}$$

$$\Rightarrow \quad 3\left(\frac{a_1}{a_2}+1\right) = 5\left(\frac{a_1}{a_2}-1\right) \Rightarrow \frac{a_1}{a_2} = 4$$

$$\therefore \quad \frac{I_1}{I_2} = \frac{a_1^2}{a_2^2} = \frac{16}{1}$$

5 MARKS QUESTIONS

50. (a) According to the Huygens's principle, each point of the wavefront is the source of secondary disturbance and the wavelets emanating from these points spread out in all directions with the speed of the wave. A common tangent to all the wavelets in the forward direction gives the new position of



wavefront at a later time.

From $\Delta ABB'$, $\quad \sin i = \dfrac{BB'}{AB'} = \dfrac{v_1 \times t}{AB'}$ $\quad \ldots(i)$

From $\Delta AA'B'$, $\quad \sin r = \dfrac{AA'}{AB'} = \dfrac{v_2 \times t}{AB'}$ $\quad \ldots(ii)$

$\therefore \quad \dfrac{\sin i}{\sin r} = \dfrac{v_1}{v_2}$

We know $\quad n_1 = \dfrac{c}{v_1}$ and $n_2 = \dfrac{c}{v_2}$

where n_1 and n_2 are the refractive indices of the 1^{st} and 2^{nd} media.

So, $\quad n_1 \sin i = n_2 \sin r$

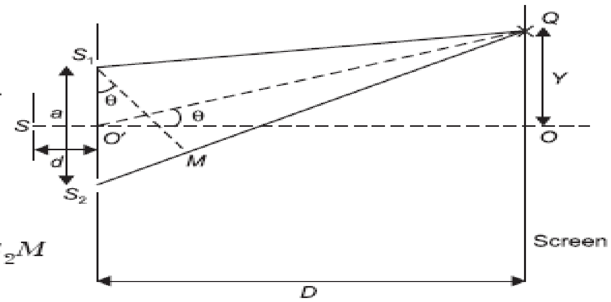
which is Snell's law of refraction.

(b) (i) Frequency remains the same. When the light of particular frequency is incident it interacts with the atoms of the matter, which further causes forced oscillations. As the frequency of charged oscillator and the frequency of wave emitted by charged oscillator is same, therefore the frequency of reflected and refracted light is same.
(ii) No, energy carried by a light wave does not depend on its speed. Instead it depends on its amplitude.

51. (a) (i) 'Two independent monochromatic sources of light cannot produce a sustained interference pattern'. Give reason.
(ii) Light waves each of amplitude a and frequency *n*, emanating from two coherent light sources superpose at a point. If the displacements due to these waves is given by $y_1 = a \cos t$ and $y_2 = a \cos (\omega t + \phi)$, what is the phase difference between the two, obtain the expression for the resultant intensity at the point.
(b) In Young's double slit experiment, using monochromatic light of wavelength, the intensity of light at a point on the screen where path difference is, is *K* units. Find out the intensity of light at a point where path difference is $\dfrac{\lambda}{3}$.

52.

(*a*) When waves from the slits meet at a point on the screen with same phase, the maxima are obtained and with a phase difference of π, the minima are obtained. According to the Young's experiment, the path difference between the waves is given by



$$\Delta P = S_2Q - S_1Q = S_2M$$

i.e. $\sin\theta = \dfrac{\Delta P}{a}$

From $\Delta QOO'$, $\tan\theta = \dfrac{Y}{D}$

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For dark fringes, $\Delta P = (2n-1)\dfrac{\lambda}{2}$

Thus, $\dfrac{Y'_n a}{D} = (2n-1)\dfrac{\lambda}{2} \Rightarrow Y'_n = \dfrac{(2n-1)D\lambda}{2a}$

The separation between two consecutive dark or bright fringes is called fringe width.

i.e., $\beta = Y_n - Y_{n-1} = \dfrac{n\lambda D}{a} - \dfrac{(n-1)\lambda D}{a} = \dfrac{\lambda D}{a}$

Here β is the fringe width.

(*b*) Given: For an interference pattern, $\dfrac{I_{\min}}{I_{\max}} = \dfrac{9}{25}$, $\dfrac{I_1}{I_2} = ?$

Here $\dfrac{I_1}{I_2} = \dfrac{a_1^2}{a_2^2}$ and $\dfrac{I_{\min}}{I_{\max}} = \dfrac{\left(\dfrac{a_1}{a_2}-1\right)^2}{\left(\dfrac{a_1}{a_2}+1\right)^2}$

$$\therefore \quad \frac{\left(\dfrac{a_1}{a_2}-1\right)^2}{\left(\dfrac{a_1}{a_2}+1\right)^2} = \frac{9}{25} \Rightarrow \frac{\dfrac{a_1}{a_2}-1}{\dfrac{a_1}{a_2}+1} = \frac{3}{5}$$

$$\Rightarrow \quad 3\left(\frac{a_1}{a_2}+1\right) = 5\left(\frac{a_1}{a_2}-1\right) \Rightarrow \frac{a_1}{a_2} = 4$$

$$\therefore \quad \frac{I_1}{I_2} = \frac{a_1^2}{a_2^2} = \frac{16}{1}$$

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SECTION B

1 MARK QUESTIONS

Q1. What is interference of light? Give an example of interference of light in everyday life.

Q2. Why are coherent sources necessary to produce a sustained interference pattern?

Q3. State the path difference between two waves of constructive interference.

Q4. Draw a diagram to show refraction of a plane wave front incident in a convex lens and hence draw the refracted wave front.

Q5. How would the angular separation of interference fringes in Young's double slit experiment change when the distance between the slits and screen is doubled?

Q6. In a single-slit diffraction experiment, the width of the slit is made double the original width. How does this affect the size and intensity of the central diffraction band. (CBSE 2012]

Q7. Define the term 'coherent sources' which are required to produce interference pattern in Young's double slit experiment.

Q8. One of the slits of Young's double-slit experiment is covered with a semi-transparent paper so that it transmits lesser light. What will be the effect on the interference pattern?

Q9. Draw a graph showing the intensity distribution of fringes due to diffraction at a single-slit. [CBSE 2018]

MCQ

Q10. A single slit diffraction pattern is obtained using a beam of red light What happened the red light is replaced by the blue light?

A) There is no change in diffraction pattern

B) Diffraction fringes become narrower and crowded

C) Diffraction fringes become broader and farther apart

D) The diffraction pattern disappears

Q11. In Young's double slit experiment, a maximum is obtained when the path difference between the interfering waves is:

A) $n\lambda$ B) $n\ \lambda/2$ C) $(2n + 1)\ \lambda/2$ D) $(2n - 1)\ \lambda/4$

Q12. For sustained interference, we need two sources which emit radiations :

A) of the same intensity

B) of the same amplitude

C) having a constant phase difference

D) None of these

Q13. Two sources of light are said to be coherent when both give out light waves of the same:

A) amplitude and phase

B) intensity and wavelength

C) speed

D) wavelength and a constant phase difference

Q14. The intensity of light emerging from the two slits, in Young's experiment is in the ratio 1 : 4. The ratio of the intensity of the minimum to that of the consecutive maximum will be:

A) 1 : 4 B) 1 : 9 C) 1 : 16 D) 2 : 3

Q15. Which of the following is conserved when light waves interfered?

A) phase B) intensity C) amplitude D) none of these

Q16. In Young double slit experiment, a minimum is obtained when the phase difference of the superposing waves, is :

A) $n\pi$ B) $(n + 1/2)\pi$ C) $(2n + 1)\pi$ D) zero

Q17. The fringe width (β) of a diffraction pattern and the slit width d are related as:

A) $\beta \propto d$ B) $\beta \propto 1/d$ C) $\beta \propto \sqrt{d}$ D) $\beta \propto 1/d^2$

Q18. In Young's double slit experiment, the central point on the screen is:

A) bright B) dark C) first bright and later dark

D) first dark and later bright

Q19. In Young's double slit experiment the distance between the slit and the screen is doubled and the separation between the slit is reduced to half. The fringe width:

A) is doubled B) become four time C) is halved D) remain unchanged

2 MARKS QUESTIONS

Q20. Write two points of difference between interference and diffraction?

Q21. Draw the shape of the reflected wavefront when a plane wavefront is an incident on

(a) a concave mirror.

(b)a prism.

Q22. What is a sustained interference pattern? State the necessary conditions forobtaining a sustained interference of light.

Q23. State with reason how would linear with of central maxima change if

(i) monochromatic yellow light is replaced with red light and

(ii) distance between the slit and the screen is increased.

Q24. How is the width of central maxima affected if

(i)width of the slit is doubled

(ii) the wavelength of the light is increased

What happens to the width of central maxima if the whole apparatus is immersed in water and why?

3 MARKS QUESTIONS

Q25. A parallel beam of light of wavelength 600nm is incident normally on a slit of width ‘a’. If the distance between the slit and the screen is 0.8m and the distance of second order maximum from the centre of the screen is15mm, calculate the width of the slit.

Q26. A beam of light consisting of two wavelengths 6500 A^o and 5200 A^o is used to obtain interference fringes. The distance between the slits is 2.0 mm and the distance between the plane of the slits and the screen is 120 cm.

(a) Find the distance of the third bright fringe on the screen from the central maxima for the wavelength 6500A^o

(b) What is the least distance from the central maxima where the bright fringes due to both the wavelengths coincide?

Q27. Monochromatic light from a narrow-slit illuminates two narrow slits 0.3 mm apart producing an interference pattern with bright fringes 1.5 mm apart on a screen 75 cm away. Find the wavelength of the light. How will the fringe width be altered if-

i) the distance of the screen is doubled

ii) the separation between the slits is doubled.

5 MARKS QUESTIONS

Q28. (a) Using Huygens's construction of secondary wavelets explain how a diffraction pattern is obtained on a screen due to a narrow slit on which a monochromatic beam of light is incident normally.

(b) Show that the angular width of the first diffraction fringe is half that of the central fringe.

(c) Explain why the maxima at $\theta = \left(n + \frac{1}{2}\right)\frac{\lambda}{a}$ become weaker with increasing *n*.

Q29. (a) Write three characteristic features to distinguish between the interference fringes in Young's double slit experiment and the diffraction pattern obtained due to a narrow single slit.

(b) A parallel beam of light of wavelength 500 nm falls on a narrow slit and the resulting diffraction pattern is observed on a screen 1 m away. It is observed that the first minimum is a distance of 2.5 mm away from the centre. Find the width of the slit.

Q30. (a) Distinguish between interference and diffraction.

(b) A monochromatic light of wavelength 500 nm is incident normally on a single slit of width 0.2 mm to produce a diffraction pattern. Find the angular width of central maximum obtained on screen.

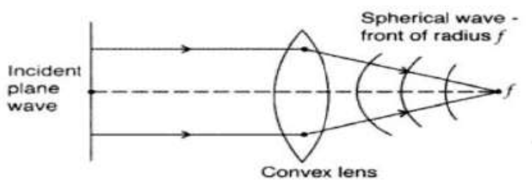
****

SECTION-B ANSWERS

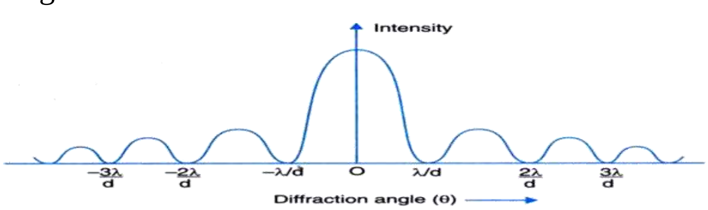
1 MARKS

1. When two light waves of same frequency and having zero or constant phase difference travelling in the same direction superpose each other , the intensity in the region of superposition gets redistributed becoming minimum at some points and maximum at others. This phenomenon is called interference of light.

   Example :When thin soapy water films (or other thin films) are exposed to white light ,they exhibit colours due to interference.
2. Coherent sources have a constant phase difference this ensures that the position of maxima and minima do not change with time. Hence sustained interference pattern is obtained.
3. Path difference$\Delta = n\,\lambda$

   Where n = 0,1,2.....
4. 

5. Angular separation $\theta = \lambda/d$ and it is independent of slit-screen separation

   $\therefore$ There will be no change
6. If the width of the diffraction slit is doubled, the size of the central diffraction band will become half and its intensity will become four times of its original value.
7. The source which emits a light wave with the same frequency, wavelength and phase or having a constant phase difference is known as a coherent source.
8. There will be an interference pattern whose fringe width is the same as that of the original. But there will be a decrease in the contrast between the maxima and the minima, i.e. the maxima will become less bright and the minima will become brighter.
9. 

MCQ

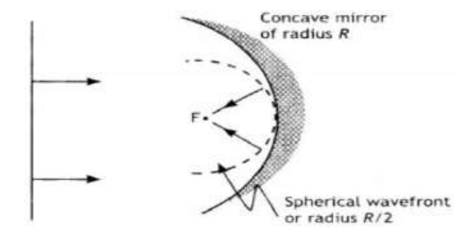
10. B
11. A
12. C
13. D
14. B
15. D
16. C
17. B
18. A
19. B

2 MARKS

20.

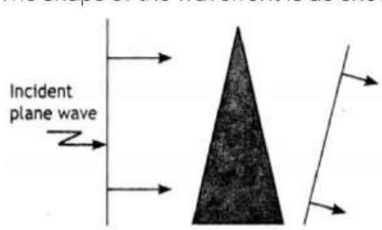
Interference	Diffraction
Interference occurs due to superposition of light coming from two coherent sources.	It is due to the superposition of the waves coming from different parts of the same wave front
All bright fringes are of equal intensity	The intensity of bright fringes decreases with increasing distance from the central bright fringes.

21.



(a)

The shape of the wavefront is as shown.



(b)

22. Sustained interference means the positions of that maxima and minima of light intensity do not change with time throughout the screen.

Conditions for sustained interference :

1The two sources should continuously emit waves of same frequency or wavelength.

2The two sources of light should be coherent.

3The two sources of light should be narrow.

4The two sources of light should be monochromatic.

5The interfering wave must travel nearly along same direction.

23. The linear width of central maxima β_0 =2Dλ /a

(i)It is replaced with red light the linear width of Central Maxima increases because λ red > λyellow

(ii) If D is increased linear width of Central maximum increases.

24. The linear width of central maxima β_0 = 2D λ /a

(i)When wavelength of light is increased the width of central maxima increases

(ii)When width of slit increase the width of central maxima decreases.

As the wavelength of light in water decreases so the width of central maxima also decreases.

3MARKS

25.

Λ = 600nm , D = 0.8m

The distance of second order maximum from the centre of the screen = 15mm = 15X10^{-3}m

$$a = \frac{n\lambda}{\sin\theta} = \frac{n\lambda D}{x}$$

$$a = \frac{(2x600x10^{-9}x0.9)}{15x10^{-3}} = 6.4x10^{-5}m$$

26. (a) y3 = n. Dλ/d

= 3 x 1.2m x 6500 x 10-10m / 2 x 10-3m

= 0.12cm

(b) Let nth maxima of light with wavelength 6500 Å coincides with that of mth maxima of 5200Å.

m x 6500Ao x D/d = n x 5200A° x D/d

m/n = 5200/6500

= 4/5

Least distance = y4 = 4.D (6500Ao)/d

= 4 x 6500 x 10-10 x 1.2/ 2 x 10-3m

= 0.16cm.

27. Given:

d = 0.3 mm = 3 x10^{-4}m

X = 1.5 mm = 1.5x10^{-3}m

D = 75 cm = 0.75 m.

To find wavelength: -

λ= X d /D

=1.5 x 10^{-3} x 3 x 10^{-4}/ 0.75

= 6 x 10^{-7}m

= 6000 A.U.

1) If distance of screen is doubled.

We have X = λ D/d and

X'= λ D'/d

$\frac{X'}{X} = \frac{D'}{D}$

$\frac{X'}{X} = \frac{2D}{D}$

$\frac{X'}{X} = 2$

= 2 x 1.5 x 10^{-3}

= 3 x 10^{-3}m

= 3 mm

2) If separation between the slits is doubled

We have $X = \lambda D/d$

$$\frac{X'}{X} = \frac{d}{d'}$$

$$\frac{X'}{X} = \frac{d}{2d}$$

$$\frac{X'}{X} = 1/2$$

$= X/2$

$= 1.5 \times 10^{-3}/2$

$= 0.75 \times 10^{-3}$m

5 MARKS

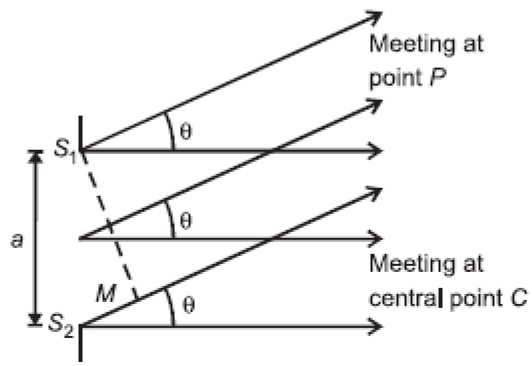
28.

a)

We treat each point on the wavefront at the slit, as secondary sources [Using Huygen's principle].

As the incoming wavefront is parallel to the plane of the slit, these sources are in phase [using Huygen's principle]. The path difference between the waves coming out from the two edges of the slits is $S_2P - S_1P = S_2M$.

$\therefore \quad S_2M = a \sin\theta \approx a\theta$



[We are taking parallel beam of light because angles are very small]

For any two point sources, S_1 and S_2 in the plane of the slit having a separation y, the path difference would be

$$S_2P - S_1P \approx y\theta \quad \text{i.e. } \Delta P \approx y\theta$$

As the initial phase difference is zero, the phase difference between the waves is introduced only due to this path difference.

For the central point on the screen, $\theta = 0 \Rightarrow \Delta P = 0$

i.e. $\quad \Delta\phi = 0$

All the parts of the slit contribute in phase. So, the maximum intensity is obtained at C.

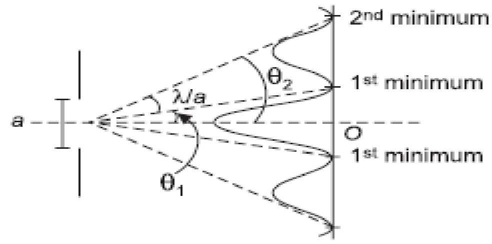
b)

$\therefore \qquad \theta_1 = \frac{\lambda}{a}$

For 2^{nd} minimum, $\theta_2 = \frac{2\lambda}{a}$

Angular width of 1^{st} secondary maximum,

$$\Delta\theta = \frac{2\lambda}{a} - \frac{\lambda}{a} = \frac{\lambda}{a}$$



The central fringe lies between 1^{st} minima on both sides of the central maximum. Hence, the angular width of central fringe is given by $2\theta = \frac{2\lambda}{a}$

Hence, the angular width of central fringe is twice the angular width of first fringe.

(c) The maxima become weaker and weaker with increasing n. This is because the effective part of the wavefront, contributing to the maxima, becomes smaller and smaller, with increasing n.

29. (a) (i) Interference is the superposition of light waves from two different wavefronts originating from the same source, while the diffraction is the interaction of light waves from different parts of the same wavefront.

(ii) In an interference pattern, fringes may or may not be of the same width, while in diffraction pattern, they are never of the same width.

(iii) In an interference pattern, bright fringes are of uniform intensity, while in diffractions pattern, they are of varying intensity.

(b) Given: $\lambda = 5 \times 10^{-7}$ m, $D = 1$ m, $y = 2.5 \times 10^{-3}$m

We know that the half of the width of the central maximum, $y = \frac{\lambda}{a}D$

$\Rightarrow 2.5 \times 10^{-3} = \frac{5 \times 10^{-7}}{a} \times 1$

$\therefore a = 2 \times 10^{-4}$ m or 200 μm

30. (a)

Interference	Diffraction
It is due to superposition of two Waves coming from coherent sources.	It is due to superposition of secondary wavelets originating from different parts of same wavefront.
Width of interference bands is equal	Width of diffraction bands is unequal
Intensity of all fringes is same	Central maxima is bright but intensity decreases with increase in order of maximum.

(b) given λ= 500 nm & a= 0.2 mm,

we have) ω = 2λ/a, ω= .005 rad

SECTION C

1 MARK QUESTIONS

Q1. Draw the type of wave front that corresponds to a beam of light diverging from a point source.

Q2. When monochromatic light is incident on a surface separating two media the reflected and refracted light both have same frequency as the incident frequency. Explain why. [CBSE 2011,13,16]

Q3. Draw intensity distribution curve for interference.

Q4. Sketch the wave front emerging from (a) a point source of a light and (b) linear source of light like a slit. [CBSE2000,09]

Q5. When a light travel from a rare to a denser medium, it loses some speed does the reduction in speed imply a reduction in the energy carried by the light wave? [CBSE 2013,16,17]

Q6. In the wave picture of light, intensity of light is determined by the square of amplitude of the wave. What determines the intensity of light in the photon picture of light? [CBSE 16]

Q7. How will the intensity of maxima and minima in the young's double slit experiment change if one of the two slits is covered by a transparent paper which transmits only half of the light intensity?

MCQ

Q8. In a Young's double slit experiment the distance between the slit is 1 mm and the distance of screen from the slit is 1 m. If light of wavelength 6000 A is used then the fringe width is:
A) 0.4 mm B) 0.5 mm C) 0.6 mm D) 0.8 mm

Q9. A phase difference of 5π corresponds to a path difference (in terms of λ) of:
A) 5λ B) 10λ. C) $5\lambda/2$ D) 2λ

Q10. Images of a distant lamp seen through a fire cloth rotate on rotating the cloth. This is due to the phenomenon of:
A) interference B) diffraction C) polarization D) scattering

Q11. The phenomenon of interference of light is based on the principle of
A) Polarisation of light waves B) Dispersion of light waves
C) Principle of superposition D) Huygens principle

Q12. The locus of all points which oscillates in phase is called as
A) Waves B) Wave front C) Wavelets D) Both b and c

Q13. The energy of the wave travels in a direction __ to the wavefront.
A) Parallel B) Perpendicular C) Both a and b D) None

Q14. Each point of the wave front is the source of secondary disturbance and the wavelets originating from these points spread out

A) In only one direction

B) In all directions with the speed of wave

C) In all directions

D) None

Q15. Each point of the wave front is the source of secondary disturbance and the wavelets originating from these points spread out in all directions with the speed of wave, this is called as

A) Principle of superposition B) Huygens principle

C) Polarization D) None

Q16. At particular point in the medium, the resultant displacement produced by a number of waves is the __ of all the displacement produced by each of the waves.

A) Algebraic sum B) Vector sum C) Both a and b D) None

Q17. When the phase difference between the displacement produced by the waves does not change with time then that two sources are called as

A) Incoherent sources B) Coherent sources C) Collinear sources D) None

2 MARKS QUESTIONS

Q18. State the condition for diffraction of light to occur in the diffraction of single slit experiment, how would the width an intensity of central maxima changes if

(i) slit with is halved and

(ii) visible light of longer wavelength is used

Q19. How will the angular separation and visibility of fringes in Young's double slit experiment change when (i) screen is moved away from the plane of the slits, and (ii) width of the source slit is increased

Q20. What two main changes in diffraction pattern of single slit will you observe when the monochromatic source of light is replaced by a source of white light?

Q21. Find the ratio of the intensity of two points P and Q on the screen in young's double slit experiment when waves from source S_1 and S_2 have phase difference of $\pi/3$ and $\pi/2$ respectively.

Q22. Show that the central maximum is twice as wide as the other maxima and the pattern becomes narrower as the width of the slit is increased. [CBSE2006]

3 MARKS QUESTIONS

Q23. A parallel beam of light of wavelength 600nm is incident normally on a slit of width ‘a’. If the distance between the slit and the screen is 0.8m and the distance of second order maximum from the centre of the screen is15mm, calculate the width of the slit.

Q24. A beam of light consisting of two wavelengths 6500 A^o and 5200 A^o is used to obtain interference fringes. The distance between the slits is 2.0 mm and the distance between the plane of the slits and the screen is 120 cm.

(a) Find the distance of the third bright fringe on the screen from the central maxima for the wavelength 6500A^o

(b) What is the least distance from the central maxima where the bright fringes due to both the wavelengths coincide?

Q25. (a) Distinguish between interference and diffraction.

(b)A monochromatic light of wavelength 500 nm is incident normally on a Single slit of width 0.2 mm to produce a diffraction pattern. Find the angular width of central maximum obtained on screen.

5 MARKS QUESTION

Q26. State the essential condition for diffraction of light to take place. Use Huygens’s principle to explain diffraction of light due to a narrow single slit and the formation of a pattern of fringes obtained on the screen. Sketch the pattern of fringes formed due to diffraction at a single slit showing variation of intensity with angle θ.

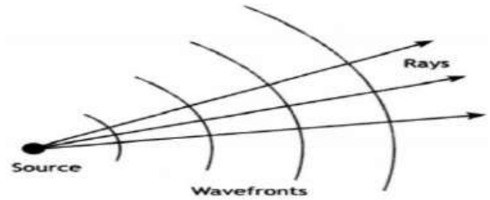
Q27. Red colour of light of wavelength λ is passed from two narrow slits which are distance *d* apart and interference pattern is obtained on the screen distance *D* apart from the plane of two slits. Then find the answer to following parts assuming that slit widths are equal to produce intensity I0 from each slit.

(a) Intensity at a point on the screen, situated at a distance 1/4 th of fringe separation from centre.
(b) Intensity in the screen, if the sources become incoherent by using two different lamps behind lamps S_1 and S_2.
(c) Angular position of 10th maxima, and the angular width of that fringe.
(d) Find the distance between 5th maxima and 3rd minima, at same side of central maxima.
(e) If the phase difference between the two waves reaching two slits from the source slit is (i) 5π and (ii) 2π, then what will be the colour of central fringe?

SECTION C-ANSWERS

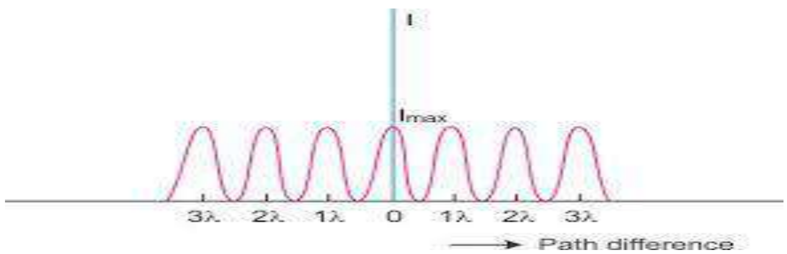
1 MARKS

1.

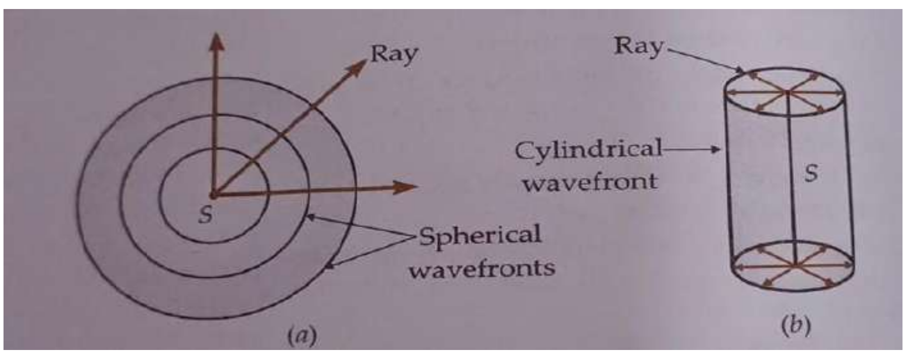


2. Both reflection and refractions occur due to interaction of light with the atoms at the surface of separation. These atoms may be regarded as the oscillators .Light incident on such atoms forces them to vibrate with the frequency of light, so both the reflected and refracted lights have same frequency as the frequency of incident light.

3.



4.



5. No, it does not imply a reduction in the energy carried by the light wave.. The energy carried by the wave depends on the amplitude of the wave but not on the speed of the wave propagation.

6. It is determined by the number of photons incident per unit area around that point.

7. Intensity of maxima decreases and that of minima increases

MCQ ANSWERS

8. C

9. C

10. B
11. C
12. B
13. B
14. B
15. B
16. B
17. B

2 MARKS

18. Diffraction of light is highly pronounced If the size of the obstacle is comparable to the wavelength of the light used

    The linear width of central maxima $\beta_0 = 2D\lambda/a$

    (i) if slit with is half the width of the central maximum is doubled its area becomes 4 times and hence intensity becomes 1/4th of the initial intensity.

    (ii) if visible light of longer wavelength is used the width of Central maximum increases and hence intensity decreases.

19. (i) When the screen is moved away from the slits , the distance D increases . Fringe width increases but angular separation remains unchanged .

    (ii) The interference pattern becomes less and less sharp . When the source slit becomes so wide that the condition is not satisfied , the interference pattern disappears . But the angular width remains unchanged.

20. Following changes are observed

    (i) In each diffraction order, the diffracted image of the slit gets dispersed into component colours of white light . As fringe with higher wavelength is wider than the violet fringe with smaller wavelength .

    (ii) In higher order spectra , the dispersion is more and it causes overlapping of different colours .

21. Intensity at any point of an interference pattern is given by $I=2I_0(1+\cos\phi)$

    Where I_0 is the intensity of either wave.

    Therefore, $I_P/I_Q = [1+\cos\phi_P]/[1+\cos\phi_Q] = [1+\cos\pi/3]/[1+\cos\pi/2]$

    $=[1+1/2]/[1+0] = 3/2 = 3:2$

22. The directions of different minima in diffraction pattern is given by

$\theta_n = X_n / D$

Also $\theta_n = n\,\lambda / d$

Hence $X_n = n\,\lambda\, D / d$

Width of secondary maxima = $X_n - X_{n-1} = \lambda\, D / d$

Width of central maxima $\beta_0 = 2X_1 = 2\beta$

Thus the central maxima is twice as wide as any seconadary maximum.

Since the width of the seconadary maximum is inversly proportional to the slit width hence as the slit width increases the seconadary maximum becomes narrower.

3 MARKS

23. λ=600nm , D= 0.8m

The distance of second order maximum from the centre of the screen = 15mm = $15X10^{-3}$m

$$a = \frac{n\lambda}{\sin\theta} = \frac{n\lambda D}{x}$$

$$a = \frac{(2x600x10^{-9}x0.9)}{15x10^{-3}} = 6.4x10^{-5}m$$

24.

(a) y3 = n. Dλ/d

= 3 x 1.2m x 6500 x 10-10m / 2 x 10-3m

= 0.12cm

(b) Let nth maxima of light with wavelength 6500 Å coincides with that of mth maxima of 5200Å.

m x 6500Ao x D/d = n x 5200A^o x D/d

m/n = 5200/6500 = 4/5

Least distance = y4= 4.D (6500Ao)/d

= 4 x 6500 x 10-10 x 1.2/ 2 x 10-3m

= 0.16cm.

25. (a)

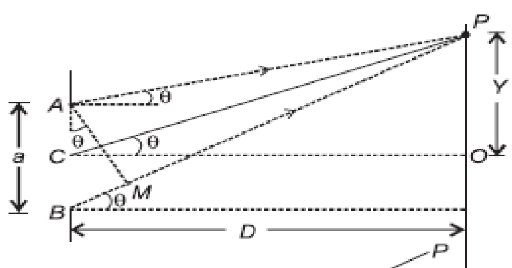
Interference	Diffraction
It is due to superposition of two Waves coming from coherent sources.	It is due to superposition of secondary wavelets originating from different parts of same wavefront.
Width of interference bands is equal	Width of diffraction bands is unequal
Intensity of all fringes is same	Central maxima is bright but intensity decreases with increase in order of maximum.

(b) given λ= 500 nm & a= 0.2 mm,

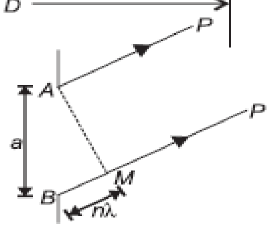
we have $\omega = 2\lambda/a$, $\omega = .005$ rad

5 MARKS

26.

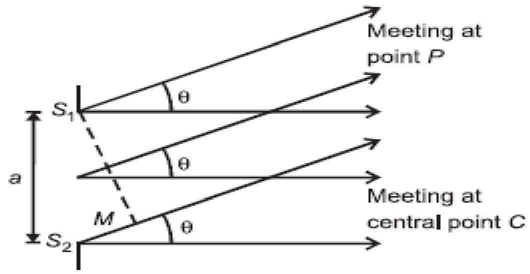


The wavelength of incident light should be comparable to the aperture of the slit/ opening or size of the obstacle.
We consider a single slit AB on which a plane wavefront is incident. The slit width is so small in comparison to the distance of the screen from the slit that the rays coming out of it, can be considered almost parallel.



According to the Huygen's principle, each point on the slit will behave like a fresh source of secondary wavelets. The waves from the different parts of the same wavefront reach a point on the screen and superpose to form a diffraction pattern.
For n^{th} secondary minimum, $a \sin \theta_n = n\lambda$, where $n = 1, 2, 3$ ....
$a \sin \theta_n$ is the path difference between the waves reaching a point on the screen.

We treat each point on the wavefront at the slit, as secondary sources [Using Huygen's principle].



[We are taking parallel beam of light because angles are very small]

As the incoming wavefront is parallel to the plane of the slit, these sources are in phase [using Huygen's principle]. The path difference between the waves coming out from the two edges of the slits is $S_2P - S_1P = S_2M$.

$\therefore \quad S_2M = a \sin\theta \approx a\theta$

For any two point sources, S_1 and S_2 in the plane of the slit having a separation y, the path difference would be

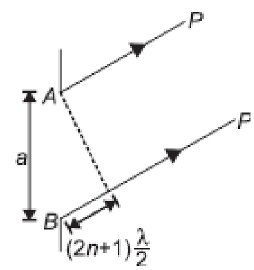
$$S_2P - S_1P \approx y\theta \quad \text{i.e. } \Delta P \approx y\theta$$

As the initial phase difference is zero, the phase difference between the waves is introduced only due to this path difference.

For the central point on the screen, $\theta = 0 \Rightarrow \Delta P = 0$

i.e. $\quad \Delta\phi = 0$

All the parts of the slit contribute in phase. So, the maximum intensity is obtained at C.



We can imagine as if the slit is divided into $2n$ parts.

The separation between two adjacent parts of the slit is $a/2n$. For a separation of a, the path difference is $n\lambda$. So, for a separation of $a/2n$, the path difference between the waves will be $\Delta P = \frac{n\lambda}{a} \times \frac{a}{2n} = \frac{\lambda}{2}$

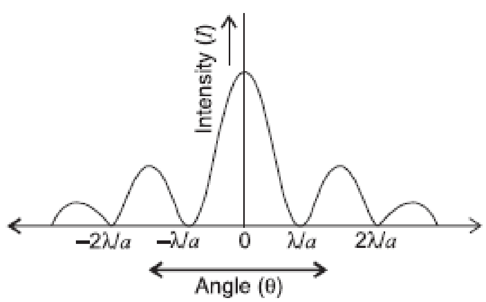
i.e. the phase difference, $\Delta\phi = \pi$ will be there and the waves will superpose destructively. We find the fringes of minimum intensity on the screen.

For n^{th} maximum, $a \sin\theta'_n = (2n + 1)\,\frac{\lambda}{2}$, where $n = 1, 2, 3, \ldots\ldots\ldots$

We can imagine as if the slit is divided into odd number of parts (e.g. 3, 5, 7, etc.).

In this case, only $(2n+1)^{\text{th}}$ part of the slit illuminates the screen. This is the reason why the intensity of secondary maxima falls rapidly.

The pattern given below shows the variation of intensity (I) with angle (θ).



27.

(*a*) According to the question,

$$X_n = \frac{1}{4}.\beta$$

$$X_n = \frac{1}{4}\ \frac{\lambda D}{d}$$

$\therefore$ Path difference $= \frac{\lambda}{4}$

Phase difference,

$$\phi = \frac{2\pi}{\lambda}\times\frac{\lambda}{4} = \frac{2\pi}{2}$$

$$\therefore \quad I = 4I_0\cos^2\frac{\phi}{2} = 4I_0\cos^2\frac{\pi}{4} = 2I_0$$

(*b*) If I_1 and I_2 be the intensities of waves from the sources, then the net intensity will be $I_{net} = I_1 + I_2$

(*c*) $\theta_{10} = 10\frac{\lambda}{d}$ $\left[\because \theta_n = \frac{n\lambda}{d}\right]$

θ = angular fringe width of 10^{th} maxima

$\theta = \frac{\lambda}{d}$ (independent of n)

(*d*)
$$x_5^{max} - x_3^{min} = \frac{5\lambda D}{d} - (2\times 3-1)\frac{\lambda}{2}\frac{D}{d}$$
$$= [10 - 5]\ \frac{\lambda d}{2d}$$
$$= 2.5\ \frac{\lambda D}{d}$$

(*e*) (*i*) $\theta = 5\pi$

$$\therefore \ \mathrm{I} = 4I_0\cos^2\frac{5\pi}{2} = 0$$

Therefore, dark fringe will be formed.

(*ii*) $\theta = 2\pi$

$$\therefore \ I = 4I_0\cos^2\ \frac{2\pi}{2} = 4I_0$$

Therefore, the colour of fringe will be bright red.

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Unit VII: Dual Nature of Radiation and Matter

CHAPTER–11: DUAL NATURE OF RADIATION AND MATTER

GIST OF CHAPTER

Dual nature of radiation, Photoelectric effect, Hertz and Lenard's observations; Einstein's photoelectric equation-particle nature of light.
Experimental study of photoelectric effect
Matter waves-wave nature of particles, de-Broglie relation.

UNITS AND DIMENSIONS

Physical quantity	**Symbol**	**Dimension**	**Unit**
Plank's constant	h	$[ML^2T^{-2}]$	Js
Stopping potential	V_0	$[ML^2T^{-3}A^{-1}]$	V
Work function	ϕ_0	$[ML^2T^{-2}]$	J; eV
Threshold frequency	υ_0	$[T^{-1}]$	Hz
De-Broglie wavelength	Λ	[L]	M

IMPORTANT RESULTS AND FORMULAE

1. Energy of photon:
   $E=hf=\frac{hc}{\lambda}$

2. Momentum of photon:
   $P=\frac{h}{\lambda}=\frac{hf}{c}$
3. Work function:
   $W_0=hf_0=hc/\lambda_0$
4. Cut off potential:
   $eV_0=\frac{1}{2}mv_{max}^2$
5. Einstein equation:
   $hf= W_o + K_m$
   $K_m = hf – W_0 = hf – hf_0$
6. The de-Broglie's wavelength og the particle of mass *m* and moving with velocity *v* is given by:

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

7. The de-Broglie wavelength of a particle of mass *m* and kinetic energy K is given by:

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}}$$

8. If a particle of mass *m* is carrying charge q_0 is accelerated through potential V, then its de-Broglie wavelength is given by:

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mq_0V}}$$

9. The de-Broglie wavelength associated with orbital electron in the nth orbit ofhydrogen atom is given by:

$$\lambda_n = \frac{12.27}{\sqrt{V}}\,\text{Å}$$

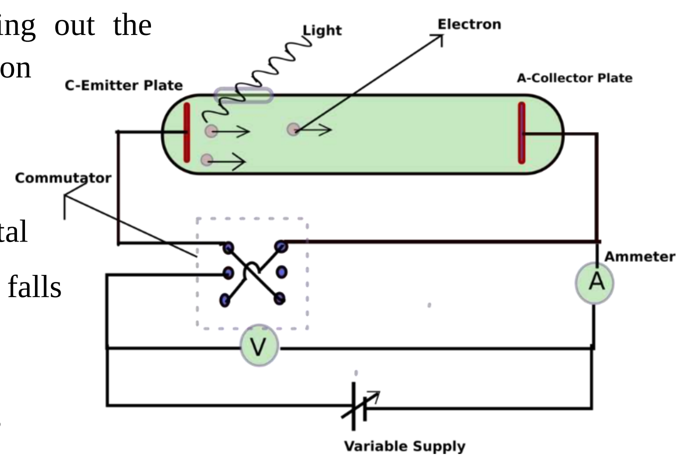
DEFINITION & CONCEPTS:-

Free electrons:- In metals, the electrons in the outer shell of the atoms are loosely bound. They move about freely throughout the lattice of positive ions. Such loosely bound electrons are called free electrons.

Work function of a metal. The minimum energy, which must be supplied to the electron so that it can just come out of a metal surface, is called the work function of the metal. It is denoted by W_0.

Work function depends on (i) nature of the metal (ii) the conditions of its surface.

Electron emission:- The phenomenon of ejecting out the electron from metal surface is called electron emission.



PHOTOELECTRIC EMISSION/ EFFECT :-. The phenomenon of ejection of electrons from a metal surface, when light of sufficiently high frequency falls on it, is known as photoelectric effect.

The electrons so emitted are called **photoelectrons**

Hertz's observation:-While demonstrating the existence of electromagnetic waves, Hertz found that high voltage sparks passed across the metal electrodes of the detector loop more easily when the cathode was illuminated by ultraviolet light from an arc lamp. The uv light falling on metal surface caused the emission of negatively charged particles (electrons) into surrounding space and enhance the high voltage sparks**.**

Hallwachs and Lenard Observation:- It was observed that if the frequency of incident light is less than certain minimum value (Threshold frequency) emission of photo electrons do not takes place.

Threshold frequency. The minimum frequency (ν_0), which the incident light must possess so as to eject photoelectrons from a metal surface, is called threshold frequency of the metal. **Mathematically- Work function of metal W = hν_0**

Laws of photoelectric effect.

1. Photoelectric emission takes place from a metal surface, when the frequency of incident light is above its threshold frequency.

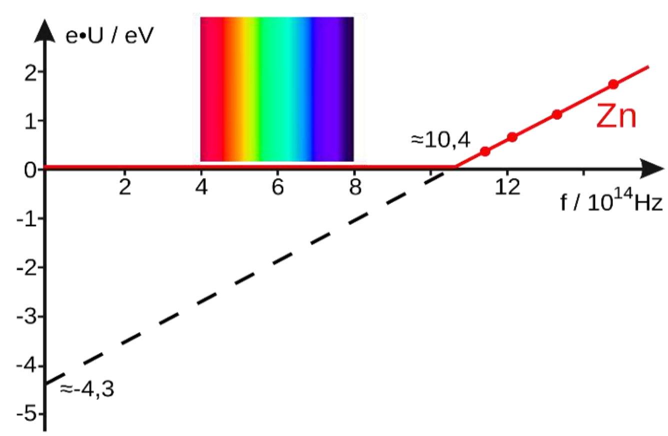
2. The photoelectric emission starts as soon as the light is incident on the metal surface.

3. The maximum kinetic energy with which an electron is emitted from a metal surface is independent of the intensity of light and depends upon its frequency.

4. The number of photoelectrons emitted is independent of the frequency of the incident light and depends only upon its intensity.

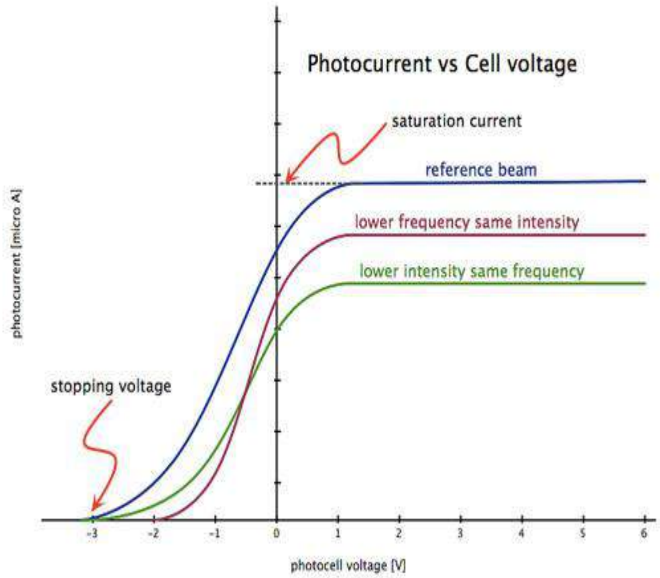
The Effect of Intensity The number of electrons emitted per second is observed to be directly proportional to the intensity of light. This happens above the threshold frequency. Below this threshold frequency there is no photocurrent at all, howsoever high the intensity of light is.

The graph between the photoelectric current and the intensity of light is a straight line when the frequency of light used is above a specific minimum threshold value.



The Effect of the Potential

The photoelectric current increases with increase in accelerating (positive) potential of collector plate.For a certain positive potential of plate A, the photoelectric current becomes maximum and constant or saturates. *This maximum value of the photoelectric current is called* ***saturation current****.*



Saturation current corresponds to the case when all the photoelectrons emitted by the emitter plate C reach the collector plate A.

Saturation current **increases with increase in intensity** of incident radiation.

The photoelectric current **decreases with negative potential** of collector plate.

STOPPING POTENTIAL V_0

At certain negative potential of the collector plate the photocurrent becomes zero. This negative potential is called **STOPPING POTENTIAL V_0**.

The stopping potential is measure of maximum kinetic energy of photoelectron.

$$Max.KE\ of\ photo\ electron = e\,V_o = \frac{1}{2} m v_{max}{}^2$$

Where v_{max} is the maximum velocity with which the photoelectrons are emitted

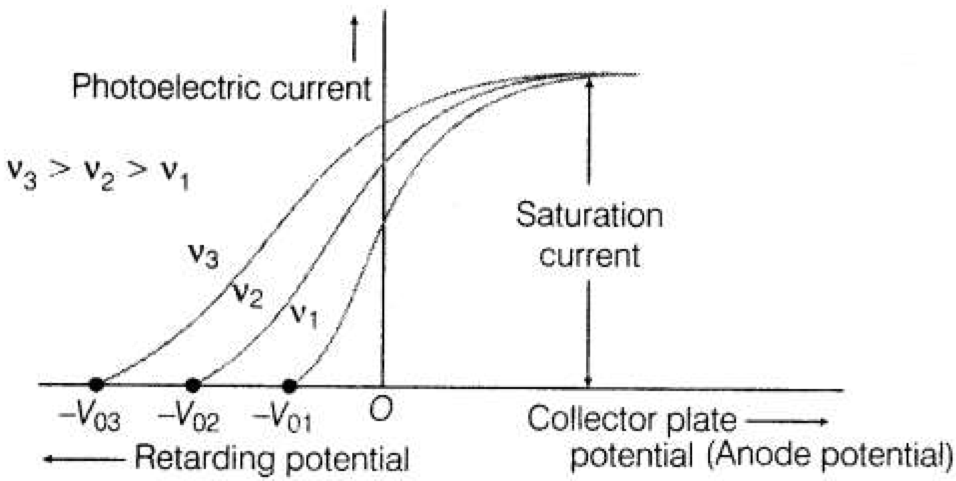
Effect of intensity of incident radiation on stopping potential

- Stopping potential **does not change** on changing the intensity of incident radiation.
- The maximum kinetic energy of photoelectron **thus does not depend on intensity of incident radiation.**

EFFECT OF FREQUENCY:

Effect of frequency on photocurrent

- Saturation Photocurrent **does not change** on changing frequency of incident radiation.
- The rate of emission of photoelectron does not depend on frequency of incident radiation.

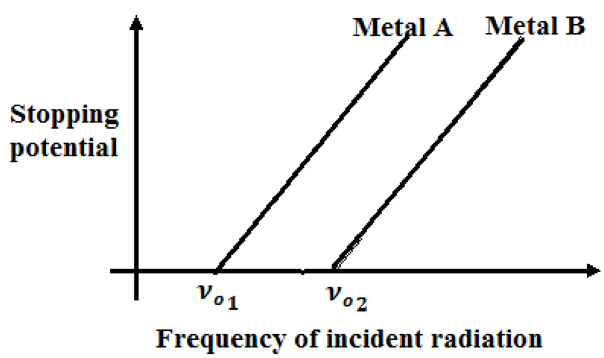


Effect of frequency on stopping potential

- Stopping potential increases on increasing frequency of incident radiation. maximum kinetic energy of photoelectron thus depends on frequency of incident radiation

Graph between stopping potential and frequency

- Graph between stopping potential and frequency of incident radiation is always a straight line.
- Slope of this graph is constant and its value *is* $\frac{h}{e}$.
- Thus **maximum kinetic energy of photoelectron** vary linearly with frequency of incident radiation.
- There exists a certain minimum cut-off frequency ν_o for which the stopping potential is zero.



EINSTEIN'S PHOTOELECTRIC THEORY

Electromagnetic Radiation energy is built up of discrete units PHOTONS – the so called quanta of energy of radiation

In interaction of Electromagnetic Radiation with matter, radiation behaves as if it is made up of particles called photons.

Photo electric emission: Each Photon of incident radiation interacts with a single electron and if energy of photon ($\boldsymbol{h\nu}$) is equal to or greater than work function, the electron is emitted.

When light of frequency ν is incident on a metal surface, whose work function is W (i.e. h), then the maximum kinetic energy of the emitted photoelectrons is given by

$$\boldsymbol{E_K = \frac{1}{2} m v_{max}{}^2 = h\nu - \phi_o = h(\nu - \nu_o)}$$

This is called **EINSTEIN'S PHOTOELECTRIC EQUATION**. It can explain the laws of photoelectric emission.

Properties of Photon :-

(i) In interaction of radiation with matter, radiation behaves as if it is made of particles like photons.

(ii) Each photon has energy (E= $h\nu$) and momentum (p=$h\nu$/c)

(iii) All photons of a particular frequency ν or wavelength have same energy (E= $h\nu$=h c/ $\boldsymbol{\lambda}$) and same momentum(p=$h\nu$/c= h/ $\boldsymbol{\lambda}$) irrespective of intensity of radiations.

(iv) Velocity of photon in different media is different due to change in it's wave length.

(v) Rest mass of photon is zero.

(vi) During collision of photon and electron energy and momentum are conserved.

If stopping potential is V_o then , $Max. KE\ of\ photo\ electron = e\,V_o$

$$\Rightarrow e\,V_o = h\nu - \phi_o = h(\nu - \nu_o)$$

$$\Rightarrow \boldsymbol{V_o = \frac{h\nu}{e} - \frac{\phi_o}{e} = \frac{h}{e}(\nu - \nu_o)}$$

This explains why the $\boldsymbol{V_o}$versus $\boldsymbol{\nu}$ curve is a straight line with slope = (h/e), independent of the nature of the material.

DE-BROGLIE HYPOTHESIS.

Both radiation and matter have dual nature. A moving particle of momentum p is associated with a wave called de-Broglie wave of wavelength λ .

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

This is De-Broglie wave equation the wavelength of the wave associated is called de-Broglie wavelength of the particle.

De-Broglie wavelength of electron. Consider an electron having mass m moving with final velocity v when accelerated through potential V. Kinetic energy gained by electron due to work done by electric field is eV. Then

$$K.E. = eV = \frac{p^2}{2m} = \frac{1}{2}mv^2 \Rightarrow P = \sqrt{2mK} = \sqrt{2meV}$$

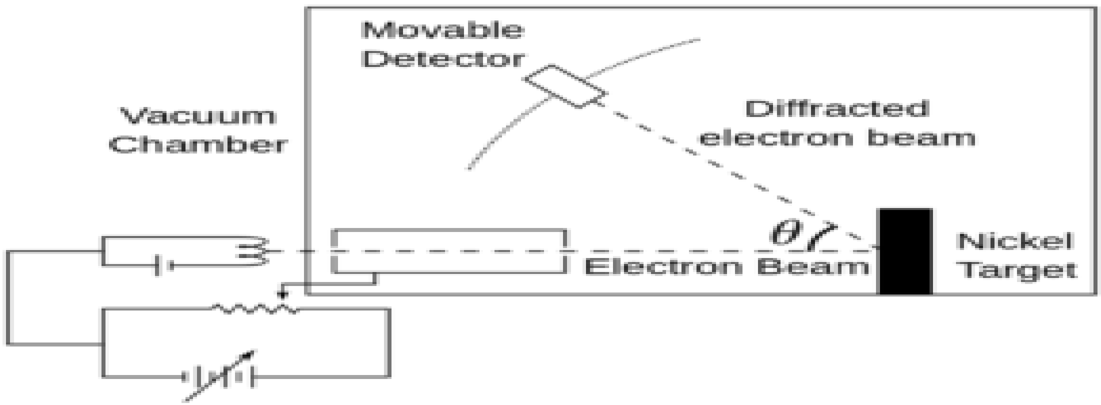
So, If an electron accelerated through a potential difference V acquires kinetic energy E possesses de-Broglie wavelength,

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2meV}} = \frac{12.27}{\sqrt{V}}\text{Å}$$

DAVISSON AND GERMER EXPERIMENT - Experimental Demonstration of wave nature of electrons.

The experimental setup for the Davisson and Germer experiment is enclosed within a vacuum chamber. Thus the deflection and scattering of electrons by the medium are prevented. The main parts of the experimental setup are as follows:

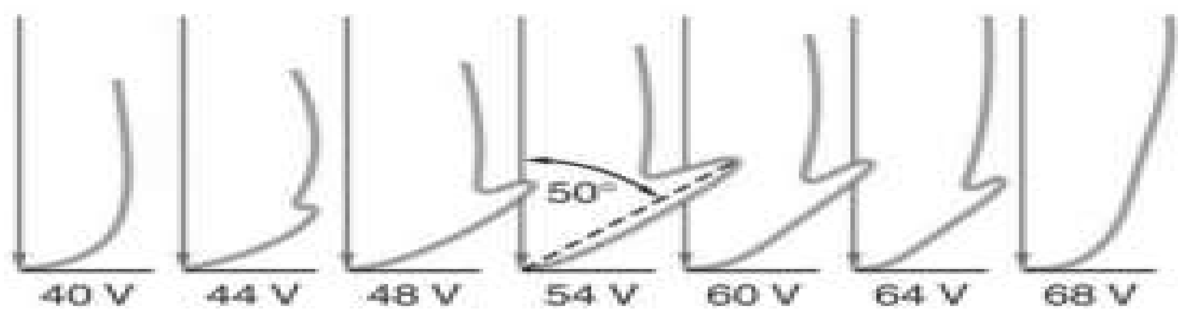
- **Electron gun**: An electron gun is a Tungsten filament that emits electrons via thermionic emission i.e. it emits electrons when heated to a particular temperature.
- **Electrostatic particle accelerator**: Two opposite charged plates (positive and negative plate) are used to accelerate the electrons at a known potential.
- **Collimator**: The accelerator is enclosed within a cylinder that has a narrow passage for the electrons along its axis. Its function is to render a narrow and straight (collimated) beam of electrons ready for acceleration.
- **Target**: The target is a Nickel crystal. The electron beam is fired normally on the Nickel crystal. The crystal is placed such that it can be rotated about a fixed axis.
- **Detector**: A detector is used to capture the scattered electrons from the Ni crystal. The detector can be moved in a semicircular arc as shown in the diagram



Observations of the Davisson and Germer Experiment

The intensity (strength) of this electronic current received by the detector and the scattering angle is studied. This current is called the electron intensity.

The intensity of the scattered electrons is not continuous. It shows a maximum and a minimum value corresponding to the maxima and the minima of a diffraction pattern produced by X-rays. It is studied from various angles of scattering and potential difference



Plots between I – *the intensity of scattering (X-axis) and the angle of scattering θ for given values of Potential difference.*

Results of the Davisson and Germer Experiment

From the Davisson and Germer experiment, we get a value for the scattering angle θ and a corresponding value of the potential difference V at which the scattering of electrons is maximum. From these two values from the data collected by Davisson and Germer, the λ. Is obtained.

If an electron is accelerated by potential difference V then using De-Broglie Hypothesis

$$\lambda = \frac{12.27}{\sqrt{V}}\text{Å} = \frac{12.27}{\sqrt{54}}\text{Å} = 1.67\ \text{Å}$$

Now the value of 'd' from X-ray scattering is 0.092 nm. Therefore for V = 54 V, the angle of scattering is 50^0, using condition for maxima, we have:

$$n\lambda = 2d\ \sin(90^0 - 50^0) \Rightarrow\ for\ n = 1, \qquad \lambda = 2(0.092)\sin(90^0 - 50^0) = 1.65\text{Å}$$

Therefore the experimental results are in a close agreement with the theoretical values got from the de Broglie equation.

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QUESTION BANK
CHAPTER 11-DUAL NATURE OF RADIATION AND MATTER

Section-A
1 Mark Questions

Directions: These questions consist of two statements, each printed as Assertion and Reason. While answering these questions, you are required to choose any one of the following four responses.
(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.
(e) If the Assertion is false but Reason is correct

Q.1 **Assertion**: An electron is not deflected on passing through certain region of space. This observation confirms that there is no magnetic field in that region.

Reason: The deflection of electron depends on angle between velocity of electron and direction of magnetic field.

Q.2 **Assertion:** The photon behaves like a particle.

Reason: If E and P are the energy and momentum of the photon, then $p = E/c$.

Q.3 **Assertion:** Photoelectric effect demonstrates the wave nature of light.

Reason: The number of photoelectrons is proportional to the frequency of light.

Q.4 Photon is not a ……………., but it is a ………………..

Q.5 The minimum amount of energy required by an electron to just escape from a metal surface is called………………. of the metal.

Q.6. Which of the following statements is true regarding the photoelectric experiment?

a. The stopping potential increases with the increase in the intensity of incident light.
b. The photocurrent increases with the intensity of light.
c. The photocurrent increases with the increase in frequency
d. All of the above

Q.7. De-Broglie equation states the:

(a) dual nature (b) particle nature (c) wave nature (d) none of these

Q.8 A metal's work function is:

a) The minimum current needed to remove an electron from a metal surface

b) The highest frequency needed to remove an electron from a metal surface

c) None of the mentioned

d) the least amount of energy required to remove an electron from a metal surface

Q.9. Only when the incident light exceeds a particular threshold……… does photoelectric emission occur.

(a) Power (b) Wavelength (c)Intensity (d) Frequency

Q.10. The photoelectric effect may be described using the following theories:

(a) wave theory of light (b) Bohr's theory (c) quantum theory of light

(d) corpuscular theory of light.

CASE STUDY BASED QUESTIONS

Q.11**.** Photoelectric emission is possible only if the incident light is in the form of packets of energy, each having a definite value, more than the work function of the metal. This shows that light is not of wave nature but of particle nature. It is due to this reason that photoelectric emission was accounted by quantum theory of light.

I. Packet of energy are called

(a)electron (b)quanta (c) frequency (d)neutron

II. One quantum of radiation is called

(a)meter (b)meson (c)photon (d)quark

III. Energy associated with each photon

(a) hc (b) mc (c) hv (d) hk

IV. Which of the following waves can produce photo electric effect?

(a) UV radiation (b) Infrared radiation (c) Radio waves (d) Microwaves

V. Work function of alkali metals is

(a) less than zero

(b) just equal to other metals

(c) greater than other metals

(d) quite less than other metals

2 Mark Questions

Q.12. Write the basic features of photon picture of electromagnetic radiation on which Einstein's photoelectric equation is based.

Q.13 Define the term stopping potential and Threshold frequency in relation to photoelectric effect.

Q.14. In photoelectric effect, why should the photoelectric current increase as the intensity of monochromatic radiation incident on a photosensitive surface is increased? Explain.

Q.15. Light of wavelength 3500 Å is incident on two metals A and B. Which metal will yield more photoelectrons if their work functions are 5 eV and 2 eV respectively?

Q.16. The momentum of photon of electromagnetic radiation is 3.3 x10^{-29} kg-m/s. Find out the frequency and wavelength of the wave associated with it.

Q.17. What is meant by work function of a metal? How does the value of work function influence the kinetic energy of electrons liberated during photoelectron emission?

Q.18. Why is photoelectric emission not possible at all frequencies?

3 Mark Questions

Q.19. Define the terms threshold frequency and stopping potential in relation to the phenomenon of photoelectric effect. How is the photoelectric current affected on increasing the (i) frequency (ii)intensity of the incident radiation and why? **CBSE2006**

Q.20 (i) State two important features of Einstein's photoelectric equation.
(ii) Radiation of frequency 1015 Hz is incident on two photosensitive surfaces P and Q. There is no photoemission from surface P. Photoemission occurs from surface Q but photoelectrons have zero kinetic energy. Explain these observations and find the value of work function for surface Q.

Q21.Explain giving reasons for the following:

(a) Photoelectric current in a photocell increases with the increase in the intensity of the incident-radiation.

(b) The stopping potential (V_0) varies linearly with the frequency (v) of the incident radiation for a given photosensitive surface with the slope remaining the same for different surfaces.
(c) Maximum kinetic energy of the photoelectrons is independent of the intensity of incident radiation.

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SECTION-A

Answer Key

Q.1 (e) If electron is moving parallel to the magnetic field, then the electron is not deflected i.e., if electron is not deflected, we cannot be sure that there is no magnetic field in that region.

Q.2 (a)

Q3. (d) Photoelectric effect demonstrates the particle nature of light. Number of emitted photoelectrons depends upon the intensity of light.

Q.4 material body, packet of energy

Q5. Work function

Q.6. (b) The photocurrent increases with the intensity of light

Q.7. (a) dual nature

Q.8. d) the least amount of energy required to remove an electron from a metal surface

Q.9. d) Frequency

Q.10. c) quantum theory of light

Q.11. *CASE STUDY*

I. B II. C III. C IV. A V. D

Q.12. Features of the photons: (i)Photons are particles of light having energy E = hν and momentum p = h/λ

(ii) Photons travel with the speed of light in vacuum, independent of the frame of reference.

(iii) Intensity of light depends on the number of photons crossing unit area in a unit time.

Q.13. The minimum retarding (negative) potential of anode of a photoelectric tube for which photoelectric current stops or becomes zero is called the stopping potential.

Threshold frequency is defined as the minimum frequency of incident radiation which can cause photoelectric emission. It is different for different metal.

Q.14. The photoelectric current increases proportionally with the increase in intensity of incident radiation. Larger the intensity of incident radiation, larger is the number of incident photons and hence larger is the number of electrons ejected from the photosensitive surface

Q.15. Metal B will yield more photo electrons. work function of Metal B is lower than that of A for the same wavelength of light. Hence metal B will give more electrons

Q.16. (i) Given, $h = 6.63\ 10^{-34}$ J/s, $c= 3 \times 10^{8}$ m/s and $p = 3.3 \times 10^{-29}$ - kg m/s

Momentum, p= $h\nu/c$ or $\nu = pc/h = 3.3 \times 10^{-29} \times 3 \times 10^{8} / 6.63 \times 10^{-34} = 1.5 \times 10^{13}$ Hz

$\lambda = c/\nu = 3 \times 10^{8} / 1.5 \times 10^{13} = 2 \times 10^{-5}$ m

Q.17. Work Function: The minimum energy required to free an electron from metallic surface is called the work function. Smaller the work function, larger the kinetic energy of emitted electron.

Q.18. Photoelectric emission is possible only if the energy of the incident photon (hv) is greater than the work function ($\omega_0 = hv_0$) of the metal. Hence the frequency v of the incident radiation must be greater than the threshold frequency v_0.

Q.19. Threshold frequency (ν_0) : It is the minimum frequency below which below which no emission of photoelectron takes place is known as threshold frequency (ν_0) .

Stopping potential (V_0) : Its is the minimum negative potential at which the photoelectric current becomes zero.

(i) On increasing the frequency of incident radiation, the magnitude of photoelectric current remains unchanged because increased frequency means increased energy of photon but number of photon remains unchanged.

(ii) On increasing the intensity of incident radiation, the photoelectric current increases in the same ratio, because increased intensity means increased number of incident photons which results in increased number of ejected photoelectrons and hence increased photoelectric current.

Q.20. (i) Important features of photoelectric effect:

(a) Radiation behaves as if it is made of particles like photons. Each photon has energy E = hv and momentum $p = h/\lambda$.

(b) Intensity of radiation can be understood in terms of number of photons falling per second on the surface. Photon energy depends only on frequency and is independent of intensity.

(c) Photoelectric effect can be understood as the result of the one to one collision between an electron and a photon.

(d) When a photon of frequency ν is incident on a metal surface, a part of its energy is used in overcoming the work function and other part is used in imparting kinetic energy, so

$KE = h(\nu - \nu_0)$

(ii) Since no photoelectric emission takes place from P, it means frequency of incident radiation (10^{15} Hz) is less than its threshold frequency $(v_0)_P$. Photo emission takes place from Q but kinetic energy of photoelectrons is zero. This implies that frequency of incident radiation is just equal to the threshold frequency of Q.

For Q, work function $\phi_0 = hv_0$

$$= \frac{(6.6 \times 10^{-34}) \times (10^{15})}{(1.6 \times 10^{-19})} \text{ eV} = \mathbf{4.125 \text{ eV}}$$

Q21. (a) The collision of a photon can cause emission of a photoelectron (above the threshold frequency). As the intensity increases, number of photons increases. Hence, the current increases.

(b) We have, $eV_s = h(v - v_0)$

$\therefore \quad V_s = \frac{h}{e}(v) + \left(-\frac{hv_0}{e}\right)$

$\therefore \quad$ Graph of V_s with v is a straight line and slope $\left(\frac{h}{e}\right)$ is a constant.

(c) Since maximum kinetic energy for different surfaces is given by $(K.E.)_{max} = h(v - v_0)$,

hence, it depends on the frequency and not on the intensity of the incident radiation.

****

Section-B

1 Mark Questions

Directions: These questions consist of two statements, each printed as Assertion and Reason. While answering these questions, you are required to choose any one of the following four responses.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

(c)If the Assertion is correct but Reason is incorrect.

(d) If both the Assertion and Reason are incorrect.

(e) If the Assertion is false but Reason is correct

Q.22 **Assertion :** In process of photoelectric emission, all emitted electrons do not have same kinetic energy.

Reason : If radiation falling on photosensitive surface of a metal consists of different wavelength then energy acquired by electrons absorbing photons of different wavelengths shall be different.

Q.23 **Assertion :** The kinetic energy of photoelectrons emitted from metal surface does not depend on the intensity of incident photon.

Reason : The ejection of electrons from metallic surface is not possible with frequency of incident photons below the threshold frequency.

Q.24 **Assertion :** Photoelectric saturation current increases with the increase in frequency of incident light.

Reason : Energy of incident photons increases with increase in frequency and as a result photoelectric current increases.

Q.25 The de- Broglie wavelength of a moving particle is ……………. proportional to its momentum.

Q26. The phenomenon of photoelectric emission was discovered by………..in………..

Q.27. In photoelectric effect what determines the maximum velocity of the electron reacting with the collector?

a. Frequency of incident radiation alone

b. The potential difference between the emitter and the collector

c. The work function of metal

d. All of these

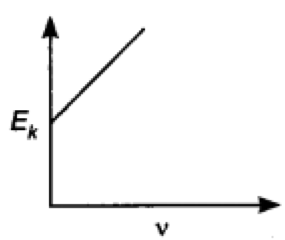
Q. 28. Calculate the de Broglie wavelength associated with the electron which has a kinetic energy of 5 eV.

a. 5.47 Å b. 2.7 Å c. 5.9 Å d. None of the above

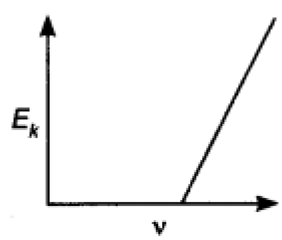
Q.29. For a metal having a work function W_0, the threshold wavelength is λ. What is the threshold wavelength for the metal having work function $2W_0$?

a. λ/4 b. λ/2 c. 2λ d. 4λ

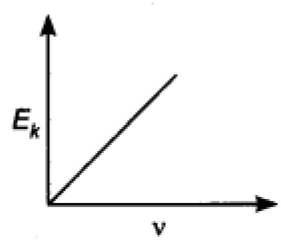
Q.30. How does the maximum kinetic energy of a photoelectron vary with the frequency (ν) of the incident radiation?



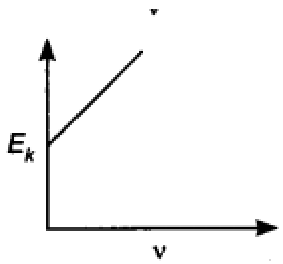
a.



b.



c.

d. 

Q.31. Kinetic energy of emitted electrons depends upon:

(a) frequency

(b) intensity

(c) nature of atmosphere surrounding the electrons

(d) none of these

CASE STUDY BASED QUESTIONS

Q.32 The discovery of the phenomenon of photoelectric effect has been one of the most important discoveries in modern science. The experimental observations associated with this phenomenon made us realize that our, 'till then', widely accepted picture of the nature of light – The electromagnetic (wave) theory of light– was quite inadequate to understand this phenomenon. A 'new picture' of light was needed and it was provided by Einstein through his 'photon theory' of light. This theory, regarded light as a stream of particles. Attempts to understand photoelectric effect thus led us to realize that light, which was being regarded as 'waves', could also behave like 'particles'. This led to the idea of 'wave-particle duality' vis-à-vis the nature of light. Attempts to understand this 'duality', and related phenomenon, led to far reaching, and very important developments, in the basic theories of Physics.

I. Which of the following phenomena explain the wave nature of light?

(a) Interference (b) Diffraction (c) polarization (d) all of them

II. Wave –particle duality is shown by

(a) Light only (b) matter only (c) both light and matter (d) None of them

III. The experiment to explain the wave nature of light i.e electromagnetic wave theory is given by

(a) Hertz (b) Einstein (c) Lenard (d) Huygen

IV. The concept of photoelectric effect given by Einstein explains that the light is a

(a) Photon (b) Wave (c)Particle (d) Both

V. The practical application of the phenomenon of photoelectric effect and the concept of 'matter waves' is

(a)Photocells

(b) Automatic doors at shops and malls

(c) automatic light switches

(d) All of them

Two Marks Questions

Q.33 Monochromatic light of frequency 6.0×10^{14} Hz is produced by a laser. The power emitted is 2.0×10^{-3} W Calculate the (i) energy of a photon in the light beam and (ii) number of photons emitted on an average by the source.

Q.34**.** Write Einstein's photoelectric equation and point out any two characteristic properties of photons on which this equation is based.

Q.35. The Kinetic Energy (K.E.), of a beam of electrons, accelerated through a potential V, equals the energy of a photon of wavelength 5460 nm. Find the de Broglie wavelength associated with this beam of electrons.

3 Marks Questions

Q.36. (a) Define photoelectric work function? What is its unit?

(b) In a plot of photoelectric current versus anode potential, how does

(i) Saturation current varies with anode potential for incident radiations of different frequencies but same intensity?

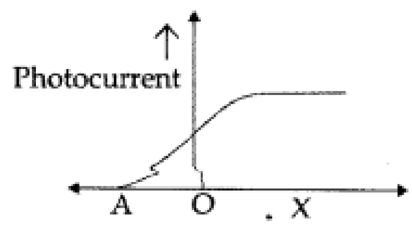
(ii) The stopping potential varies for incident radiations of different intensities but same frequency.

(iii) Photoelectric current vary for different intensities but same frequency of radiations? Justify your answer in each case?

Q.37 Draw a graph showing the variation of stopping potential with frequency of the incident radiations. What does the slope of the line with the frequency axis indicate. Hence define threshold-frequency?

Q.38.(a) why photoelectric effect cannot be explained on the basis of wave nature of light? Give reason. (b) Write the basic features of photon picture of electromagnetic radiation on which Einstein's photoelectric equation is based. CBSE2013

Q.39. The given graph shows the variation of photocurrent for a photosensitive metal:



(a) Identify the variable X on the horizontal axis.

(b) What does the point A on the horizontal axis represent?

(c) Draw this graph for three different values of frequencies of incident radiation v_1, v_2 and v_3 ($v_1 > v_2 > v_3$) for same intensity.

(d) Draw this graph for three different values of intensities of incident radiation I_1 I_2 and I_3 ($I_1 > I_2 > I_3$) having same frequency.

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Answer Key

Section-B

1 Mark's Questions

Q22. (b) Both statement I and II are true; but even it radiation of single wavelength is incident on photosensitive surface, electrons of different KE will be emitted.

Q.23(b)

Q.24 (d) Photoelectric saturation current is independent of frequency. It only depends on intensity of light

Q.25. inversely

Q.26. Heinrich Hertz, 1887

Q.27 (d) All of these

Q.28 (a) 5.47 Å

Q.29. (b) λ/2

Q.30. (b)

Q.31. (a) frequency

CASE STUDY BASED QUESTIONS

Q.32. I. d II. C III. A IV. B V. d

Two Mark's Questions

Q.33. Calculating (i) Energy of a photon = hν= $6.63 \times 10^{-34} \times 6.0 \times 10^{14}$ J = 3.978×10^{-19} J

(ii) Number of photons emitted per second = Power x Energy of photon

= $2\, x 10^{-3}$ x $3.978\, x\, 10^{-19}$

= 5.03×10^{15} photons/second

Q.34. If radiation of frequency (ν) greater than threshold frequency (ν_0) irradiate the metal surface, electrons are emitted out from the metal. So Einstein's photoelectric equation can be given as

$$K_{max} = \frac{1}{2} m v^2 = h\nu - h\nu_0$$

Characteristic properties of photons:

(Q) Energy of photon is directly proportional to the frequency (or inversely proportional to the wavelength.

(ii) In photon-electron collision, total energy and momentum of the system of two constituents remains constant.

Q.35.

Given : $\lambda = 5460 \text{ nm} = 5460 \times 10^{-9} \text{ m} \qquad \lambda_B = ?$

$$\text{Energy of the photon (K)} = \frac{hc}{\lambda} \qquad \ldots(i)$$

$$\text{de-Broglie wavelength, } (\lambda_B) = \frac{h}{p} = \frac{h}{\sqrt{2mk}} \ldots(ii)$$

$$\therefore \quad \lambda_B = \frac{h}{\sqrt{2m.\frac{hc}{\lambda}}} = \sqrt{\frac{h\lambda}{2mc}}$$

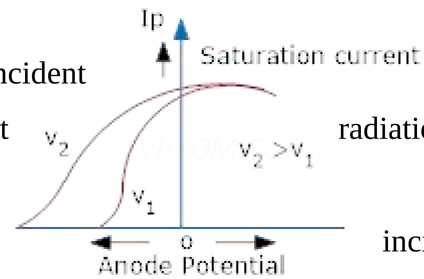
$$= \left[\frac{(6.63 \times 10^{-34}) \times (5460 \times 10^{-9})}{2 \times (9.1 \times 10^{-31}) \times (3 \times 10^{8})}\right]^{\frac{1}{2}}$$

$$= \mathbf{25.75 \times 10^{-10} \text{ m}}$$

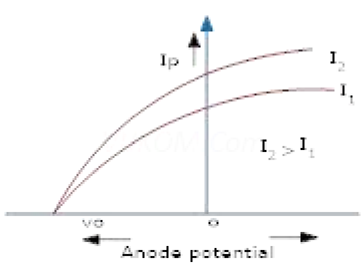
3 Mark's Questions

Q.36 (a) The minimum amount of energy required to take out an electron from the surface of metal. It is measured in electron volt (eV).

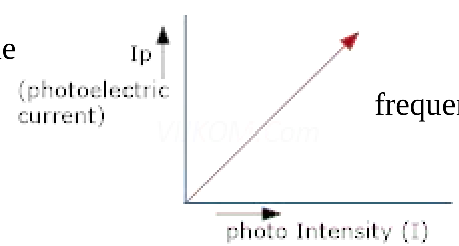
(b) (i) Saturation current depends only on the intensity of incident radiation but is independent of the frequency of incident radiation.



(ii) Stopping potential does not depend on the intensity of incident radiations.



(iii) Photoelectric current is directly proportional to the intensity of incident radiations, provided the given frequency is greater than the threshold frequency.

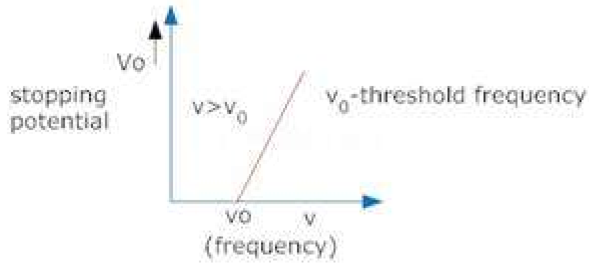


Q.37

Slope of the graph

$= \frac{\Delta v_o}{\Delta v}$

Einstein photoelectric equation



$eV_o = hv - \phi_o -----(1)$

Differentiating equation (1)

$e\Delta V_o = h\Delta v$

$\frac{\Delta V_o}{\Delta v} = \frac{h}{e}$

Thus slope is equal to the ratio of Planck's constant to the charge on electron. Threshold frequency – The minimum values of frequency of the incident light below which photoelectric emission is not possible is called as threshold frequency.

Q.38 (a) Wave nature of radiation cannot explain the following:

(i) The instantaneous ejection of photoelectrons.

(ii) The existence of threshold frequency for a metal surface.

(iii) The fact that kinetic energy of the emitted electrons is independent of the intensity of light and dependence upon its frequency.

Thus, the photoelectric effect cannot be explained on the basis of wave nature of light.

(b) Photon picture of electromagnetic equation is based on particle nature of light. Its basic features are:

(i) In interaction with matter, radiation behaves as if it is made up of particles called photons.

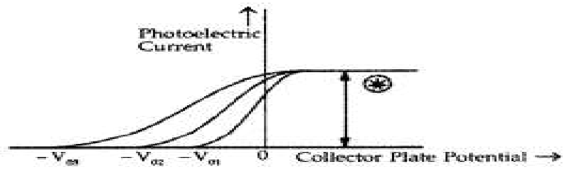
(ii) Each photon has energy E = h v and momentum p = h v/c and c, the speed of light

Q.39.

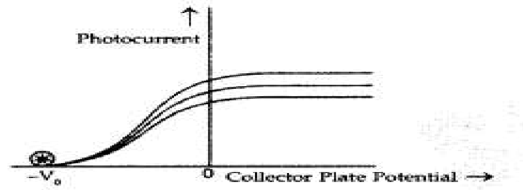
(a) 'X' is a collector plate potential. (b)

'A' represents the stopping potential. (c)

Graph for different frequencies



(d) Graph for different intensites :



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SECTION-C

1 Mark Questions

Directions: These questions consist of two statements, each printed as Assertion and Reason. While answering these questions, you are required to choose any one of the following four responses.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

(c)If the Assertion is correct but Reason is incorrect.

(d) If both the Assertion and Reason are incorrect.

I If the Assertion is false but Reason is correct

Q.40 **Assertion:** When the speed of an electron increases its specific charge decreases.

Reason: Specific charge is the ratio of the charge to mass.

Q.41 **Assertion:** Photosensitivity of a metal is high if its work function is small.

Reason: Work function $=hf_0$, where f_0 is the threshold frequency. [AIIMS 1997]

Q.42 **Assertion:** Though light of a single frequency (monochromatic) is incident on a metal, the energies of emitted photoelectrons are different.

Reason: The energy of electrons emitted from inside the metal surface, is lost in collision with the other atoms in the metal.

Q.43. **Assertion (A):** The photoelectrons produced by a monochromatic light beam incident on a metal surface have a spread in their kinetic energies.

ReasonI: The energy of electrons emitted from inside the metal surface, is lost in collision with the other atoms in the metal. (CBSE Sample paper 2022)

Q.44. A proton and an alpha particle are accelerated through the same potential difference. The ratio of their de-Broglie wavelengths will be……….

Q.45. The Davison and Germer experiment established the existence of…………….

Q.46 The photoelectric current is unaffected by

1. incident light frequency

2.metal work function

3.stopping potential

4.incident light intensity

(a) (i) and (iv) only

(b) (ii) and (iii) only

I (iii) only

(d) (ii) only

Q.47. Which of the following will emit photoelectrons when it collides with a metal?

(a) UV radiations (b) Infrared radiation (c) Radio waves (d) Microwaves

Q.48. What will be the de-Broglie wavelength of an electron accelerated from rest through a potential difference of 100 volts?

(a) 12.3 Å (b) 1.23 Å (c) 0.123 Å (d) None of these

Q.49. Two beams, one of red light and the other of blue light having the same intensity are incident on a metallic surface to emit photoelectrons. Which emits electrons of greater frequency?

(a) Both (b) Red light (c) Blue light (d) None

Q.50. In the Davisson and Germer experiment, the velocity of electrons emitted from the electron gun can be increased by

(a)Increasing the potential difference between the anode and filament

(b) Increasing the flame current

(c) Decreasing the flame current

(d) Decreasing the potential difference between anode and filament

Q.51. The work function for a metal surface is 4.14 eV. The threshold wavelength for this metal surface is:

(a) 4125 Å (b) 2062.5 Å (c) 3000 Å (d) 6000 Å

(CBSE Sample paper 2022)

CASE STUDY BASED QUESTIONS

Q.52 Lenard observed that when ultraviolet radiations were allowed to fall on the emitter plate of an evacuated glass tube, enclosing two electrodes (metal plates), current started flowing in the circuit connecting the plates. As soon as the ultraviolet radiations were stopped, the current flow also stopped. These observations proved that it was ultraviolet radiations, falling on the emitter plate, that ejected some charged particles from the emitter and the positive plate attracted them.

(I)Alkali metals like Li, Na, K and Cs show photo electric effect with visible light but metals like Zn, Cd and Mg respond to ultraviolet light. Why?

(a) Frequency of visible light is more than that for ultraviolet light

(b) Frequency of visible light is less than that for ultraviolet light

I Frequency of visible light is same for ultraviolet light

(d) Stopping potential for visible light is more than that for ultraviolet light

(II)Why do we not observe the phenomenon of photoelectric effect with non-metals?

(a)For non-metals the work function is high

(b) Work function is low

I Work function can't be calculated

(d) For non-metals, threshold frequency is low

(III)What is the effect of increase in intensity on photoelectric current?

(a)Photoelectric current increases

(b) Decreases

(c) No change

(d) Varies with the square of intensity

(IV)Name one factor on which the stopping potential depends

(a)Work function

(b) Frequency

© Current

(d) Energy of photon

(V)How does the maximum K.E of the electrons emitted vary with the work function of metal?

(a) It doesn't depend on work function

(b) It decreases as the work function increases

(c) It increases as the work function increases

(d) It's value is doubled with the work function

Q.53.Name the phenomenon which is used to establish the wave nature of electrons in the Davisson-Germer experiment. CBSE (2020)

Q.54. Calculate the kinetic energy of an electron having de Broglie wavelength of 1Å.

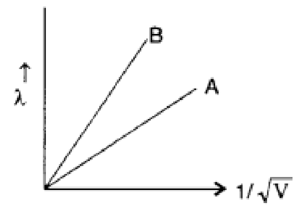
CBSE (2017)

Q.55. Name the three important features in photoelectric effect which can be explained by Einstein's photoelectric equation . CBSE (2017)

TWO MARK's QUESTIONS

Q.56. The de-broglie wavelengths associated with an electron and proton are equal. Prove that the kinetic energy of the electron is greater than that of then proton.

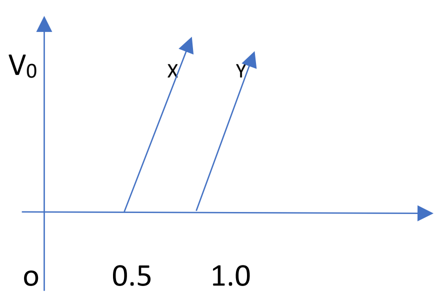
Q.57 Two lines, A and B, in the plot given below show the variation of de-Broglie wavelength, λ versus $1/\sqrt{V}$, Where V is the accelerating potential difference, for two particles carrying same charge. Which one of two represents a particle of smaller mass? (All India 2008)



THREE MARK's QUESTIONS

Q.58. A proton and an alpha particle have the same de – Broglie wavelength. Determine the ratio of (i) their accelerating potentials (ii) their speeds. CBSE 2015

Q.59. The graph in figure, shows the variation of stopping potential with frequency v of the incident radiation for two photosensitive metals X and Y.



(i)which of the metals has large threshold wavelength? Give reason.

(ii) Explain giving reason, which metal gives out electrons, having large K.E. for the same wavelength of the incident radiation

(iii) If the distance between the light source and metal X is doubled, how will the K.E of electrons emitted from it change? Give reason. CBSE 2008

Q.60. a) State three important properties of photons which describe the particle picture of electromagnetic radiation.

(b) Use Einstein's photoelectric equation to define the terms. (i) stopping potential and

(ii) threshold frequency.

SECTION C- Answer Key

Q.40(b)

Q.41(b) Less work function means less energy is required for ejecting out the electrons

Q.42.(a) When a light of single frequency falls on the electrons of inner layer of metal, then this electron comes out of the metal surface after a large number of collisions with atom of it's upper layer.

Q.43 (a)

Q.44. $2\sqrt{2}:1$

Q.45. electron wave

Q.46 (c) (iii) only

Q.47. (a) UV radiations

Q.48. (b) 1.23 Å

Explanation: The value of V is given 100 volts.

Equation of de Broglie wavelength of electron $\lambda = h/2meV$

$\lambda = 6.6\times10^{-34}/2(9.1\times10^{-31})(1.6\times10^{-19})(100)$

$\lambda = 6.6\times10^{-34}/2(9.1\times10^{-31})(1.6\times10^{-19})(100)$

$\lambda = 6.6\times10^{-34} / 5.4\times10^{-10}$m

$\lambda = 1.277\times10^{10}m=1.23$Å

Q.49. (c) Blue light

Explanation: Einstein's photoelectric equation is given by $E_k = hv - \phi_\phi$

Where, E_k is the maximum kinetic energy of the ejected electron.

Energy of the photon of the blue light $(hv)_{blue}$ is higher compared to red light $(hv)_{red}$. In photoelectric emission, $E_k \propto (hv)$. Therefore, blue light emits electrons of greater kinetic energy than that of red light.

Q.50. (a) increasing the potential difference between the anode and filament

Explanation: if, e is the charge on electron, V is the potential difference, m is the mass of the particle and v is the velocity of the particle then, $eV = \frac{1}{2} mv^2$

Therefore, in the Davisson and Germer experiment, velocity of electrons emitted from electron guns can be increased by increasing the potential difference between anode and filament.

Q.51. (iii) 3000 Å

Q.52. (I)b (ii) a (III) a (IV) b (V) b

Q.53. Electron diffraction.

Q.54. de-Broglie wavelength

$\lambda = h/mv$=h/p

Kinetic Energy= $p^2/2m = \frac{1}{2m}(\frac{h}{\lambda})^2 = (6.626x10^{-34})^2/2x9.11x10^{-31}x(1x10^{-10})^2$

$= 2.409x10^{-17}J$

Q.55.(i)For a given metal and frequency of incident radiation, the number of photoelectrons ejected per second is directly proportional to the intensity of incident radiation.

(ii) Maximum kinetic energy of the emitted photo electron is independent of the intensity of incident radiations.

(iii) Emission of photoelectrons is instantaneous

TWO MARK's QUESTIONS

Q.56. de-broglie wavelength of a particle of mass m and kinetic energy E is

$\lambda = \boldsymbol{h}\ \sqrt{\boldsymbol{2mE}}$

or $E= h^2/2m\ \lambda^2$

for particle having same λ, $E\alpha\ 1/m$

As mass of electron as smaller than that of proton, so the electron has a higher kinetic energy and it is moving faster.

Q.57.

According to de-Broglie wavelength, $\lambda = \frac{h}{\sqrt{2meV}}$

$$\frac{\lambda}{1/\sqrt{V}} = \frac{h}{\sqrt{2me}} \quad \Rightarrow \quad \frac{\lambda}{1/\sqrt{V}} = \frac{1}{\sqrt{m}} \times \frac{h}{\sqrt{2e}}$$

The slope is given by slope $\propto \frac{1}{\sqrt{m}}$

Slope of B > slope of A

$$\frac{1}{\sqrt{m}_B} > \frac{1}{\sqrt{m}_A} \quad \Rightarrow \quad \sqrt{m}_B < \sqrt{m}_A$$

$\therefore \quad m_B < m_A$

$\therefore$ **B represents a particle of smaller mass**

THREE MARK's QUESTIONS

Q.58 (i) The de -Broglie wavelength of a particle is given by

$\lambda = 12.27/ V$ Å where, V is the accelerating potential of the particle.

It is given that

$\lambda_{proton} = \lambda_{alpha}$

12.27 / proton = 12.27 / alpha

$V_{proton} / V_{alpha} = 1$

(ii) The de – Broglie wavelength (λ) of a particle is also given by

$\lambda = h /mv$

$\lambda_{proton} = h/m_{proton} v_{proton}$

λ alpha = $h/ m_{alpha} v_{alpha}$

We known $m_{alpha} = 4m_{proton}$

$\lambda_{alpha} = h / 4m_{proton} v_{alpha}$

$\lambda_{proton} = \lambda_{alpha}$

$h / m_{proton} v_{proton} = h / 4 m_{proton} v_{alpha}$

$v_{proton} / v_{alpha} = 4$

Q.59. (i) The threshold frequency for metal X is less and hence threshold wavelength of metal X will be larger.

(ii) As threshold frequency for X is less than that of Y and work function $\phi_0 = h \nu_0$, hence work function for X is less than that of Y. Lesser the work function, more will be its K.E.

$(K.E.)_{max} = h \nu - \phi_0$, K.E. of X will be more.

(iii)If the distance between the light source and metal X is halved, intensity of incident light becomes four times its previous value but frequency of light remains unchanged. Therefore, the K.E. of ejected electron remains unchanged.

Q.60.(a)

Basic features of photon picture of electromagnetic radiation:

(i) Radiation behaves as if it is made of particles like photons. Each photon has energy E = hv and momentum $p = h/\lambda$.

(ii) Intensity of radiation can be understood in terms of number of photons falling per second on

the surface. Photon energy depends only on frequency and is independent of intensity.
(iii) Photoelectric effect can be understood as the result of one to one collision between an electron and a photon.

(iv)When a photon of frequency (v) is incident on a metal surface, a part of its energy is used in overcoming the work function and other part is used in imparting kinetic energy, so KE = h(v – v_0).

(b) (i) Stopping potential or cut-off potential. The minimum value of the negative potential 'V_0', which should be applied to the anode in a photo cell so that the photo electric current becomes zero, is called stopping potential.

The maximum kinetic energy (K_{max}) of photoelectrons is given by,

$$K_{max} = eV_0 \qquad \text{or} \quad \frac{1}{2}mv^2_{max} = eV_0$$

(ii) Threshold frequency. The minimum frequency V_0, which the incident light must possess so as to eject photoelectrons from a metal surface, is called threshold frequency of the metal.

Mathematically $\phi_0 = hv_0$,
where [ϕ_0 is work function and h is plank's constant.]

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QUESTION BANK

CHAPTER 12-ATOMS

SECTION A

Multiple Choice Questions (1 Mark each)

Q.1 In Bohr's theory of model of hydrogen atom, name the physical quantity which equals to an integral multiple of $h/2\pi$?

(a) Momentum (b) Angular momentum

(c)Angular frequency (d)Angular velocity

Q.2 What is the relation between 'n' and radius 'r' of the orbit of electron in hydrogen atom according to Bohr's theory?

(a) 'r' is directly proportional to n (b) 'r' is directly proportional to n^2

(c) 'n^2' is directly proportional to r (d) 'r' is inversely proportional to n^2

Q.3 What is Bohr's frequency condition?

(a) $hv=E_i-E_f$ (b) $hv= E_f -E_i$ (c) $hv=E-E_f$ (d) $h=E_i-E_f$

Q.4 Write the expression for Bohr's radius in hydrogen atom?

(a) $r=4\Pi E_0$ x $h^2 / 4 \pi^2 me$ (b) $r=4\Pi E_0$ x $h^2 / 4 \pi^2 me^2$

(c) $r=4\Pi E_0$ x $h^2 / 4 \pi me^2$ (d)) $r=4\Pi E_0$ x $h/ 4 \pi^2 me^2$

Q.5 Name the spectral series of hydrogen atom lying in visible region?

(a) Paschen series (b)Pfund series (c)Bracket series (d) Balmer series

Q.6 The total energy of an electron in 1st excited state of hydrogen atom is about -3.4eV. What is the kinetic energy of electron in this state?

(a) -3.4 eV (b) 3.4 eV (c) 0.34 eV (d) -0.34 eV

Q7. Which of the following spectral series in hydrogen atom gives spectral line of 4860 ^{0}A?

(a)Lyman (b) Balmer (c) Paschen (d) Brackett

Q.8 When hydrogen atom is in first excited level, its radius is

(a)same (b) half (c) twice (d) 4 times

Q.9 Rutherford model of atom was unstable because

(a)nuclei will break down (b)electron move in circular orbit

(c)orbiting electrons radiate energy (d) electrons are repelled by the nucleus

Assertion –Reason type questions(1 mark each)

Answer: A Both are correct and reason is correct explanation of assertion.

Answer: B Both are correct but reason is not the correct explanation of assertion.

Answer: C Reason is wrong.

Answer: D Both are wrong.

Q10. **Assertion:** According to Bohr's atomic model the ratio of angular momenta of an electron in first excited state and in ground state is 2:1.

Reason: In a Bohr's atom the angular momentum of the electron is directly proportional to the principal quantum number.

Q11. **Assertion:** The positively charged nucleus of an atom has a radius of almost 10^{-15}m.

Reason: In a-particle scattering experiment, the distance of closest approach for particles is $\simeq 10^{-15}$m.

Q12. **Assertion:** For the scattering of a-particles at a large angles, only the nucleus of the atom is responsible.

Reason: Nucleus is very heavy in comparison to α particle.

Q13.**Assertion**: Bohr had postulated that the electrons in stationary orbits around the nucleus do not radiate

Reason: According to classical physics all moving electrons radiate.

Q14. **Assertion:** Atoms are not electrically neutral.

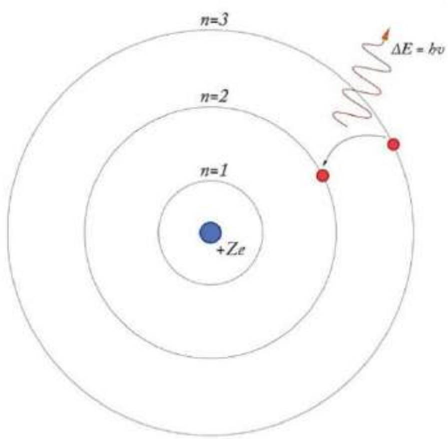
Reason: Number of protons and electrons are different.

Case study based questions (4 marks)

Q 15. BOHR ATOM MODEL

Rutherford gives Rutherford's model of the atom after performing an Alpha particle scattering experiment.

This model is a modification of the earlier Rutherford Model. According to this model, an atom consists of a small, positively-charged nucleus and negatively-charged electrons orbiting around it in an orbital. These orbital can have different sizes, energy, etc. And the energy of the orbit is also related to its size. The lowest energy is found in the smallest orbit. So if the electron is orbiting in nth orbit then we will study about its Velocity in nth orbital, Radius of nth orbital, Energy of electron in nth orbit, etc. Energy is also emitted due to the transition of electrons from one orbit to another orbit. This energy is emitted in the form of photons with different wavelengths. This wavelength is given by the Rydberg formula. When electrons make transitions between two energy levels in an atom various spectral lines are obtained. The emission spectrum of the hydrogen atom has been divided into various spectral series like Lyman series, Balmer series, Paschen series etc.



Bohr model

(I). The formula which gives the wavelength of emitted photon when electron jumps from higher energy state to lower was given by

(a) Balmer (b) Paschen (c) Lyman (d) Rydberg

(II). What is true about Bohr's atomic Model?

(a) His model was unique totally different from other

(b) His model is a modification of Rutherford atomic model.

(c) His model is a modification of Thomson atomic model.

(d) None of the above

(III). Bohr's atomic model is applicable for

(a) All types of atoms (b) Only for hydrogen atom

(c) For hydrogen like atoms (d) For H2 gas.

(IV). The cause of rejection of Rutherford atomic model was

(a) It was totally wrong (b) It could not justify its stability

(c) Rutherford was unable to explain it (d) none of the above.

Short Answer type questions (2 marks each)

Q16.The ground state energy of hydrogen atom is -13.6eV. What is the kinetic energies and potential Energies of the electron in the ground state and second excited state.

Q17. Define impact parameter. Represent diagrammatically the shape of trajectory of alpha particles.

Q18. Show graphically the variation of radius of orbit with principal quantum number n.

Q19. The radius of innermost electron orbit of a hydrogen atom is 5.3×10^{-11} m. What is the radius of orbit in the second excited state?

Q20. Define ionization energy. How would the ionization energy change when electron in hydrogen atom is replaced by the particle of mass 200 times that of the electron but having the same charge? [Given Rydberg constant, $R = 10^7\ m^{-1}$] (2016)

Q21.Write two important limitations of Rutherford nuclear model of the atom. (2017)

Q22. Calculate the de-Broglie wavelength of the electron orbiting in the n = 2 state of hydrogen atom. (2016)

Q23. Derive an expression for the radius of nth Bohr's orbit in Hydrogen atom.

Short answer type questions. (3 marks each)

Q24. In a Geiger-Marsden experiment, calculate the distance of the closest approach to the nucleus of Z= 80, when an α-particle of 8 MeV energy impinges on it before it comes momentarily to rest and reverses its direction. How will the distance of the closest approach be affected when the kinetic energy of the a-particle is doubled?

Q25. Derive an expression for the frequency of radiation emitted when a hydrogen atom de-excites from level n to level (n – 1). Also show that for large values of n, this frequency equals to classical frequency of revolution of an electron. (CBSE SQP 2020-21)

Long answer type questions. (5 marks each)

Q26. (i) Using Bohr's postulates, derive an expression for the total energy of the electron in the stationary states of the hydrogen atom. (CBSE 2013)

(ii) Using Rydberg formula, calculate the wavelengths of the spectral lines of the first member of the Lyman series and of the Balmer Series.

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ANSWERS (SECTION A)

MCQs - Answers

1.(b) Angular momentum

2. (b)‘r’ is directly proportional to n^2

3.(b) $hv=E_f-E_i$

4. (b) $r=4\Pi E_0 \times h^2 / 4\pi^2 me^2$

5. (d) Balmer series

6. (b) kE=-E =-(-3.4)=3.4 eV

7. (b) Balmer

8. (d) 4 times

9. (c)orbiting electrons radiate energy

Assertion and Reason- Answers

10. Correct answer: A

11. Correct Answer: A

12. Correct Answer: A

13. Correct Answer: B

14. correct Answer D

Case Study Based question- Answers

15. (I) (d) Rydberg

(II) (b) His model is a modification of Rutherford atomic model.

(III) (c) For hydrogen like atoms

(IV) (b) It could not justify its stability

Short answer type questions (2M)- Answers

16. KE= 13.6 eV, PE= -27.2eV in the ground state

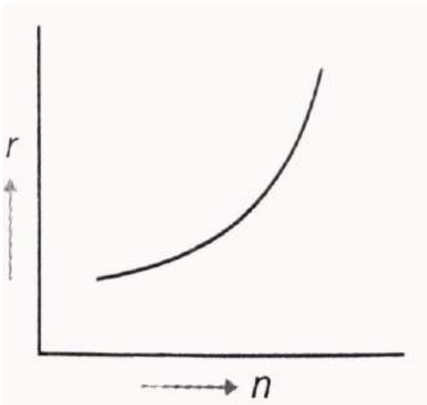
KE= 1.51 eV, PE = -3.02eV in the second excited state

17. Impact parameter perpendicular distance of the velocity vector of a-particle from the central line of the nucleus of the atom is called impact parameter (b).

for figure refer page no 115

$$b = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Ze^2 \cot \theta/2}{K}$$

18. Orbital radius is directly proportional to the square of principal quantum number



19. For n=1, r1 = 5.3x 10^{-11} m for ground state therefore r2 = 4 r1 , and r3= 9r1

r2 = 2.12x10^{-10}m r3= 4.77 x 10^{-10} m

λmin =3.646×10^{-7}m=364.6 nm**. This wavelength lies in the ultraviolet region**

20. Ionization energy: It is the minimum amount of energy required to remove an electron from the outermost orbit of an atom in its ground state.

$E_0 = \frac{me^4}{8\varepsilon_0^2 h^2}$ i.e., $E_0 \propto m$

Therefore, ionization energy will become 200 times.

21. According to Rutherford's atomic model, the electron orbiting around the nucleus continuously radiates energy because of its acceleration due to which the atom will not remain stable. So, Rutherford could not explain the stability of an atom.

(ii) Since electron spirals inwards, its angular velocity and frequency change continuously, therefore it will emit a continuous spectrum. Therefore, this model could not explain the line spectra of hydrogen.

22. Kinetic Energy is given by the formula

$\boldsymbol{E = \frac{13.6\ eV}{n^2} = \frac{13.6\ eV}{2^2} = \frac{13.6\ eV}{4}}$

$$= \mathbf{3.4 \times 1.6 \times 10^{-19}\, J}$$

De Broglie's wavelength,

$$\boldsymbol{\lambda = \frac{h}{\sqrt{2mE}} = \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} E}} = 0.067\, nm}$$

23. from Bohr's first postulate,

coloumb force F = centripetal force F_{cp}

$$\therefore \frac{Ze^2}{4\pi\varepsilon_0 r_n^2} = \frac{m_e v_n^2}{r_n}$$

$$v_n^2 = \frac{Ze^2}{4\pi\varepsilon_0 r_n m_e} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

according to Bohr's second postulate,

$$m_e r_n v_n = \frac{nh}{2\pi}$$

$$m_e^2 r_n^2 v_n^2 = \frac{n^2h^2}{4\pi^2}$$

$$v_n^2 = \frac{n^2h^2}{4\pi^2 m_e^2 r_n^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

iv from equation (1) and (2)

$$\frac{n^2h^2}{4\pi^2 m_e^2 r_n^2} = \frac{Ze^2}{4\pi\varepsilon_0 r_n m_e}$$

$$r_n = \frac{n^2h^2\varepsilon_0}{\pi m_e Z e^2}$$

$$r_n = \left(\frac{\epsilon_0 h^2}{\pi m_e^2 z e^2} n^2\right)$$

this is the required equation for radius of n^{th} orbit.

<u>Short answer type questions (3M)- Answers</u>

24. At closest approach, all K.E. of α-particles is completely converted into the P.E. of α-particle.

$$K.E. = 8MeV = 8 \times 10^6 \times 10^{-19} J.$$

K.E. is converted into P.E.

$$\frac{1}{4\pi\varepsilon_0} \cdot \frac{Ze2e}{r_0} = 12.8 \times 10^{-13}$$

$$9 \times 10^9 \times \frac{80 \times 2 \times 16 \times 10^{-19}}{r_0} = 12.8 \times 10^{-13}$$

$$r_0 = \frac{9 \times 10^9 \times 160 \times \left(1.6 \times 10^{-19}\right)^2}{12.8 \times 10^{-13}} (m)$$

$$r_0 = \frac{9 \times 1.6 \times 1.6 \times 1.6 \times 10^{-14}}{12.8}$$

$$= 2.88 \times 10^{-14m}.$$

As we see that K.E.$= \frac{1}{4\pi\varepsilon_0} \cdot \frac{Ze2e}{r_0}$

$$Hence, \quad K.E. \propto \frac{1}{r_0}$$

If K.E. become twice, closest approach will be halved.

Hence, $r_0' = \frac{r_0}{2}$

25. from Bohr's theory frequency of the radiation emitted when an electron de- excites from level n_2

to level n_1 is given as

$$f = \frac{2\pi^2 mk^2 z^2 e^4}{h^3} \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

Given n_1 =n-1, n_2 =n

$$f = \frac{2\pi^2 mk^2 z^2 e^4}{h^3} \frac{2n-1}{(n-1)^2 n^2}$$

For large n, 2n-1=2n, n-1=n and z=1

Thus, $f = \frac{4\pi^2 mk^2 e^4}{n^3\, h^3}$

Which is same as orbital frequency of electron in n^{th} orbit

$$f = \frac{V}{2\pi r} =, \frac{4\pi^2 mk^2 e^4}{n^3\, h^3}$$

Long answer question (5M) - Answers

26. $mvr = \frac{nh}{2\pi}$

$$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0} \frac{e^2}{r^2}$$

$$r = \frac{e^2}{4\pi\varepsilon_0 mv^2}$$

$$r = \frac{\varepsilon_0 n^2 h^2}{\pi m e^2}$$

P.E. $U = -\frac{1}{4\pi\varepsilon_0} . \frac{e^2}{r}$

$$= \frac{me^4}{4\varepsilon_0 n^2 h^2}$$

K.E. $= \frac{1}{2} mv^2 = \frac{1}{2} m \left(\frac{nh}{2\pi mr}\right)^2$

$$= \frac{n^2 h^2 \pi^2 m^2 e^4}{8\pi^2 m e_0^2 n^4 h^4}$$

K.E. $= \frac{me^4}{8\varepsilon_0^2 n^2 h^2}$

T.E. = K.E. + P.E.

$= -\frac{me^4}{8\varepsilon_0^2 n^2 h^2}$

(b) Rydberg formula for first member of Lyman series

$$\frac{1}{\lambda} = R \left(\frac{1}{1^1} - \frac{1}{2^2}\right)$$

$$\lambda = \frac{4}{3R}$$

For first member of Balmer Series

$$\frac{1}{\lambda} = R \left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$\lambda = \frac{36}{5R}$$

****

SECTION B

Multiple choice questions (1 mark each)

Q.1 Why did Thomson's atomic model fail?

(a) Thomson's model failed to explain the scattering of alpha particles through large angles in Rutherford experiment.

(b) Thomson's model failed to explain the scattering of alpha particles through small angles in Rutherford experiment.

(c) Thomson's model failed to explain the scattering of beta particles through large angles in Rutherford experiment.

(d)) Thomson's model failed to explain the scattering of beta particles through small angles in Rutherford experiment.

Q.2 How much is the radius of Bohr's inner most orbit?

(a) r=0.51 ^{0}A (b) r=0.35 ^{0}A (c) r=0.23 ^{0}A (d) r=0.53 ^{0}A

Q3. The transition from the state n = 5 to n = 1 in a hydrogen atom results in UV radiation. Infrared radiation will be obtained in the transition

(a) $2 \rightarrow 1$ (b) $3 \rightarrow 2$ (c) $4 \rightarrow 3$ (d) $6 \rightarrow 2$

Q.4 The energy of hydrogen atom in its ground state is -13.6eV. The energy of level corresponding to n=5 is

(a)-0.54eV (b)-5.40eV (c)-0.85eV (d)-2.75eV

Q.5 Hydrogen atom are excited from ground state of the principal quantum number 4 then number of spectral lines observed will be

(a)3 (b)6 (c)5 (d) 2

Q.6 In Bohr model of hydrogen atom which of the following is quantised?

(a) linear velocity of electron (b) angular velocity of electron

(c) linear momentum (d)angular momentum

Assertion –Reason Type Questions (1 mark)

Answer: A Both are correct and reason is correct explanation of assertion.

Answer: B Both are correct but reason is not the correct explanation of assertion.

Answer: C Reason is wrong.

Answer: D Both are wrong.

Q7. **Assertion**: The force of repulsion between atomic nucleus and α-particle varies with distance according to inverse square law.

Reason: Rutherford did a-particle scattering experiment

Q8. **Assertion** : Total energy of revolving electron in any stationary orbit is negative.

Reason : Energy is a scalar quantity. It can have positive or negative value.

Q9.**Assertion:**Balmer series lies in the visible region of electromagnetic spectrum

Reason:$1/\lambda=R(1/2^2-1/n^n)$, where n=3,4,5…..

Case study based question (5 marks)

Q 10. HYDROGEN EMISSION SPECTRA

Hydrogen spectrum consist of discrete bright lines in dark background is known as Hydrogen Emission spectrum. There is one more type of Hydrogen spectrum that exist where we get dark lines on bright background. It is known as absorption spectra.

Balmer found empirical formula by the observation of a small part of the spectrum and it is represented by $1/\lambda = R(1/2^2-1/n^2)$ where n = 3,4,5 …

(I) Number of spectral lines in Hydrogen atom is

(a) 8 (b)6 (c) 15 (d) infinity

(II) Which series of hydrogen spectrum corresponding to ultra violet region

(a) Balmer series (b) Bracket series (c) Paschen series (d)Lymen Series

(III) Which of the following lines of Hydrogen Spectrum belongs to Balmer Series

(a)1025 ^{0}A (b) 1218 ^{0}A (c)4861 ^{0}A (d)18751 ^{0}A

(IV) Rydberg Constant is

(a) Universal constant (b) same for same elements

(c) different for different elements (d) none of the above

(V) Hydrogen is excited from ground state to another state with a Principal quantum number equals to 4. Then the number of spectral lines in emission spectra will be

(a) 3 (b) 5 (c) 6 (d)2

Short Answer type questions (2 marks each)

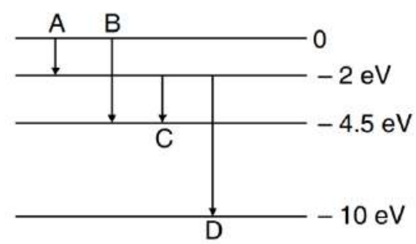
Q11.Find the ratio of energies of photons produced due to transition of an electron of hydrogen atom from its (i) second permitted energy level to the first level (ii) the highest permitted energy level to the first permitted level

Q 12. When an electron in hydrogen atom jumps from the third excited state to the ground state, how would the de Broglie wavelength associated with the electron change? Justify your answer.

Q.13 Define the distance of closest approach. An α-particle of kinetic energy 'K' is bombarded on a thin gold foil. The distance of the closest approach is 'r'. What will be the distance of closest approach for an α- particle of double the kinetic energy?

Q.14 In the ground state of hydrogen atom, its Bohr radius is given as 5.3×10^{-11} m. The atom is excited such that the radius becomes 21.2×10^{-11} m. Find (i) the value of the principal quantum number and (ii) the total energy of the atom in this excited state. (2016)

Q.15 The energy levels of a hypothetical atom are given below. Which of the shown transitions will result in the emission of photon of wavelength 275 nm? (2016)



Q.16 Show that the radius of the orbit in hydrogen atom varies as n^2, where n is the principal quantum number of the atom. (CBSE 2015)

Short answer type questions (3 marks each)

Q 17. A monochromatic radiation of wavelength 975 Å excites the hydrogen atom from its ground state to a higher state. How many different spectral lines are possible in the resulting spectrum? Which transition corresponds to the longest wavelength amongst them. (CBSE Sample QP 2018)

Long answer type questions (5 marks each)

Q. 18. (i) Draw a schematic arrangement of the Geiger- Marsden experiment and describe it.

(ii) How did the scattering of a-particle by a thin foil of gold provide an important way to determine an upper limit on the size of the nucleus? Explain briefly.

****

ANSWERS (SECTION B)

ANSWERS OF MCQ(1mark)

1.(a) Thomson's model failed to explain the scattering of alpha particles through large angles in Rutherford experiment.

2. (d) r=0.53 ^{0}A

3. (c) 4 → 3

4. (a)-0.54eV

5. (b)6

6. (d)angular momentum

Answers of Assertion Reason (1 mark)

7. Correct Answer: B

8. correct Answer B

9. Correct Answer: B

Case Study based question - Answers (5 marks)

10. (I) (d) infinity

(II) (d)Lyman Series

(III) (c)4861 ^{0}A

(IV) (a)Universal constant

(V) (c) 6

Short answer type questions (2M)- Answers

11. ΔE= Ei – Ef Ratio=3:4

12. Wave length decreases. P = $\sqrt{2mKE}$ = h/λ

E is proportional to 1/ λ

13. Distance of closest approach: It is the distance of charged particle from the centre of the nucleus, at which the whole of the initial kinetic energy of the (far off) charged particle gets converted into the electric potential energy of the system.

Distance of closest approach (r_C) is given by

$$r_c = \frac{1}{4\pi\varepsilon_0}\frac{2Ze^2}{K}$$

'K' is doubled and r_C becomes $\frac{r}{2}$

14. (i)

$$r = r_0 n^2$$

$$21.2\ X\ 10^{-11} = 5.3\ X\ 10^{-11}\ n^2$$

$$n = 2$$

(ii)

$$E = -\frac{13.6eV}{n^2}$$

$$= -\frac{13.6eV}{2^2} = -3.4eV$$

15. (i) Energy of Photon $= \frac{hc}{\lambda}$

$$= \frac{6.64\times10^{-34}\times3\times10^{8}}{275\times10^{-9}\times1.6\times10^{-18}}\ \text{eV}$$

$$= 4.5\ eV$$

(ii) The transition is B.

16.

$$\frac{1}{4\pi\varepsilon_0}\cdot\frac{e^2}{r^2} = \frac{mv^2}{r}$$

$$r = \frac{e^2}{4\pi\varepsilon_0 mv^2}$$

$$mv^2 r = \frac{e^2}{4\pi\varepsilon_0} \qquad \text{............(1)}$$

According to the Bohr's Postulates,

$$mvr = \frac{nh}{2\pi}$$

$$m^2v^2r^2 = \frac{n^2h^2}{4\pi^2}$$

Using the value of mv^2r from eqn. (1)

$$\frac{e^2}{4\pi\varepsilon_0}mr = \frac{n^2h^2}{4\pi^2}$$

$$r = \left(\frac{n^2}{m}\right)\left(\frac{h}{2\pi}\right)\frac{4\pi\varepsilon_0}{e^2}$$

The above equation show that r is directly proportional to n^2

Short answer type questions (3M)- Answers

17. The corresponding to the given wavelength

$$E = \frac{12400}{\lambda} = \frac{12400}{975} = 12.71\ eV$$

The excited state

$$E_n - E_1 = 12.71$$

$$-\frac{13.6}{n^2} + 13.6 = 12.71$$

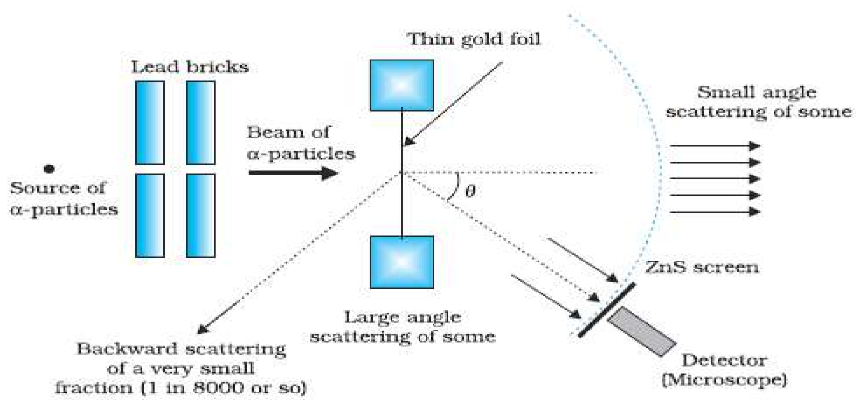
$$\therefore \quad n = 3.9 \approx 4$$

$$total\ no\ of\ spectral\ lines\ emitted : \frac{n(n-1)}{2} = 6$$

Longest wavelength will corresponding to the transition n=1 to n=4.

Long answer type questions (5M)- Answers

18. (i) Geiger-Marsden experiment: Alpha particles emitted by a $^{214}_{83}Bi$ radioactive source were collimated into a narrow beam by passing them through lead bricks. The beam was allowed to fall on a thin foil of gold of thickness 2.1×10^{-7} m. The scattered alpha particles were observed through a rotatable detector consisting of zinc sulphide screen and a microscope. The scattered alpha particles on striking the screen produced brief light flashes or scintillations. These flashes may be viewed through a microscope.



From the experiment, it was observed that only a small fraction of number of α-particles rebound back. This shows that the number of α-particles undergoing head on collision is very small. The conclusion is that the entire positive charge of atom is concentrated in a small volume called the nucleus.

(ii) The alpha particles those are incident directly on the gold nucleus, experience a very large force of repulsion and undergo maximum deflection as observed in the experiment. At the distance of head on approach, the entire kinetic energy of α-particle is converted into electrostatic potential energy. This distance of head on approach gives an upper limit of the size of nucleus (denoted by r_0) and is given by

$$E_k = \frac{1}{4\pi\varepsilon_0} . \frac{(Ze)(2e)}{r_0}$$

$$r_0 = \frac{1}{4\pi\varepsilon_0} . \frac{(Ze)(2e)}{E_k}$$

This is about 10^{-14} m.

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SECTION C

Multiple Choice Questions (1 Mark)

Q.1 What is the ratio of radii of orbits corresponding to 1^{st} excited state and ground state of hydrogen atm?

(a) 2:1 (b)1:4 (c)4:1 (d)1:2

Q.2 The ratio between Bohr radii is

(a) 1: 2: 3 (b) 2 : 4 : 6 (c) 1 : 4 : 9 (d) 1 : 3 : 5

Q3. An alpha particle of energy 5 Mega eV is scattered through 180 degree by a fixed uranium nucleus. The distance of closest approach is of the order of

(a)1 ^{0}A (b)10^{-10} cm (c)10^{-12} cm (d)10^{-15} cm

Q.4 The total energy of the electron in the ground state of hydrogen atom is -13.6 eV. The kinetic energy of the electron in the first excited state will be

(a) 1.7 eV (b) 3.4 eV (c) 6.8 eV (d)13.6 eV

Q.5 When an electron jumps from 4^{th} orbit to 2^{nd} orbit,one gets the

(a) second line of paschen series (b) second line of lyman series

(c)second line of balmer series (d) first line of pfund series

Q.6 If P.E and K.E represent potential and kinetic energies of the orbital electron then

(a) K.E=-P.E/2 (b) K.E=-P.E (c) K.E=-2P.E (d) none of the above

Assertion –Reason Type Questions (1 Mark each)

Answer: A Both are correct and reason is correct explanation of assertion.

Answer: B Both are correct but reason is not the correct explanation of assertion.

Answer: C Reason is wrong.

Answer: D Both are wrong.

Q7. **Assertion:** Electrons in the atom are held due to coulomb forces

Reason: The atom is stable only because the centripetal force due to Coulomb's law is balanced by the centrifugal force.

Q8. **Assertion:** Rydberg's constant varies with the mass number of given element.

Reason: The reduced mass of electron is dependent on the mass of nucleus only.

Q9. **Assertion:** In Lyman series, the ratio of minimum and maximum wavelength is ¾

Reason: Lyman series constitute spectral lines corresponding to transition from higher energy to ground state of hydrogen atom.

Case study based question (5 marks)

Q10. ENERGY OF ELECTRON FOR HYDROGEN ATOM

Electrons are revolving around the nucleus in particular stable orbits. The energy of the electron is increasing as we go from the orbit closer to nucleus to outer side. The ground state energy is the lowest energy and it is -13.6 eV for hydrogen atom. Thus, the minimum amount of energy required to remove or free the electron from the ground state is the ionisation energy and it has value +13.6 eV. When electrons jumps from higher energy orbit to lower energy orbit emits energy in the form of photons which are in the form of spectral lines and called as emission lines. The light emitted by the ordinary source of light consist of different wavelength. But the laser light is the monochromatic one which emits light of single wavelength. In case of hydrogen atom, the ground state energy is that energy state for which n = 1. And the states for which n > 1, all are the excited states. Where n shows the principal quantum number.

(I) In hydrogen atom, the energy corresponding to principal quantum number n =2 is___

(a) -13.6 eV (b) -3.4 Ev (c) +13.6 eV (d) +3.4 eV

(II) For ground state of hydrogen atom the value of principal quantum number is___

(a) n = 2 (b) n = 0 (c) n = 1 (d) n = infinity

(III) The minimum energy required to remove the electron from the ground state of the hydrogen atom is called as___

(a) excitation energy (b) ionisation energy

(c) ground state energy (d) excited state energy

(IV) The acronym LASER stands for?

(V) If n = infinity then what is the energy of the state and what does it means?

Short answer type questions (2 marks each)

Q 11. What is the maximum number of spectral lines emitted by a hydrogen atom when it is in the third excited state? Which one will have lowest wavelength?

Q 12. The wavelength of the second line of Balmer series in Hydrogen atom is 4861Angstrom. Calculate the wave length of the first line.

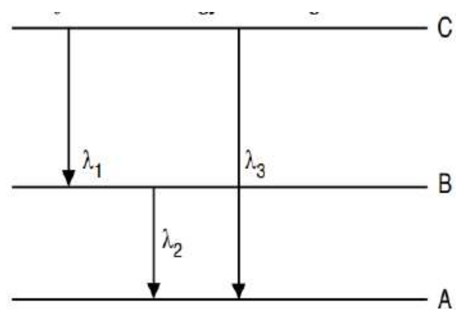
Q13. Calculate the shortest wavelength in the Balmer series of hydrogen atom. In which region (infra-red, visible, ultraviolet) of hydrogen spectrum does this wavelength lie?

Q14 The ground state energy of hydrogen atom is – 13.6 eV. If an electron makes a transition from an energy level – 1.51 eV to – 3.4 eV, calculate the wavelength of the spectral line emitted and the series of hydrogen spectrum to which it belongs. (CBSE 2017)

Q15 Energy of electron in first excited state in Hydrogen atom is -3.4eV. Find KE and PE of electron in the ground state. (CBSE SQP 2019-20)

Short answer type questions (3 marks each)

Q16. (i) State Bohr's quantization condition for defining stationary orbits. How does de-Broglie hypothesis explain the stationary orbits? (ii) Find the relation between the three wavelengths λ_1, λ_2 and λ_3 from the energy level diagram shown below. (2016)



Long answer type questions (5 marks each)

Q.17 (i) Write two important limitations of Rutherford model which could not explain the observed features of atomic spectra. How were these explained in Bohr's model of hydrogen atom ? Use the Rydberg formula to calculate the wavelength of the H_a line. (Take $R = 1.1 \times 10^7 \text{ m}^{-1}$).

(CBSE 2015)

(ii) Using Bohr's postulates, obtain the expression for the radius of the n^{th} orbit in hydrogen atom.

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ANSWERS (SECTION C)

MCQs- Answers (1 mark)

1.(c)Ground state, n=1

Excited state, n=2

r proportional to n^2

$r2/r1= 2^2/1^2$

r2/r1=4 =4:1

2. (c) 1:4:9

3. (c)10^{-12} cm

4. (b) 3.4 eV

5. (c)second line of balmer series

6. (a)K.E=-P.E/2

Assertion Reason - Answers (1 mark)

7. Correct Answer: C

8. Correct Answer: B

9. Correct Answer: B

Case Study based question – Answers (5 marks)

10. (I) b) -3.4 eV

(II) c) n = 1

(III) b) ionisation energy

(IV) The acronym LASER stands for Light Amplification by Stimulated Emission of Radiation.

(V) When the principal quantum number n = infinity then the corresponding state is having energy 0 eV. And this energy of atom is possible only when electron is totally removed from the nucleus and hence it goes to rest.

Short answer type questions (2M) – Answers

11. third excited state, n2 = 4, and n1 = 3, 2, 1 Hence there are 3 spectral lines.

Greater the energy lower the wavelength

12. For the first line in balmer series

$\lambda 1 = R(1/2^2 - 1/3^2) = 365R$

For second balmer line:

$4861 = R(1/2^2 - 1/4^2) = 163R$ Divide both equations:

$\lambda = 4861 \times 27/20 = 6562.35\ ^0A$

13. For shortest wavelength in the Balmer series: n1=2 n2=∞

$\lambda min = 3.646 \times 10^{-7} m = 364.6$ nm**. This wavelength lies in the ultraviolet region**

14. $\boldsymbol{h\nu = \frac{hc}{\lambda} = (E_2 - E_1)}$

$$\boldsymbol{\lambda = \frac{h\nu}{(E_2 - E_1)}}$$

$$\boldsymbol{\lambda = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{[-0.85 - (-3.4)] \times 6 \times 10^{-19}}}$$

$$\boldsymbol{\lambda = 4.87 \times 10^{-7} m}$$

This wavelength belongs to Balmer series.

15. Energy of electron in n=2 is 3.4eV

Energy ground state = -13.6eV

K.E. = - T.E.= +13.6eV

$E_n = \frac{x}{n^2}$

$= -13.6eV = \frac{x}{2^2}$

Energy of ground state x=-13.6eV.

P.E. = 2T.E. = -2 x 13.6 eV = -27.2 eV

Short answer type questions (3M) – Answers

16. (i) $L = \frac{nh}{2\pi}$ i.e. angular momentum and orbiting electron is quantized

According to de-Broglie hypothesis

linear momentum, $p = \frac{h}{\lambda}$

for circular orbit, $L = r_n p$ where r_n is radius of n^{th}orbit

$$= \frac{r_n h}{\lambda}$$

also $L = \frac{nh}{2\pi}$

$$\frac{r_n}{\lambda} = \frac{nh}{2\pi}$$

$$2\pi r_n = n\lambda$$

∴ circumference of permitted orbits are integral multiples of the wavelength λ

(ii)

$$E_C - E_B = \frac{hc}{\lambda_1} \qquad ......(1)$$

$$E_B - E_A = \frac{hc}{\lambda_2} \qquad .....(2)$$

$$E_C - E_A = \frac{hc}{3} \qquad .....(3)$$

According to equations (1) and (2)

$$E_C - E_A = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2} \qquad ......(4)$$

Using equation (3) and (4), we get

$$\frac{hc}{\lambda_3} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2}$$

$$\frac{1}{\lambda_3} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$$

Long answer type questions (5M) – Answers

17**.** (i) Limitations of Rutherford's atomic model are as follows:

(1) According to Rutherford's atomic model, the electron orbiting around the nucleus continuously radiates energy because of its acceleration, due to which the atom will not remain stable. So, Rutherford could not explain the stability of an atom.

(2) Since electron spirals inwards, its angular velocity and frequency change continuously, therefore it will emit a continuous spectrum. Therefore, this model could not explain the line spectra of hydrogen.

According to Bohr's model of hydrogen atom, Electron in an atom can revolve in certain stable orbits without emitting the energy. Energy is released or absorbed only when an electron jumps from one stable orbit to another stable orbit resulting in a discrete spectrum.

$$\frac{1}{\lambda} = R\left(\frac{1}{2^1} - \frac{1}{3^2}\right)$$

$$\frac{1}{\lambda} = 1.1 \times 10^7 \left(\frac{1}{4} - \frac{1}{9}\right)$$

$$\lambda = 656.3\ nm$$

(ii) **From Bohr′s first postulate**,

coloumb force F = centripetal force F_{cp}

$$\therefore \frac{Ze^2}{4\pi\varepsilon_0 r_n^2} = \frac{m_e v_n^2}{r_n}$$

$$v_n^2 = \frac{Ze^2}{4\pi\varepsilon_0 r_n m_e} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

according to Bohr's second postulate,

$$m_e r_n v_n = \frac{nh}{2\pi}$$

$$m_e^2 r_n^2 v_n^2 = \frac{n^2h^2}{4\pi^2}$$

$$v_n^2 = \frac{n^2h^2}{4\pi^2 m_e^2 r_n^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

iv from equation (1) and (2)

$$\frac{n^2h^2}{4\pi^2 m_e^2 r_n^2} = \frac{Ze^2}{4\pi\varepsilon_0 r_n m_e}$$

$$r_n = \frac{n^2h^2\varepsilon_0}{\pi m_e Z e^2}$$

$$r_n = \left(\frac{\varepsilon_0 h^2}{\pi m_e^2 z e^2} n^2\right)$$

this is the required equation for radius of n^{th} orbit.

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QUESTION BANK

CHAPTER 13-NUCLEI

SECTION-A

MCQ

Q1. The mass number of a nucleus is

(a) Always less than its atomic number

(b) Always more than its atomic number

(c) Always equal to its atomic number

(d) Sometimes more than and sometimes equal to its atomic number

Q2. Nuclear binding energy is equivalent to

(a) Mass of proton

(b) Mass of neutron

(c) Mass of nucleus

(d) Mass defect of nucleus

Q3. In nuclear reaction, there is conservation of

(a) Mass only (b) Momentum only (c) Energy only (d) Mass, energy and momentum

Q4. Particles which can be added to the nucleus of an atom without changing its chemical properties are called

(a) Neutrons (b) Electrons (c) Protons (d) Alpha particles

Q5. The radius of a nucleus is

(a) Directly proportional to its mass number

(b) Inversely proportional to its atomic weight

(c) Directly proportional to the cube root of its mass number

(d) None of these

Q6. The mass of an atomic nucleus is less than the sum of the masses of its constituents. This mass defect is converted into

(a) Heat energy (b) Light energy (c) Electrical energy (d) Energy which binds nucleons together

Q7. The neutrons and protons are collectively called as

a) Neutrons (b) Mass (c) Nucleons (d) None

ASSERTION AND REASON QUESTIONS

Read the assertion and reason carefully to mark the correct option out of the options given below:

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c) If assertion is true but reason is false.

(d) If the assertion and reason both are false.

(e) If assertion is false but reason is true

Q8. Assertion : Density of all the nuclei is same.

Reason : Radius of nucleus is directly proportional to the cube root of mass number

Q9. Assertion : All the radioactive elements are ultimately converted in lead.

Reason : All the elements above lead are unstable

Q10. Assertion : The mass of a nucleus can be either less than or more than the sum of the masses of nucleons present in it.

Reason : The whole mass of the atom is considered in the nucleus.

2 MARKS QUESTIONS

Q11. Why are heavy nuclei usually unstable?

Q12. Write two characteristic features of nuclear force which distinguish it from Coulomb's force

Q13. Why do stable nuclei never have more protons than neutrons?

Q14. Distinguish between isotopes and isobars. Give one example for each of the species.

3-MARKS QUESTIONS

Q 15. Define nuclear fusion. Nuclear fusion is not possible in laboratory. Explain.

Q16. Calculate binding energy per nucleon of $^{56}Fe_{26}$ nucleus. Given that mass of $^{56}Fe_{26}$ = 55.934939u, mass of proton = 1.007825u, mass of neutron = 1.008665 u and 1 u = 931 MeV.

1) $^{3}He_{2}$ and $^{3}H_{1}$ nuclei have same mass number. Do they have the same Binding energy Explain
2) If both the number of neutrons and the numbers of protons are conserved in each nuclear reaction, in what way is mass converted into energy in a nuclear reaction? Explain

5-MARKS QUESTIONS

Q 17. Distinguish between nuclear fission and fusion. Show how both these processes energy is released. Calculate the energy release in MeV in the deuterium-tritium fusion reaction

$_1H^2 + {_1H^3} \rightarrow {_2He^4} + n$

using the data mass of $_1H^2$= 2.014102 u, mass of $_1H^3$ = 3.016949 u, mass of $_2He^4$ = 4.002603 u, mass of neutron = 1.008665 u, u = 931.5 MeV

Q18. i) What characteristic property of nuclear force explains the constancy of binding energy per nucleon (B.E/A) in the range of mass number 'A' lying 30<A< 170. ii) Show that the density of nucleus over a wide range of nuclei is constant independent of mass number A.

3-MARKS QUESTIONS- CASE STUDY

Q19. As per the population rise in our country, energy demand is also increasing especially the electrical energy. For fulfilment of such demand, one of the option is to utilize nuclear sources. Nuclear energy is obtained through the nuclear fission process, where a bi nucleus gets split into two or more than two smaller nuclei along with tremendous amount of energy. This energy can be used for either constructive purpose or destructive purpose for the humans. Nuclear reaction is of two types- nuclear fission and nuclear fusion. In nuclear reactor, controlled nuclear fission reaction is carried out.

(I) The process taking out in the sun, due which we get light and heat energy

(A) Nuclear fission (B) Nuclear fusion (C) Thermal reactions (D) Nuclear holocaust

(II) The atomic energy programme in our country was launched under the leadership of

(A) C V Raman (B) H J Bhabha (C) A P J Abdul Kalam (D) Amit Bhatnagar

(III) The temperature of the core of the sun is about

(A) 10^3 to 10^4 K (B) 10^6 to 10^7 K (C) 10^9 to 10^{10} K (D) None of the above

(IV) To slow down the fast moving neutrons in nuclear reactor by

(A) Control rods (B) Moderator (C) Coolant (D) Plasamon.

Q 20. ***Read the passage given below and answer the following questions:***

Neutrons and protons are identical particle in the sense that their masses are nearly the same and the force, called nuclear force, does into distinguish them. Nuclear force is the strongest force. Stability of nucleus is determined by the neutron proton ratio or mass defect or packing fraction. Shape of nucleus is calculated by quadrupole moment and spin of nucleus depends on even and odd mass number. Volume of nucleus depends on the mass number. Whole mass of the atom (nearly 99%) is centred at the nucleus

(I) The correct statements about the nuclear force is/are

(a) charge independent

(b) short range force

(c) non-conservative force

(d) all of these.

(II) The range of nuclear force is the order of

(a) 2×10^{-10} m (b) 1.5×10^{-20} m (c) 1.2×10^{-4} m (d) 1.4×10^{-15} m

(III) A force between two protons is same as the force between proton and neutron. The nature of the force is

(a)Electrical force (b) weak nuclear force (c) gravitational force (d) strong nuclear force

(IV) All the nucleons in an atom are held by

(a) nuclear forces (b) vander waal's forces (c) tensor forces (d) coulomb forces

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ANSWER KEY-SECTION A

MCQ: 1) b 2) d 3) b 4) a 5) c 6) d 7) c

ASSERTION AND REASON: 8) a 9) a 10) e

2-MARKS QUESTIONS

11.Due to large repulsive force between the large numbers of protons in the nucleus

12.Characteristic Features of Nuclear Force

Nuclear forces are short range attractive forces (range 2 to 3 fm) while Coulomb's forces have range up to infinity and may be attractive or repulsive.

Nuclear forces are charge independent forces; while Coulomb's force acts only between charged particle

13.Protons are positively charged and repel one another electrically. This repulsion becomes so great in nuclei with more than 10 protons or so, that an excess of neutrons which produce only attractive forces, is required for stability

14.Atoms of same elements having same atomic number but different mass numbers known as isotopes. Eg. ${}_{17}Cl^{35}$, ${}_{17}Cl^{36}$ and ${}_{17}Cl^{37}$

Atoms of different elements with different atomic number but same mass number known as isobars. Eg ${}_{18}Ar^{40}$, ${}_{20}Ca^{40}$

3-MARKS QUESTIONS

15.In nuclear fusion reaction, two or more than two smaller nucei get combine together to more stable nucleus. Nuclear fusion is not possible in laboratory because it requires very high temperature such as 10^6 to 10^7K. Such high temperature are often generated in nuclear fission. That is why fission precedes fusion. These processes cannot be carried out in laboratory

16.Mass of proton = 1.007825 u

Mass of neutron = 1.008665 u

Mass of Fe = 55.934939 u

Mass of 26 protons = 26 x 1.007825 u = 26.2035 u

No of neutrons = 56-26 = 30

Mass of 30 neutrons = 30 x 1,008665 u = 30.25995 u

Total mass of 56 nucleons = 26.2035 + 30.25995 = 56.4334 u

Mass defect = Total mass – mass of Fe = 56.4334 – 55.934939 = 0.528468 u

Binding energy = mass defect x 931.5 MeV = 0.528468 x 931.5 MeV

= 492.267942 MeV

Binding energy per nucleon = Binding energy/ mass number = 492.267942/56

= 8.790 MeV

1) No, the binding energy of $_1H^3$ is greater since more energy is required to bind 2 neutrons and 1 proton in $_1H^3$ than 2 protons and 1 neutron in $_2He^3$
2) As the number of nucleons is conserved in a nuclear reaction, the total rest mass of protons and neutrons on each other side of the reaction remains same. But the binding energies of nuclei on the two sides of the reaction different. It is this difference in B.E that appears as the energy released in the nuclear reactions.

5 MARKS QUESTIONS

17.

Nuclear Fission	**Nuclear Fusion**
When the nucleus of an atom splits into lighter nuclei through a nuclear reaction the process is termed nuclear fission.	Nuclear fusion is a reaction through which two or more light nuclei collide with each other to form a heavier nucleus.
When each atom split, a tremendous amount of energy is released	The energy released during nuclear fusion is several times greater than the energy released during nuclear fusion.
Fission reactions do not occur in nature naturally	Fusion reactions occur in stars and the sun
Little energy is needed to split an atom in a fission reaction	High energy is needed to bring fuse two or more atoms together in a fusion reaction
Atomic bomb works on the principle of nuclear fission	Hydrogen bomb works on the principle of a nuclear fusion bomb.

In both reactions there is a mass defect which is converted into energy.

Now energy released in the reaction

$Q = [\ mass({}_1H^2) + mass({}_1H^3) – mass({}_2He^4) – \text{mass of neutron}]c^2$

= [2.014102 + 3.016049 -4.002603-1.008665] x 931.5 MeV

= 0.018883 x 931.5 MeV = 17.58 MeV

18.i) The approximate constancy of BE/A over most of the range is saturation property of nuclear force. In heavy nuclei, nuclear size > range of the nuclear force.

So a nuclear sense approximately a constant number of neighbhors and thus the nuclear BE/A levels off at high A. This saturation of the nuclear force

ii) The mass of the nucleus of the atom of the mass number A

A= A a.m.u.

$= A \times 1.660565 \times 10^{-27}$kg

The volume of the nucleus is $4/3\ \pi r^3 = 4/3\pi(R_O A^{-3})^3 = 4/3\pi R_0^3 A$

$\therefore$Volume=$4/3\pi(1.1\times10^{-15})^3 \times$Am3

Now the density of the nucleus= m/V; where m is mass and V is the volume of the nucleus.

$\rho = A \times 1.660565\times10^{-27}kg / 4/3\pi(1.1\times10^{-15})^3 = 2.97\times10^{17}\ Kgm{-3}$

Thus, we can see the density of the nuclei is independent of mass number and it is constant for all nuclei

3 MARKS QUESTIONS- CASE STUDY

19. (I) b (II) b (III) b (IV) a

20.(I) a (II) d (III) d (IV) a

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SECTION-B

MCQ

Q1. Binding energy per nucleon of a stable nucleus is

(a) 8 eV (b) 8 KeV (c) 8 MeV (d) 8 BeV

Q2. The binding energy per nucleon is almost constant for many nuclei. It shows that nuclear forces are

(a) Charge independent

(b) Saturated in nature

(c) Short range in nature

(d) Attractive in nature

Q3. The electrons cannot exist inside the nucleus because

(a) de-Broglie wavelength associated with electron in β -decay is much less than the size of nucleus

(b) de-Broglie wavelength associated with electron in β -decay is much greater than the size of nucleus

(c) de-Broglie wavelength associated with electron in β -decay is equal to the size of nucleus

(d) Negative charge cannot exist in the nucleus

Q4. Which one of the following has the identical property for isotopes?

(a) Physical property (b) Chemical property (c)Nuclear property (d) Thermal property

Q5. When the number of nucleons in nuclei increases, the Binding energy per nucleon

(a) Increases continuously with mass number

(b) Decreases continuously with mass number

(c) Remains constant with mass number

(d) First increases and then decreases with increase of mass number

Q6. Fusion reactions take place at high temperature because

(a) Atoms are ionised at high temperature

(b) Molecules break up at high temperature

(c) Nuclei break up at high temperature

(d) Kinetic energy is high enough to overcome repulsion

Q7. The tritium which is the isotope of hydrogen contains

(a)One proton, one neutrons

(b)One proton, two neutrons

(c)Two protons, one neutrons

(d)None

Q8. Heavy stable nuclei have more neutrons than protons. This is because of the fact that

(a)Neutrons are heavier than protons.

(b)Electrostatic force between protons is repulsive.

(c) Neutrons decay into protons through beta decay.

(d)Nuclear forces between neutrons are weaker than that between protons

ASSERTION AND REASON QUESTIONS

Read the assertion and reason carefully to mark the correct option out of the options given below:

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c) If assertion is true but reason is false.

(d) If the assertion and reason both are false.

(e) If assertion is false but reason is true

Q9. Assertion : Fragments produced in the fission of 235 U are radioactive.

Reason : The fragments have abnormally high proton to neutron ratio.

Q10. Assertion : All the radioactive elements are ultimately converted in lead.

Reason : All the elements above lead are unstable.

Q11. Assertion : It is not possible to use Cl 35 as the fuel for fusion energy.

Reason : The binding energy of Cl 35 is too small.

Q12. Assertion : Electron capture occurs more often than positron emission in heavy elements.

Reason : Heavy elements exhibit radioactivity.

(2 MARKS QUESTIONS)

Q13. For a given nuclear reaction the B.E./nucleon of the product nucleus/nuclei is more than that for the original nucleus/nuclei. Is this nuclear reaction exothermic or endothermic in nature? Justify your choice

Q14. Calculate the energy equivalent of 1amu in MeV.

(3 MARKS QUESTIONS)

Q15.A given coin has a mass of 3.0 g . Calculate the nuclear energy that would be required to separate all the neutrons and protons from each other. For simplicity assume that the coin is entirely made of 63 29Cu atoms (of mass 62.92960 u)

Q16. Calculate binding energy per nucleon of $^{209}Bi_{83}$ nucleus. Given that mass of $^{209}Bi_{83}$ = 55.934939u, mass of proton = 1.007825u, mass of neutron = 1.0086 MeV665 u and 1 u = 931 MeV.

Q17. Suppose, we think of fission of a $^{56}Fe_{26}$ nucleus into two equal fragments, $^{28}Al_{13}$. Is the fission energetically possible? Mass of $^{56}Fe_{26}$ = 55.934939u, mass of $^{28}Al_{13}$ = 55.934939u

1) How is the size of a nucleus experimentally determined? Write the relation between the radius and mass number of the nucleus is independent of its mass number

****

ANSWER KEY-SECTION B

MCQ: 1. C 2. C 3. B 4. B 5. D 6. A 7. 8. B

ASSERTION AND REASON: 9. C 10. C 11. C 12. B

2 MARKS QUESTIONS

13. As BE/nuleon of the product nuclei is more than that of original nuclei. So more mass has been converted into energy. This would result in release of energy so it is exothermic

14.One atomic mass unit (1 a.m.u.) is defined as one twelfth 112 of the mass of an atom of carbon-12.

1 a.m.u. = 1.66×10^{-27}kg

According to Einstein's mass-energy equivalence relation,

$E = (\Delta m)c2$

So, we need to find energy equivalent of 1 a.m.u.

$E=(1.66\times10^{-27}\ kg)\times(3\times10^{8}\ m/s)2$

$=1.49\times10^{-10}$ joules

But 1 MeV = 1.6×10^{-13} J

$E=1.49\times10^{-10}$ x 1.6×10^{-13} MeV

=931.5 MeV

Thus, 1 amu of mass is equivalent to 931.5 MeV of energy.

3-MARKS QUESTIONS

15.Number of atoms in a 3g coin=$6.023\times10^{23}\times3 / 63=2.868\times10^{22}$

Each copper atom has 29 protons and 34 neutrons.

Mass of the copper nucleus = 62.92960

Thus, the mass defect of each atom is $29\times1.00783+34\times1.00867-62.92960=0.59225$u.

Total mass defect of all atoms = $0.59225u\times2.868\times10^{22}=1.6985\times10^{22}$u.

Thus, the nuclear energy required=$1.6985\times10^{22}\times931MeV=1.58\times10^{25}$ MeV.

16.Bismuth nucleus contains 83 protons

Number of neutrons=209−83=126 neutrons

Now, Mass of 83 protons=83 X 1.007825=83.649475amu

Mass of 126 neutrons=126X1.008665=127.091790amu

Therefore, total mass of nucleons=83.649475+127.091790=210.741260amu

Given, mass of nucleus=208.980388amu

Now, mass defect $\triangle$m =210.741260−208.980388=1.760872

Total binding energy=1.760872 X 931.5=1640.26MeV

Therefore, average binding energy per nucleon = 1640.26/ 209 =7.848Mev

17.It is given that The atomic mass of Fe = 55.93494.0 u

The atomic mass of Al = 27.98191 u

The Q value of this nuclear reaction is given as Q = [($m$ass of Fe) –(2 mass of Al)] c2

= [55.93494 – 2 × 27.9819119] c^2

Q = (−0.02888 c2) u

But we know that 1 u = 931.5 Mev/c2 QQ = −0.02888 × 931.5 = −26.902 MeV

The Q value of the fission is negative. Therefore, fission is not possible. For a possible fission reaction, the Q value should be positive

1) It was possible to obtain the size of the nucleus through Rutherford's experiment. We can calculate the size of the nucleus, by obtaining the point of closest approach of an alpha particle

If R is the radius of nucleus having mass number A, then R = R_0 $A^{1/3}$

Where R_0= 1.2 X 10^{-15} m which is the range of order of nuclear size and A is mass number

SECTION-C

(3 MARKS QUESTIONS)

Q1. A heavy nucleus X of mass number A= 240 and B.E/A = 7.6MeV is split into two nearly equal fragments Y and Z of mass numbers A_1= 110 and A_2= 130. The binding energy of each one of these nuclei is 8.5MeV per nucleon. Calculate the total binding energy of each one of the nuclei X, Y and Z and hence the energy Q released per fission in MeV

Q2.Four nuclei of an element fuse together to form a heavier nucleus. If the process is accompanied by release of energy, which of the two the parent or the daughter nucleus would have higher binding energy

(2 MARKS QUESTIONS)

Q3. In tropical nuclear reaction e.g., $^2H_1$ + $^2H_1$−−−>$^3He_2$+ $^1n_0$+ 3.27 MeV, although number of nucleons is conserved, yet energy is released. How? Explain

Q4. Obtain approximately the ratio of the nuclear radii of the gold isotope $_{79}Au^{197}$ and the silver isotope $_{47}Ag^{107}$

****

ANSWER KEY-SECTION C

1.The nuclear reaction is

X240→Y110+Z130+Q

As per given data

Q=110×8.5+130×8.5−240×7.6

=240(0.9) MeV=216MeV

2.Since the unstable parent nuclei fuse to form a heavier stable daughter nuclei in a nuclear fusion reaction releasing some energy. So, daughter nuclei is more stable than parent nuclei. Thus daughter nucleus has more binding energy per nucleon than parent nucleus

3.In a nuclear reaction, the aggregate of the masses of the target nucleus ($_1H^2$) and the bombarding particle may be greater or less than the aggregate of the masses of the product nucleus ($_2He^3$) and the outgoing particle ($_0n^1$).

So, from the law of conservation of mass- energy some energy (3.27 Mev) is evolved or involved in a nuclear reaction. This energy is called Q-value of the nuclear reaction.

4. Let R_{Au} be the nuclear radius of the gold isotope and R_{Ag} be the nuclear radius of the silver isotope.

We have the mass number of the gold (Au)is 197

the mass number of the silver(Ag) is 107.

The ratio of the radii of te two nuclei is related with their ass number as:

$(R_{Au} / R_{Ag}) = (197/107)^{1/3} = 1.2256 = 1.23$

****

Unit IX: Electronic Devices 10 Periods

Chapter–14: Semiconductor Electronics: Materials, Devices and Simple Circuits

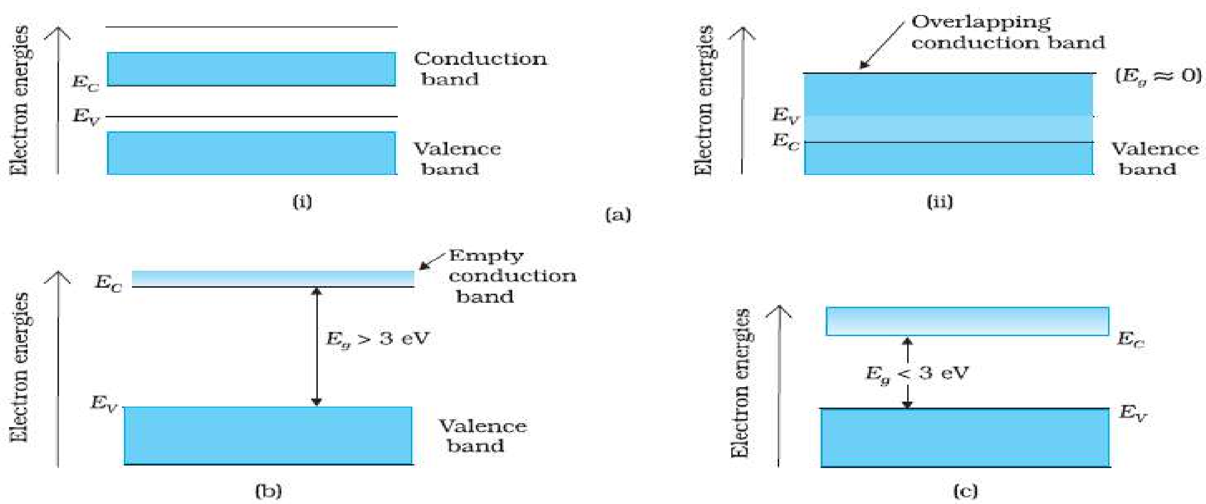
GIST OF THE CHAPTER:

Energy bands in conductors, semiconductors and insulators (qualitative ideas only) Intrinsic and extrinsic semiconductors- p and n type, p-n junction Semiconductor diode - I-V characteristics in forward and reverse bias, application of junction diode -diode as a rectifier.

Energy bands in solids:

- Due to influence of high electric field between the core of the atoms and the shared electrons, energy levels are split-up or spread-out forming energy bands.
- The energy band formed by a series of levels containing valance electrons is called valance band and the lowest unfilled energy level just above the valance band is called conduction band.
- Filled energy levels are separated from the band of unfilled energy levels by an energy gap called **forbidden gap** or energy gap or band gap.

Energy band diagram for, Conductors Semiconductors and Insulators



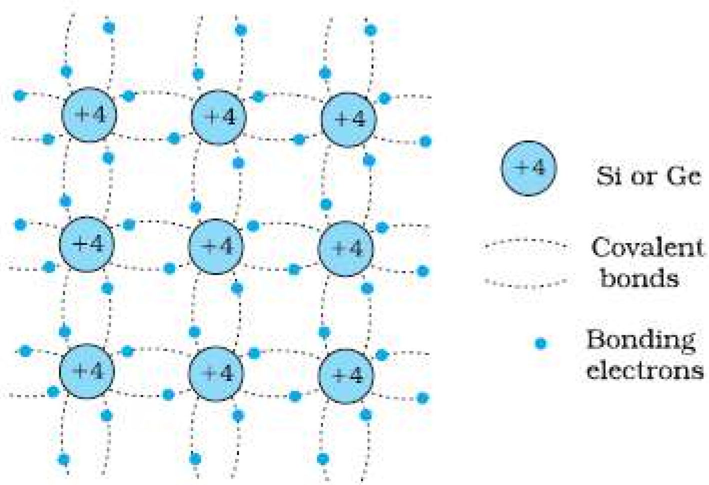
Conductors (Metals): The conduction band and valance band partly overlap each other and there is no forbidden energy gap in between.Large number of electrons are available for electrical conduction , hence the resistance is low of such materials.Even if a small electric field is applied across the metal, these free electrons start moving.Hence metals behave as a conductor.

Semiconductors: The conduction and valance bands are separated by the small energy gap (1 eV) called forbidden energy gap. The valence band is completely filled, while the conduction band is empty at zero kelvin. The electrons cross from valence band to conduction band even when a small amount of energy is supplied. The semiconductor acquires a small conductivity at room temperature.

Insulators: Electrons, however heated, cannot practically jump to conduction band from valence band due to a large energy gap (>3 eV). Therefore, conduction is not possible in insulators.

INTRINSIC SEMICONDUCTORS:

- Intrinsic Semiconductor is a pure semiconductor.
- The energy gap in Si is 1.1 eV and in Ge is 0.74 eV.
- Si: $1s^2$, $2s^2$, $2p^6$,$3s^2$, $3p^2$. (Atomic No. is 14)
- Ge: $1s^2$, $2s^2$, $2p^6$,$3s^2$, $3p^6$, $3d^{10}$, $4s^2$, $4p^2$. (Atomic No. is 32)
- Both Si and Ge have four valance electrons. The four valance electrons form four covalent bonds by sharing the electrons with neighbouring four atoms.
- In intrinsic semiconductor, the number of thermally generated electrons always equals the number of holes. So, if n_i and p_i are the concentration of electrons and holes respectively, then $n_i = p_i$. The quantity n_i or p_i is referred to as the 'intrinsic carrier concentration'.
- At 0 K, a semiconductor is an insulator i.e., it possesses zero conductivity. When temperature is increased, a few covalent bonds break up and release the electrons. These electrons move to conduction band leaving behind equal number of holes in valence band. The conductivity of an intrinsic semiconductor is due to both electrons and holes.



DOPING:

- Doping a Semiconductor: Doping is the process of deliberate addition of a very small amount of impurity (1% of crystal atoms) into an intrinsic semiconductor.
- The impurity atoms are called dopants.
- The semiconductor containing impurity is known as '**Extrinsic semiconductor'**.
- Doping of a semiconductor increases its electrical conductivity to a great extent.
- The pentavalent impurity atoms are called donor atoms, while the trivalent impurity atoms are called acceptor atom.

Extrinsic semiconductor.

A semiconductor doped with a suitable impurity (pentavalent or trivalent), so as to possess conductivity much higher than the semiconductor in pure form is called an extrinsic semiconductor.

Extrinsic semiconductors are of two types:

1) n-type semiconductor
2) p-type semiconductor

1) n-type semiconductor:

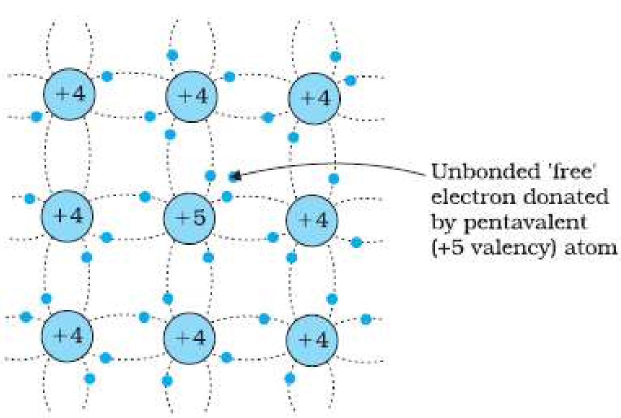
When a pentavalent impurity, such as arsenic or antimony or phosphorus is added to a pure semiconductor, the four of the five valance electrons of the impurity atoms form covalent bonds by sharing the electrons with the adjoining four silicon atoms, while the fifth electron is very loosely bound with the parent impurity atom and is comparatively free to move.

The number of free electrons become more than the holes in the semiconductor and such an extrinsic semiconductor is called n-type semiconductor. In other words, in a n-type semiconductor, electrons are majority carriers and holes are minority carriers.

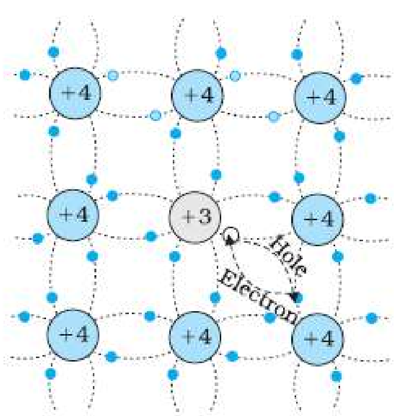
2) p-type semiconductor:

When a trivalent impurity, such as indium or gallium or boron is added to a pure semiconductor, three valance electrons of the impurity atoms form covalent bonds by sharing the electrons with the adjoining three silicon atoms.

Due to the deficiency of an electron, there is one incomplete covalent bond.The vacancy that exists with the fourth covalent bond with fourth Si atom constitutes a hole.
The semiconductor becomes deficient in electrons i.e. number of holes become more than the number of electrons. Such a semiconductor is called p-type semiconductor. It has holes as majority carriers and electrons as minority carriers.



n-type semiconductor



p-type semiconductor

Electrical conductivity of a semiconductor:

The conductivity of a semiconductor is determined by the mobility (μ) of both electrons and holes and their concentration. Mathematically- $\boldsymbol{\sigma = e\,(n_e\mu_e + n_h\mu_h)}$

P-N JUNCTION.

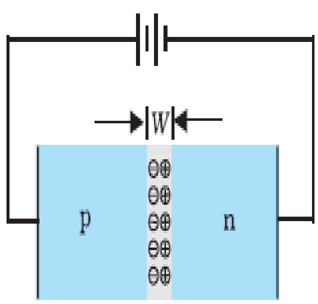
The device obtained by bringing a p-type semiconductor crystal into close contact with n-type semiconductor crystal is called a p-n junction. It conducts in one direction only. It is also called a junction diode

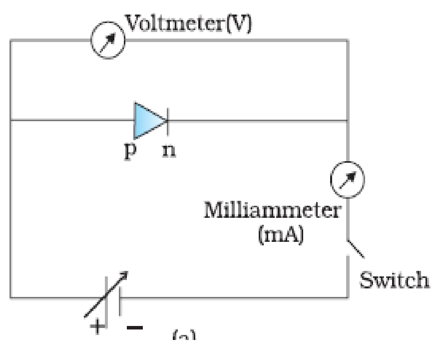
Depletion layer. It is a thin layer formed between the p and n-sections and devoid of holes and electrons. Its width is about 10^{-8} m. A potential difference of about 0.7 V is produced across the junction, which gives rise to a very high electric field (= 10^6 V/ m).

Potential Barrier: The difference in potential between p and n regions across the junction makes it difficult for the holes and electrons to move across the junction. This acts as a barrier and hence called 'potential barrier'. **Potential barrier for Si is nearly 0.7 V and for Ge is 0.3 V. The potential barrier opposes the motion of the majority carriers.**

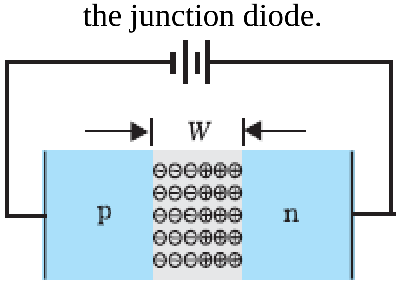
Forward biasing:

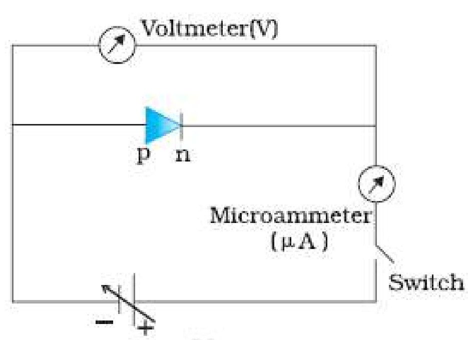
The p-n junction is said to be forward biased, when the positive terminal of the external battery is connected to p-section and the negative terminal to n-section of the junction diode.





Reverse biasing: The p-n junction is said to be reverse biased, when the positive terminal of the battery is connected to n-section and the negative terminal to p-section of the junction diode.

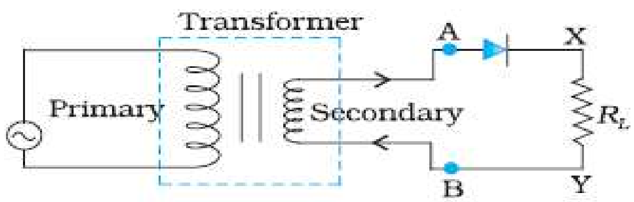




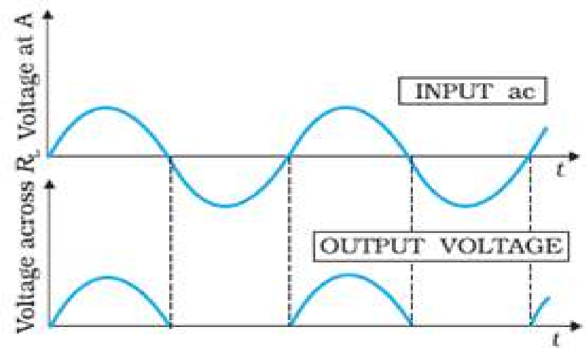
Junction diode as rectifier:

Because of its unidirectional conduction property, the p-n junction is used to convert an a,c. voltage into d. c, voltage, It is, then, said to be acting as a rectifier.

1. **Half wave rectifier:** A rectifier, which rectifies only one half of each a.c. input supply cycle, is called a half wave rectifier. A half wave rectifier gives discontinuous and pulsating d.c. output. As alternative half cycles of the a.c. input supply go waste, its efficiency is very low.

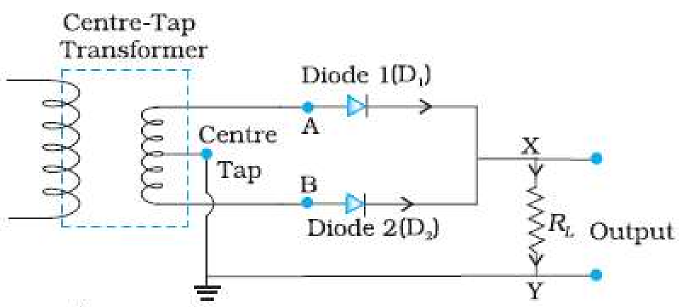


Circuit Diagram

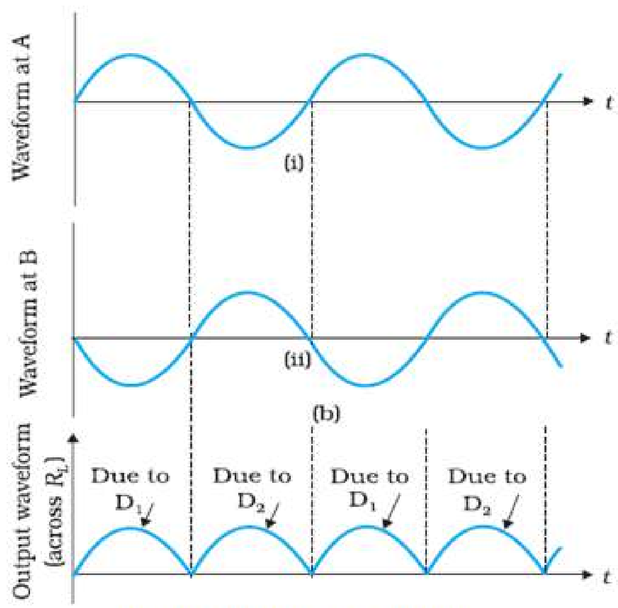


Input- Output Waveform

2. **Full wave rectifier:** A rectifier which rectifies both halves of each a.c. input cycle is called a full wave rectifier. The output of a full wave rectifier is continuous but pulsating in nature. However, it can be made smooth by using a filter circuit.



Circuit Diagram

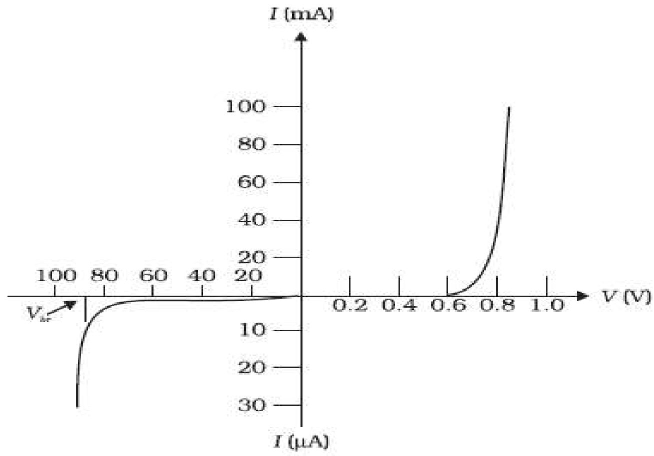


Input- Output Waveform

GRAPHS

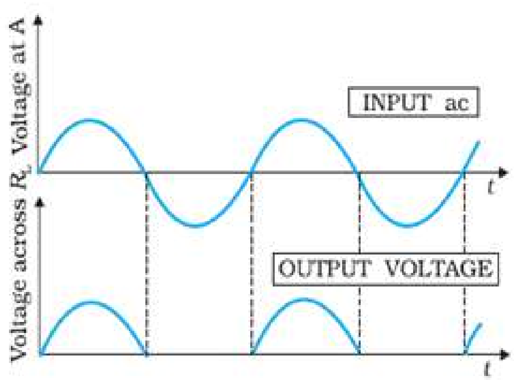
1) I -V CHARACTERISTICS:

Forward Bias & Reverse Bias Characteristics of a P-N Junction Diode

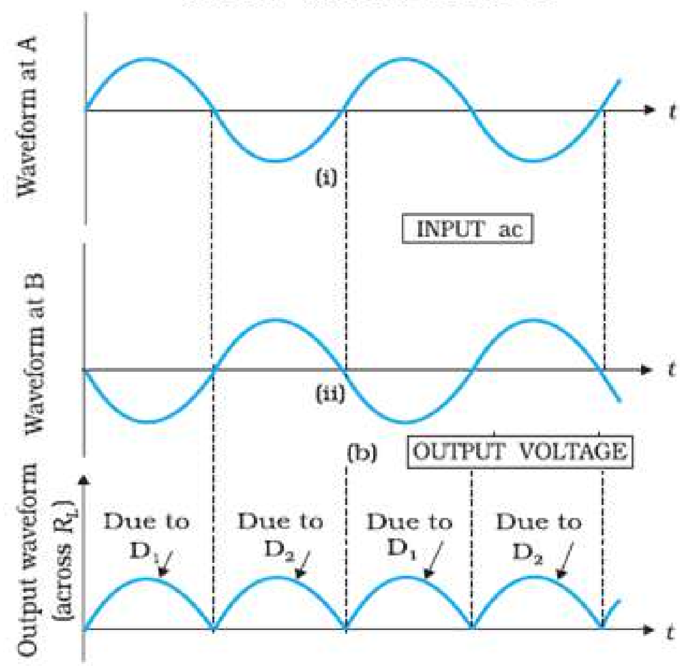


2) INPUT AND OUTPUT VOLTAGE GRAPHS OF

A HALF WAVE RECTIFIER

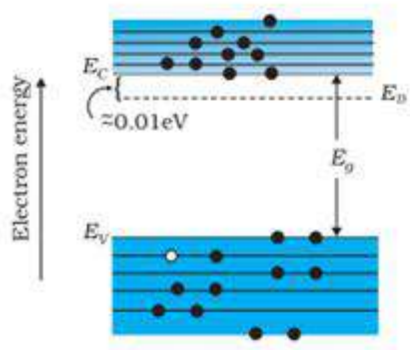


A FULL WAVE RECTIFIER

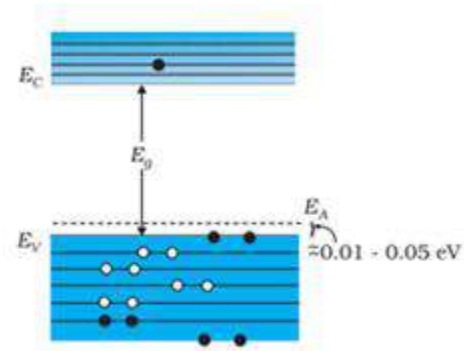


ENERGY BAND DIAGRAMS IN EXTRINSIC SEMICONDUCTORS

1) n-TYPE SEMICONDUCTOR



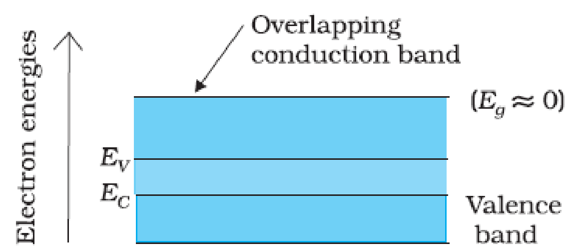
2) p-TYPE SEMICONDUCTOR



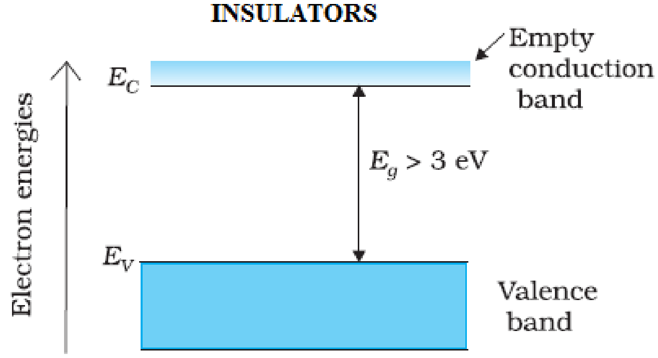
ENERGY BAND DIAGRAMS IN CONDUCTORS, INSULATORS AND SEMICONDUCTOS

CONDUCTORS HAVING PARTIALLY FILLED CONDUCTION BAND

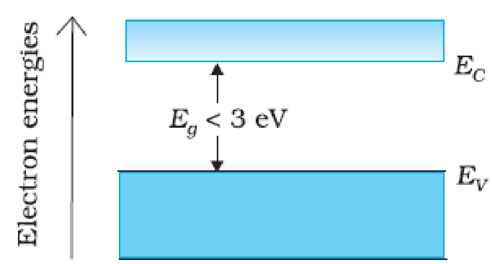
CONDUCTORS WITH OVERLAPPING CONDUCTION AND VALENCE BAND



INSULATORS



SEMICONDUTORS



TABLES

1) DIFFERENCE BETWEEN INTRINSIC AND EXTRINSIC SEMICONDUCTORS

S.NO	INRINSIC SEMICONDUCTOR	EXTRINSIC SEMICONDUCTOR
1	Pure form of semiconductor.	Impure form of semiconductor.
2	Conductivity is low	Conductivity is higher than intrinsic semiconductor.
3	The no of holes is equal to no of free electrons	In n-type, the no. of electrons is greater than that of the holes and in p-type, the no. holes is greater than that of the electrons.
4	The conduction depends on temperature.	The conduction depends on the concentration of doped impurity and temperature.

2) DIFFERENCE BETWEEN HALF WAVE AND FULL WAVE RECTIFIER

S.NO	HALF WAVE RECTIFIER	FULL WAVE RECTIFIER
1	Only half cycle of AC is rectified.	Both cycles of AC are rectified.
2	Requires only one diode	Requires two diodes.
3	The output frequency is equal to input supply frequency. (F)	The output frequency is double of the input supply frequency. (2F)
4	The electric current through the load is not continuous	A continuous electric current flow through the load.

FORMULAE

1) **Electron and hole concentration in a semiconductor in thermal equilibrium**

   $n_e n_h = n_i^2$

2) Resistance of a Diode:
   a) Static or DC Resistance $R_{dc} = V/I$
   b) Dynamic or AC Resistance

   $R_{a.c} = \Delta V / \Delta I$

MNEMONICS

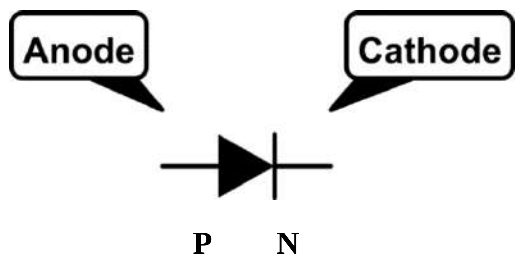
1) **TO REMEMBER NAMES OF IMPURITIES IN SEMICONDUCTORS**

   BIG PAA

   Boron**, I**ndium**, G**allium **(all three are trivalent impurities)**

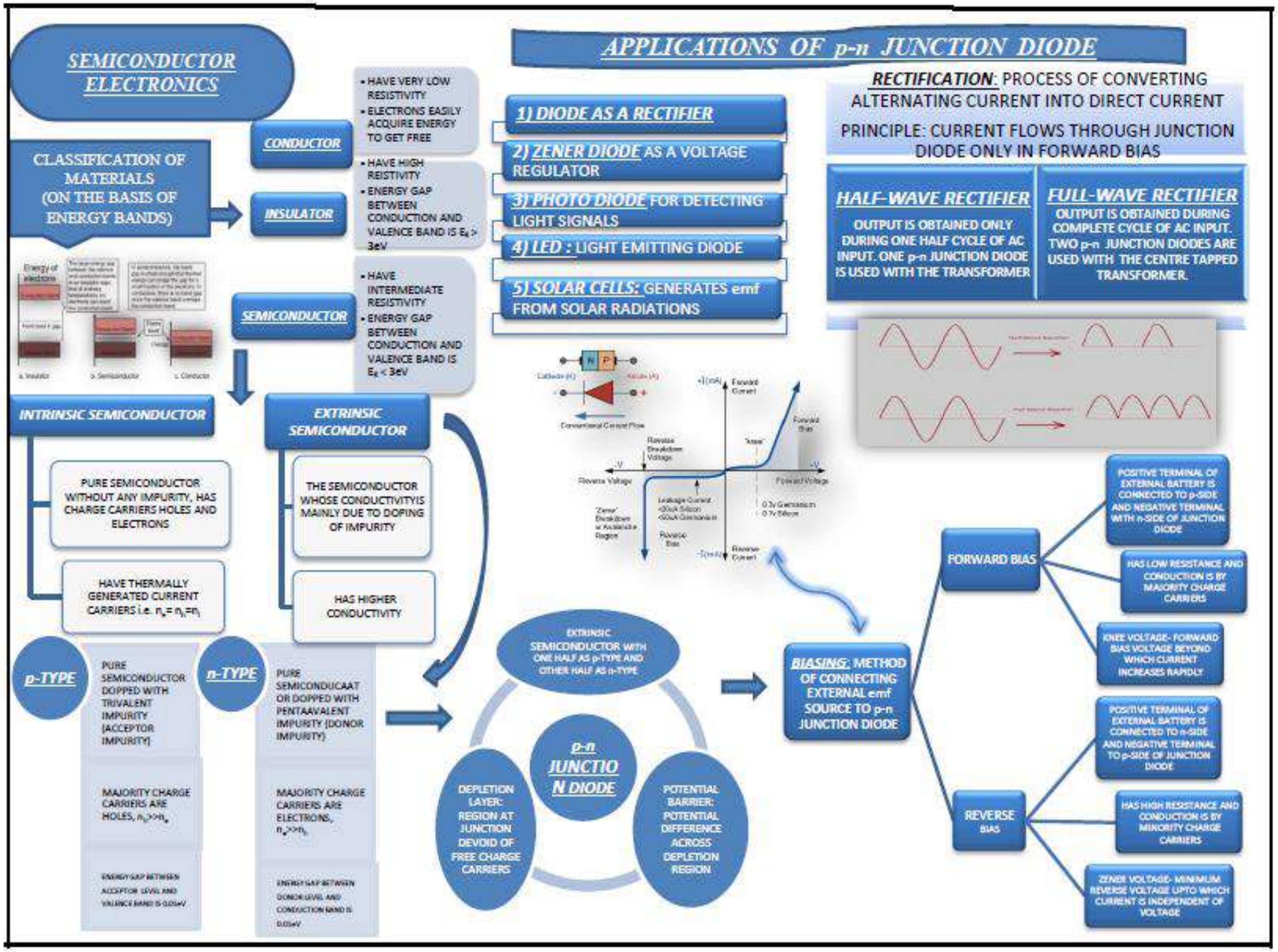
   Phosphorus**, A**ntimony**, A**rsenic **(all three are pentavalent impurities)**

2) **TO REMEMBER THE P AND N SECTIONS OF A DIODE.**
   The arrow in the schematic symbol for diodes points in the direction of Conventional (positive) current flow.



3) Current is **unidirectional** in a diode**. It flows from anode to cathode only.** To remember this, remember the mnemonics **'ACID' (ANODE CURRENT IN DIODE)**

MIND MAP


SEMICONDUCTOR ELECTRONICS
CLASSIFICATION OF MATERIALS (ON THE BASIS OF ENERGY BANDS)
CONDUCTOR
• HAVE VERY LOW RESISTIVITY
• ELECTRONS EASILY ACQUIRE ENERGY TO GET FREE
INSULATOR
• HAVE HIGH RESTIVITY
• ENERGY GAP BETWEEN CONDUCTION AND VALENCE BAND IS E_g > 3eV
SEMICONDUCTOR
• HAVE INTERMEDIATE RESISTIVITY
• ENERGY GAP BETWEEN CONDUCTION AND VALENCE BAND IS E_g < 3eV
INTRINSIC SEMICONDUCTOR
PURE SEMICONDUCTOR WITHOUT ANY IMPURITY, HAS CHARGE CARRIERS HOLES AND ELECTRONS
HAVE THERMALLY GENERATED CURRENT CARRIERS i.e. $n_e = n_h = n_i$
EXTRINSIC SEMICONDUCTOR
THE SEMICONDUCTOR WHOSE CONDUCTIVITY IS MAINLY DUE TO DOPING OF IMPURITY
HAS HIGHER CONDUCTIVITY
p-TYPE
PURE SEMICONDUCTOR DOPPED WITH TRIVALENT IMPURITY (ACCEPTOR IMPURITY)
MAJORITY CHARGE CARRIERS ARE HOLES, $n_h >> n_e$
ENERGY GAP BETWEEN ACCEPTOR LEVEL AND VALENCE BAND IS 0.05eV
n-TYPE
PURE SEMICONDUCAAT OR DOPPED WITH PENTAAVALENT IMPURITY (DONOR IMPURITY)
MAJORITY CHARGE CARRIERS ARE ELECTRONS, $n_e >> n_h$
ENERGY GAP BETWEEN DONOR LEVEL AND CONDUCTION BAND IS 0.05eV
EXTRINSIC SEMICONDUCTOR WITH ONE HALF AS p-TYPE AND OTHER HALF AS n-TYPE
p-n JUNCTIO N DIODE
DEPLETION LAYER: REGION AT JUNCTION DEVOID OF FREE CHARGE CARRIERS
POTENTIAL BARRIER: POTENTIAL DIFFERENCE ACROSS DEPLETION REGION
BIASING: METHOD OF CONNECTING EXTERNAL emf SOURCE TO p-n JUNCTION DIODE
FORWARD BIAS
POSITIVE TERMINAL OF EXTERNAL BATTERY IS CONNECTED TO p-SIDE AND NEGATIVE TERMINAL WITH n-SIDE OF JUNCTION DIODE
HAS LOW RESISTANCE AND CONDUCTION IS BY MAJORITY CHARGE CARRIERS
KNEE VOLTAGE- FORWARD BIAS VOLTAGE BEYOND WHICH CURRENT INCREASES RAPIDLY
REVERSE BIAS
POSITIVE TERMINAL OF EXTERNAL BATTERY IS CONNECTED TO n-SIDE AND NEGATIVE TERMINAL TO p-SIDE OF JUNCTION DIODE
HAS HIGH RESISTANCE AND CONDUCTION IS BY MINORITY CHARGE CARRIERS
ZENER VOLTAGE- MINIMUM REVERSE VOLTAGE UPTO WHICH CURRENT IS INDEPENDENT OF VOLTAGE
APPLICATIONS OF p-n JUNCTION DIODE
1) DIODE AS A RECTIFIER
2) ZENER DIODE AS A VOLTAGE REGULATOR
3) PHOTO DIODE FOR DETECTING LIGHT SIGNALS
4) LED : LIGHT EMITTING DIODE
5) SOLAR CELLS: GENERATES emf FROM SOLAR RADIATIONS
RECTIFICATION: PROCESS OF CONVERTING ALTERNATING CURRENT INTO DIRECT CURRENT
PRINCIPLE: CURRENT FLOWS THROUGH JUNCTION DIODE ONLY IN FORWARD BIAS
HALF-WAVE RECTIFIER
OUTPUT IS OBTAINED ONLY DURING ONE HALF CYCLE OF AC INPUT. ONE p-n JUNCTION DIODE IS USED WITH THE TRANSFORMER
FULL-WAVE RECTIFIER
OUTPUT IS OBTAINED DURING COMPLETE CYCLE OF AC INPUT. TWO p-n JUNCTION DIODES ARE USED WITH THE CENTRE TAPPED TRANSFORMER.
Forward Current
Forward Bias
Forward Voltage
Reverse Voltage
Reverse Current
Reverse Bias
Conventional Current Flow

QUESTION BANK

CHAPTER-14 Semiconductor Electronics: Materials, Devices and Simple Circuits

SECTION A

MCQ-1 MARK SECTION

1. The energy band gap is maximum in

(a) metals (b) superconductors (c) insulators (d) semiconductors

2. At absolute zero, silicon (Si) acts as

(a) non-metal (b) metal (c) insulator (d) none of these

3.The process of adding impurities to a pure semiconductor is called

(a) Mixing (b)Doping (c)Diffusing (d)None of the above

4. Silicon is doped with which of the following to obtain P type semiconductor

(a) Phosphorus (b) Gallium (c) Germanium (d) Bismuth

5.When an impurity is doped into an intrinsic semiconductor, the conductivity of the semiconductor

(a) Increases (b) decreases (c) remains the same (d) becomes zero

ASSERTION –REASONING TYPE QUESTIONS

Directions : In the following questions, A statement of Assertion (A) is followed by statement of Reason (R). Mark the correct choice as.

A ; If both Assertion and Reason are correct and the Reason is a correct explanation of the assertion.

B: If both Assertion and Reason are correct but Reason is not a correct explanation of the assertion.

C :If the Assertion is correct but Reason is incorrect.

D: If both the Assertion and Reason are incorrect.

6.**Assertion :**A pure semiconductor has negative temperature coefficient of resistance.

Reason : In a semiconductor on raising the temperature, more charge carriers are released,conductance increases and resistance decreases.

7**. Assertion :**A p-type semiconductors is a positive type crystal.

Reason :A p- type semiconductor is an uncharged crystal

8. **Assertion :**Silicon is preferred over germanium for making semiconductor devices.

Reason : The energy gap in germanium is more than the energy gap in silicon.

9. **Assertion :**The diffusion current in a p-n junction is from the p-side to the n-side.

Reason : The diffusion current in a p-n junction is greater than the drift current when the junction is in forward biased

10. **Assertion:** The energy gap between the valance band and conduction band is greater in silicon than in germanium.

Reason: Thermal energy produces fewer minority carriers in silicon than in germanium.

CASE BASED / SOURCE BASED QUESTIONS

11. On the basis of energy bands materials are also defined as metals, semiconductors and insulators. These semiconductors are classified as intrinsic semiconductors and extrinsic semiconductors also. Intrinsic semiconductors are those semiconductors which exist in pure form. And intrinsic semiconductors have number of free electrons is equal to number of holes. The semiconductors doped with some impurity in order to increase its conductivity are called as extrinsic semiconductors. Two types of dopants are used they are trivalent impurity and pentavalent impurity also. The extrinsic semiconductors doped with pentavalent impurity like Arsenic, Antimony, Phosphorus etc are called as n – type semiconductors. In n type semiconductors electrons are the majority charge carriers and holes are the minority charge carriers. When trivalent impurity is like Indium, Boron, Aluminium etc are added to extrinsic semiconductors then p type semiconductors will be formed. In p type semiconductors holes are majority charge carriers and electrons are the minority charge carriers.

(I)What is extrinsic semiconductor?

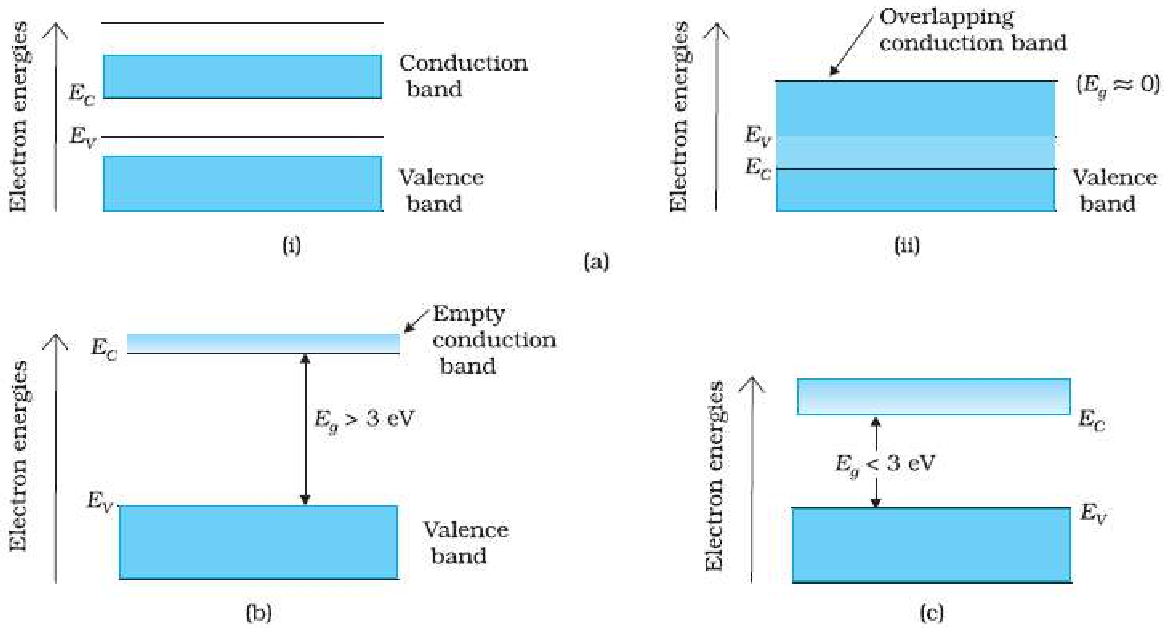
(II)What is ratio of number of holes and number of electrons in an intrinsic semiconductor?

(III)Why doping is necessary?

(IV) Majority charge carriers in p-type semiconductor are____________.

12. From Bohr's atomic model, we know that the electrons have well defined energy levels in an isolated atom. But due to interatomic interactions in a crystal, the electrons of the outer shells are forced to have energies different from those in isolated atoms. Each energy level splits into a

number of energy levels forming a continuous band. The gap between top of valence band and bottom of the conduction band in which no allowed energy levels for electrons can exist is called energy gap. Following are the energy band diagrams for conductor fig (ii), for insulators fig (b) and for semiconductors fig (c).



(I) In an insulator energy band gap is

(a) E_g= 0eV (b) E_g> 3eV (c) E_g< 3eV (d) None of this

(II)In a semiconductor, separation between conduction and valence band is of the order of

(a) E_g= 0eV (b) E_g> 3eV (c) E_g< 3eV (d) None of this

(III) Based on the band theory of conductors, insulators and semiconductors, the forbidden gap is smallest in

(a)conductor (b) insulators (c) semiconductors (d) All of these

(IV) Solids having highest energy level partially filled with electrons are

(a)semiconductor (b) conductor (c) insulator (d) none of these

2 MARKS QUESTIONS

13.What happens to the width of depletion layer of a p-n junction when it is (i)forward biased? (ii)reverse biased?

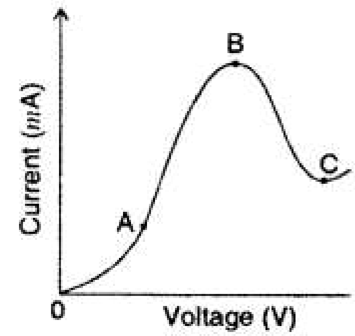
14. **E**xplain, with the help of a circuit diagram, the working of a p-n junction diode as a half- wave rectifier.

15.Distinguish between a metal and an insulator on the basis of energy band diagram.

16.Explain, how a depletion region is formed in a junction diode?

17. Carbon and silicon both have four valence electrons each, then how are they distinguished?

18. The graph shown in the figure represents a plot of current versus voltage for a given semi-conductor. Identify the region, if any, over which the semi-conductor has a negative resistance.



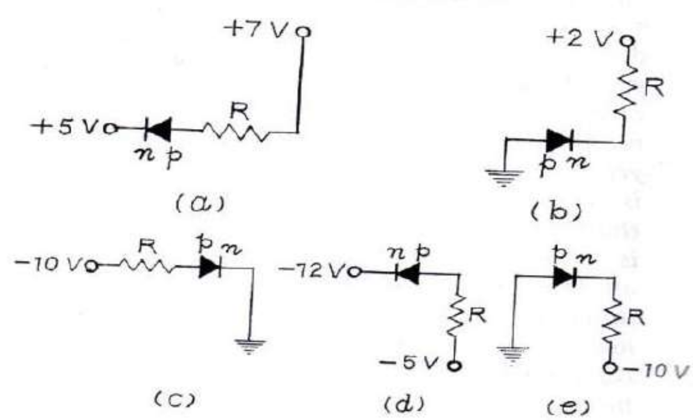
19. Plot a graph showing variation of current versus voltage for the material GaAs.

3 MARKS QUESTIONS

20.Draw the circuit diagram of a full wave rectifier using p-n junction diode. Explain its working and show the output and input waveforms. (CBSE-2011)

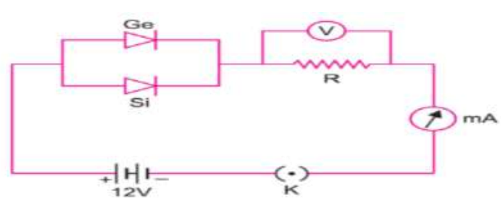
5 MARKS QUESTION

21. Indicate which of the following p- n diodes are forward biased and which are reverse biased:



22. (i) Sn, C and Si, Ge are all group 14 elements. Yet Sn is a conductor, C is an insulator while Si and Ge are semiconductor. Why?

(ii)Germanium and silicon junction diodes are connected in parallel. A resistance R, a 12 V battery, a milli ammeter (mA) and key (K) are connected as shown in figure. When Key (K) is closed, current begins to flow in milli ammeter. What will be the maximum reading of voltmeter connected across resistance R?



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SECTION A- ANSWERS

(1 MARKS)

1.c 2.c 3.b 4.b 5. A 6. A 7. D 8. C 9. B 10. b

11. CASE BASED STUDY 1:

(I) Definition of extrinsic semiconductor (II) 1:1 (III) to increase conduction (IV) holes

12. CASE BASED STUDY 2:

(I) (c) (II) (b) (III) (a) (IV) (b)

(2 MARKS)

13.(i) Width of depletion layer's decreases in forward bias

(ii) Width depletion layer increases in reverse bias.

14. **P-n Junction Diode as a Half-Wave Rectifier**

AC voltage to be rectified is connected to the primary coil of a step-down transformer. Secondary coil is connected to the diode through resistor load resistance, across which output is obtained.

Working: During positive half cycle of the input AC, the p-n junction is forward biased. Thus,the resistance in p-n junction becomes low and current flows. Hence, we get output in the load. During negative half cycle of the input AC, the p-n junction is reverse biased. Thus, resistance of p-n junction is high and current does not flow. Hence, no output in the load. So, for complete cycle of AC, current flows through the load resistance in the same direction.

15. (i) **Metal** For metals, the valence band is completely filled and the conduction band can have two possibilities either it is partially filled with an extremely small energy gap between the valence and conduction bands or it is empty, with two bands overlapping each other.

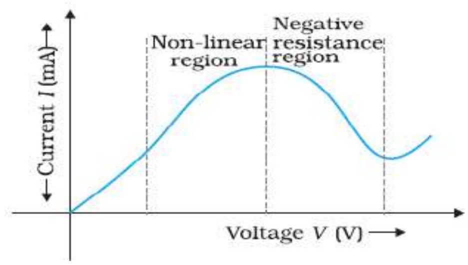
(ii) On applying a small even electric field, metals can conduct electricity.

16.With the formation of p-n junction, the holes from p-region diffuse into the n-region and electrons from n-region diffuse into p-region and electron-hole pair combine and get annihilated.This input produces potential barrier, V_B across in junction which opposes the further diffusion through the junction. Thus, small region forms in the vicinity of the junction which is depleted of free charge carrier and has only immotile ions is called the depletion region.

17.The four valence electrons of carbon are present in second orbit while that of silicon in third orbit. So, energy required to extricate an electron from silicon is much smaller than carbon.Therefore, the number of free electrons for conduction in silicon is significant on contraryof carbon. This makes silicon conductivity much higher than carbon. This is the main distinguishable property.

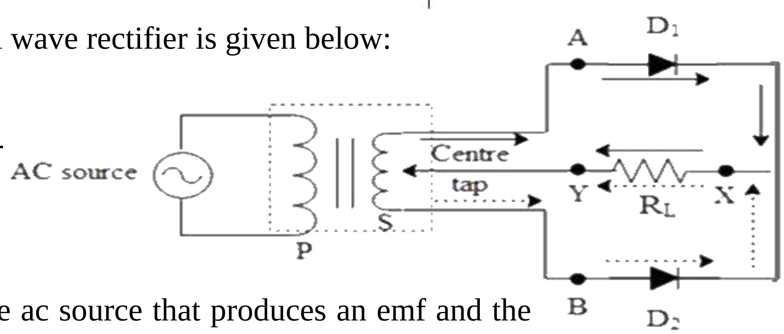
18.Between the region B and C, the semiconductor has a negative resistance.

19. A Graph showing variation of current versus voltage for GaAs



(3 MARKS)

20. The labelled diagram of a full wave rectifier is given below:

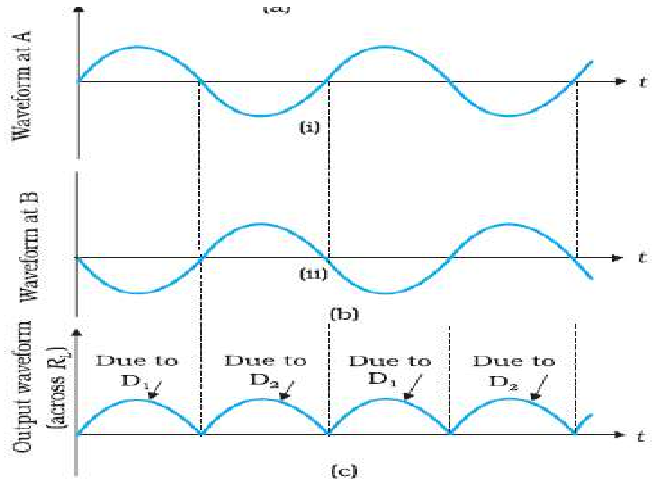


The working principle of the full-wave rectifier is as follows.

The ac source is connected to the ac source that produces an emf and the respective current through the transformers. The secondary winding of the transformed is center tapped which means that it provides the current with two paths to travel in during the positive and negative halves of the cycle respectively.

This means that during the positive half of the cycle the potential at A will be at a positive potential and hence the p junction of the diode is connected to the positive terminal and hence it is forward biased which makes the diode D_2 reverse biased and hence current will only flow through the path with the D_1.

Similarly when the polarity gets shifted during the negative half of the cycle the diode D_2 gets forward biased and current flows though path shown by the dotted lines in the diagram since B will be at positive potential in this cycle.



This in-turn produces a pulsating dc signal and filters can be further applied to converting into a complete dc signal. Hence, the principle behind a full wave rectifier is to convert ac to dc signal.

The input waveform (ac source) given to the is shown below

(5 MARKS)

21. A p-n diode is forward biased if p-side is at a higher potential than n-side.
   (a) The p-side is at a higher potential (+7V) than the n-side (+ 5V) the diode is forward biased.
   (b) The p-side is at a higher potential (zero, earthed) than the n-side (+ 2V), the diode is reverse-biased.
   (c) The p-side is at a lower potential (- 10 V) than the n-side (zero), the diode is reverse biased.
   (d) The p-side is at a higher potential (- 5V) than the n-side (-12V), the diode is forward biased.
   (e) The p-side is at a higher potential (zero) than the n-side (-10V), the diode is forward-biased.

22. i) The conduction level of any element depends on the energy gap between its conduction band and valence band. In conductors, there is no energy gap between conduction band and valence band. For insulator, the energy gap is large and for semiconductor the energy gap is moderate. The energy gap for Sn is 0 eV, for C is 5.4 eV for Si is 1.1 eV and for Ge is 0.7 eV related to their atomic size. Therefore, Sn is a conductor, C is an insulator and Ge and Si are semiconductors.

ii) The potential barrier of germanium junction diode is 0.3 V and of silicon is 0.7 V. Both germanium and silicon are forward biased. Therefore, for conduction the minimum potential difference across junction diode is 0.3 V.

Maximum reading of voltmeter connected across R = 12-0.3 = 11.7

SECTION B

MCQ-1 MARK

1. The mobility of free electrons is greater than that of free holes because

(a) they are light (b) they carry negative charge

(c) they mutually collide less (d) they require low energy to continue their motion

2.The forbidden gap for germanium is

(a) 0.12 eV (b)0.72 eV (c)7.2 eV (d)None of these

3. Semiconductor devices require

(a)large evacuated space (b)external heating arrangement

(c)low operating voltages (d)high power

4. When a forward bias is applied to a p-n junction, it

(a) raises the potential barrier. (b)reduces the majority carrier current to zero.

(c) lowers the potential barrier (d)None of the above.

5. In a full wave rectifier, input AC has a frequency ‘ν’. The output frequency of current is

(a) ν ⁄2 (b) ν (c) 2 ν (d) None of these

ASSERTION/REASONING QUESTIONS

Directions : In the following questions, A statement of Assertion (A) is followed by a statement of Reason (R). Mark the correct choice as.

A: If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

B: If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

C:If the Assertion is correct but Reason is incorrect.

D: If both the Assertion and Reason are incorrect

6. **Assertion (A):**If the temperature of a semiconductor is increased then its conductivity increases.

Reason (R): The energy gap between conduction band and valence band is very small

7. **Assertion (A)**: When a p-n junction diode is reverse biased, a feeble reverse-current flows known as reverse saturation current.

Reason (R): In reverse bias condition, the minority carries can cross the junction.

8. **Assertion**: The p-n junction diode primarily allows the flow of) current only in one direction (forward bias)

Reason: The forward bias resistance is low as compared to the reverse bias resistance.

9. **Assertion**: For a half wave rectifier the output frequency is half of input.

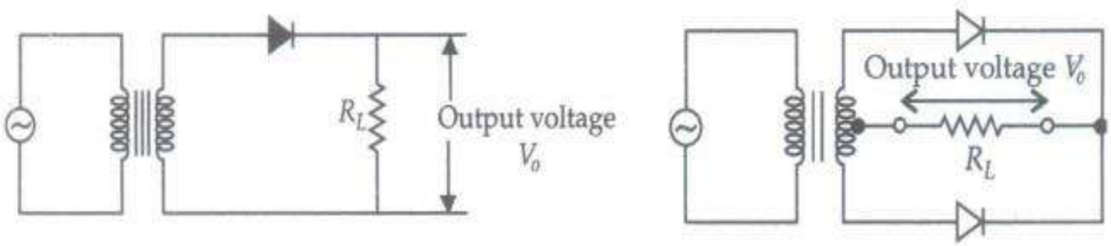
Reason: Half wave rectifier got its name from such phenomena.

10. **Assertion**: Diode is an Ohmic conductor.

Reason: Diodes obey Ohm's law

CASE BASED / SOURCE BASED QUESTIONS

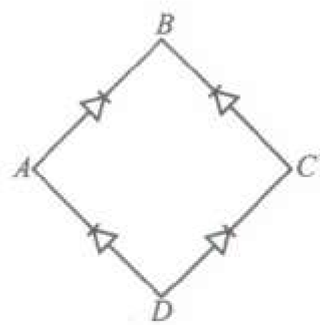
11. Rectifier is a device which is used for converting alternating current or voltage into direct current or voltage. Its working is based on the fact that the resistance of p-n junction becomes low when forward biased and becomes high when reverse biased. A half-wave rectifier uses only a single diode while a full wave rectifier uses two diodes as shown in figures (a) and (b).



(a) Half wave rectifier (b) Full wave rectifier

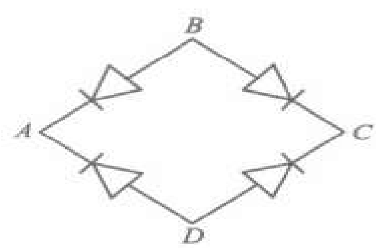
(I)If the rms value of sinusoidal input to a full wave rectifier is $V_0/\sqrt{2}$ then the rms value of the rectifier's output is

(a) $V_0/\sqrt{2}$ (b) $V_0\sqrt{2}$ (c) V_02 (d) $V_0/2$



(II) In the-diagram, the input ac is across the terminals A and C. The output across B and D is

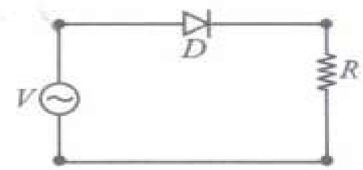
(a) same as the input (b) half wave rectified (c) zero (d)full wave rectified

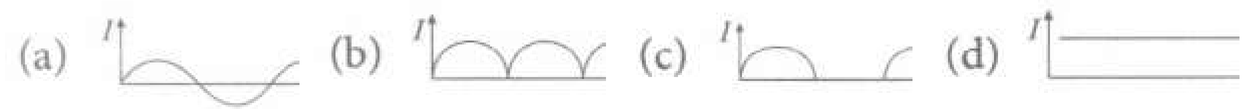


(III) A bridge rectifier is shown in figure. Alternating input is given across A and C. If output is taken across BD, then it is

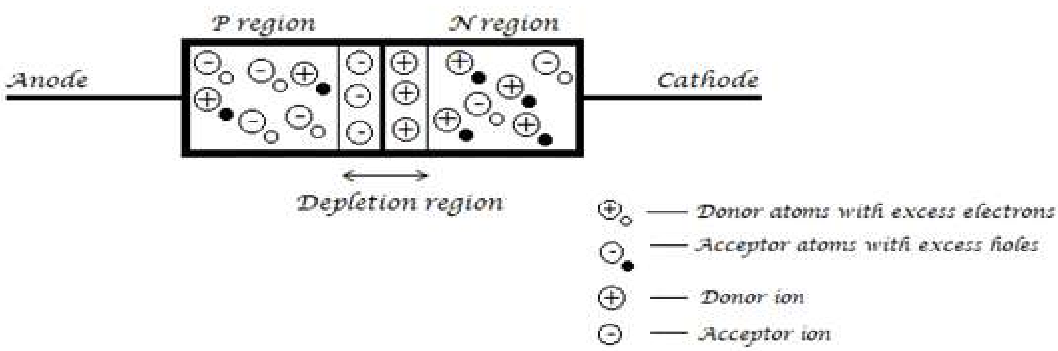
(a) zero (b) same as input (c) half wave rectified (d) full wave rectified

(IV) A p-n junction (D) shown in the figure can act as a rectifier. An alternating current source V is connected in the circuit. The current (I) in the resistor(R) can be shown by





12.



P-N Junction diode when Unbiased

A p-n junction is a single crystal of Ge or Si doped in such a manner that one half portion of it acts as p-type semiconductor and other half functions as n-type semiconductor. As soon as a p-n junction is formed, the holes from the p-region diffuse into the n-region and electron from n region diffuse in to p-region. This results in the development of V_B across the junction which opposes the further diffusion of electrons and holes through the junction. The current set up by minority charge carriers under the influence of V_B is drift current .Diffusion current and drift current are in opposite directions and no net flow of charge across the junction.

(I) In an unbiased p-n junction electrons diffuse from n-region to p-region because

(a) holes in p-region attract them

(b) electrons travel across the junction due to potential difference

(c) electron concentration in n-region is more as compared to that in p-region

(d) only electrons move from n to p region and not the vice-versa versa

(II) In the depletion layer of unbiased p-n junction

(a)it is devoid of charge carriers (b) has only electrons(c) has only holes (d) p-n junction has a weak electric field

(III) The potential of depletion layer is due to

(a) electrons (b) hole (c) ions (d) forbidden band

(IV) Name the two important processes involved in the formation of a p-n junction.

2 MARKS QUESTIONS

13. Why does the Resistivity of Semiconductors go down with Temperature?

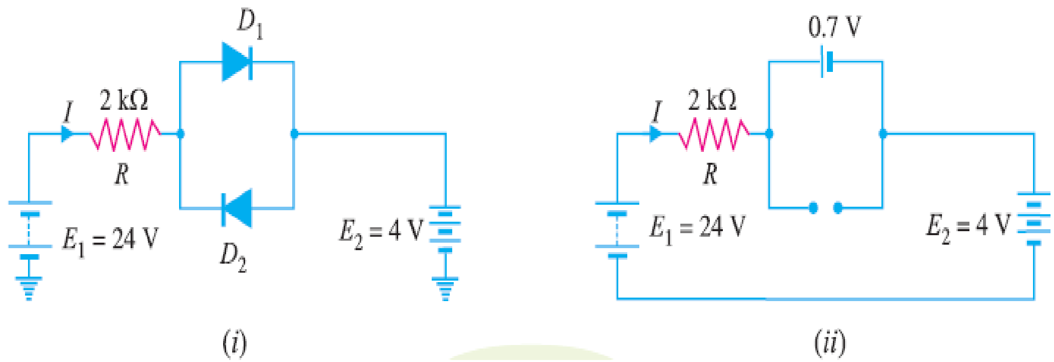
14. What is meant by intrinsic semiconductor and extrinsic semiconductor? What are the differences between intrinsic and extrinsic semiconductor?

15. What is meant by doping and doping agent?

16. Draw the voltage-current characteristic of a p-n junction diode in forwarding bias and reverse bias.

17.Explain, with the help of a circuit diagram, the working of a p-n junction diode as a full- wave rectifier. (CBSE-2011)

18. Determine the current I in the circuit shown below. Assume the diodes to be of silicon and forward resistance of diodes to be zero.



3 MARKS QUESTIONS

19. Write any two distinguishing features between conductors, semiconductors and insulators on the basis of energy band diagrams.

20 (i) Name two important processes that occur during the formation of a p-n junction.

(ii) Draw the circuit diagram of a full wave rectifier along with the input and output waveforms. Briefly explain how the output voltage/current is unidirectional. (CBSE 2016)

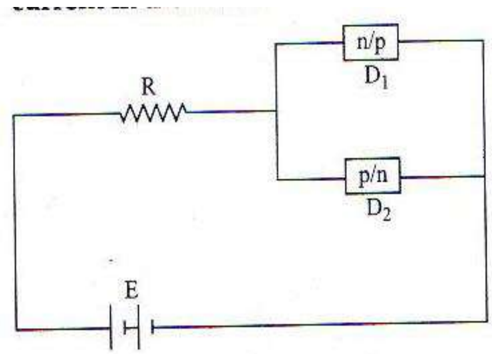
5 MARKS QUESTIONS

21. i) How are p- type semiconductors produced?

    ii) The forbidden band energy of silicon is 1.1eV. What does it mean?

    iii) What is an ideal diode?

    iv) Figure shows two p-n junction diode along with a resistance and a d.c battery E. Indicate the path and the direction of appreciable current in the circuit.



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SECTION B-ANSWERS

1. A
2. b
3. C
4. c
5. c
6. A
7. A
8. A
9. D
10. D
11. I (a)   II (d)   III (a)   IV (c)
12. I (c)   II (a)   III (c)   IV diffusion and drift

2 MARKS

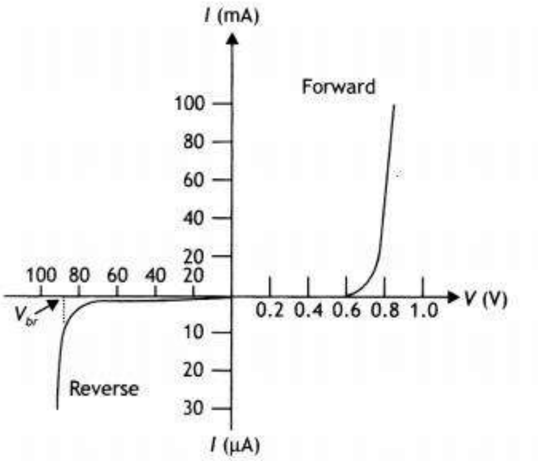
13. The difference in resistivity between conductors and semiconductors is due to their difference in charge carrier density.

The resistivity of semiconductors decreases with temperature because the number ofcharge carriers increases rapidly with increase in temperature, making the fractional change i.e. the temperature coefficient negative.

14. Any two differences

15. The technique of adding impurities to a pure semiconductor is known as **doping** and the added impurity is called **doping agent.**

16. The characteristics are as shown.



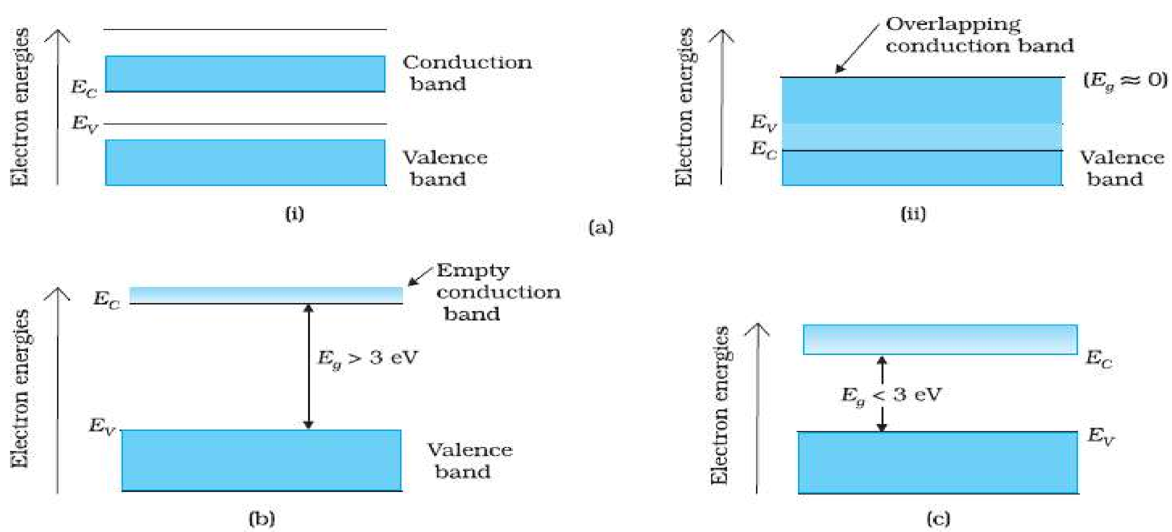
17. Full Wave rectifier

18.The conditions of the problem suggest that diode D1 is forward biased and diode D2 is reverse biased. We can, therefore, consider the branch containing diode D2 as open as shown in the figure Further, diode D1 can be replaced by its simplified equivalent circuit.

$$I = \frac{E_1 - E_2 - V_0}{R} = \frac{24 - 4 - 0.7}{2\ \text{k}\Omega} = \frac{19.3\ \text{V}}{2\ \text{k}\Omega} = \mathbf{9.65\ mA}$$

3 MARKS

19. (on the basis of diagram any two distinguish features)



20. (i)Two important processes that occur during the formation of p-n junction are diffusion and drift.

(ii) solution given in previous questions

5 MARKS

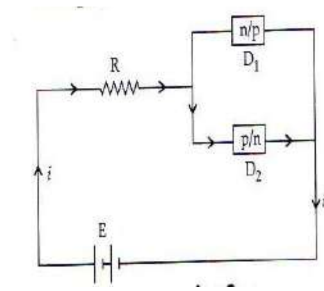
21.

i) When a trivalent impurity like aluminum, indium, boron, gallium etc. is doped with a pure germanium (or silicon), then the conductivity of the silicon increases due to deficiency of electrons i.e., and such a crystal is said to be p-type semiconductor while the impurity atoms are called acceptors.

ii) This means if energy 1.1 eV is given to an electron in the valence band, it will jump to the conduction band.

iii) An ideal diode is one which behaves as a perfect conductor when forward biased Under this situation, the forward resistance of diode is assumed to be zero and potential barrier is neglected.

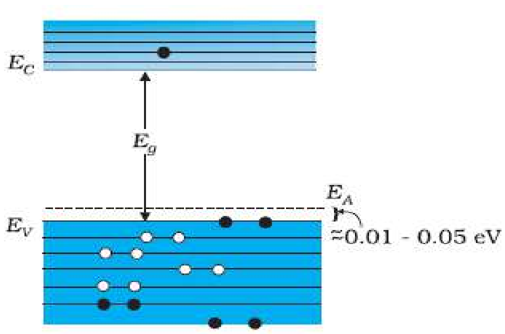
iv) Diode D_1 is reverse biased so on current flows through it due to majority carriers. And diode D_2 is forward biased. So a current flows through D_2 and the resistance R as shown in the figure.



SECTION C

MCQ- 1 MARKS SECTION

1. In the energy band diagram of a material shown below, the open circles and filledcircles denote holes and electrons respectively. The material is



(a) insulator (b)metal (c)n-type semiconductor (d)p-type semiconductor

2. As the temperature increases, the electrical resistance

(a)Increases for both conductors and semiconductors

(b)Decreases for both conductors and semiconductors

(c)Increases for conductors but decreases for semiconductors

(d) Decreases for conductors but increases for semiconductors

3. If a small amount of antimony is added to germanium crystal

(a)it becomes a p-type semiconductor

(b)the antimony becomes an acceptor atom

(c)there will be more free electrons than holes in the semiconductor

(d) its resistance is increased

4. In a n-type semiconductor, which of the following statement is true

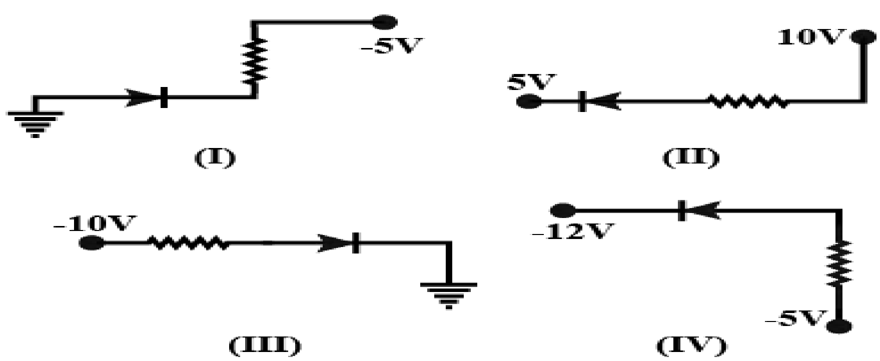
(a)Holes are minority carries and pentavalent atoms are dopants.

(b)Holes are majority carries and trivalent atoms are dopants.

(c)Electrons are majority carries and trivalent atoms are dopants.

(d)Electrons are minority carriers and pentavalent atoms are dopants

5. Which of the following diode is reverse biased?



(a) I (b) II (c) III (d) IV

ASSERTION AND REASONING QUESTIONS

6. **Assertion**: A Pure semiconductor has negative temperature coefficient of resistance.

Reason: On raising the temperature, more charge carriers are released, conductance increases and resistance decreases.

7. **Assertion:** The number of electrons in a p-type silicon semiconductor is less than the number

of electrons in a pure silicon semiconductor at room temperature.

Reason: It is due to law of mass action.

8**. Assertion:** The diffusion current in a p-n junction is from the p-side to the n-side.

Reason: The diffusion current in a p-n junction is greater than the drift current when the junction is in forward biased.

9**. Assertion :** The drift current in a p-n junction is from the n-side to the p-side.

Reason : It is due to free electrons only.

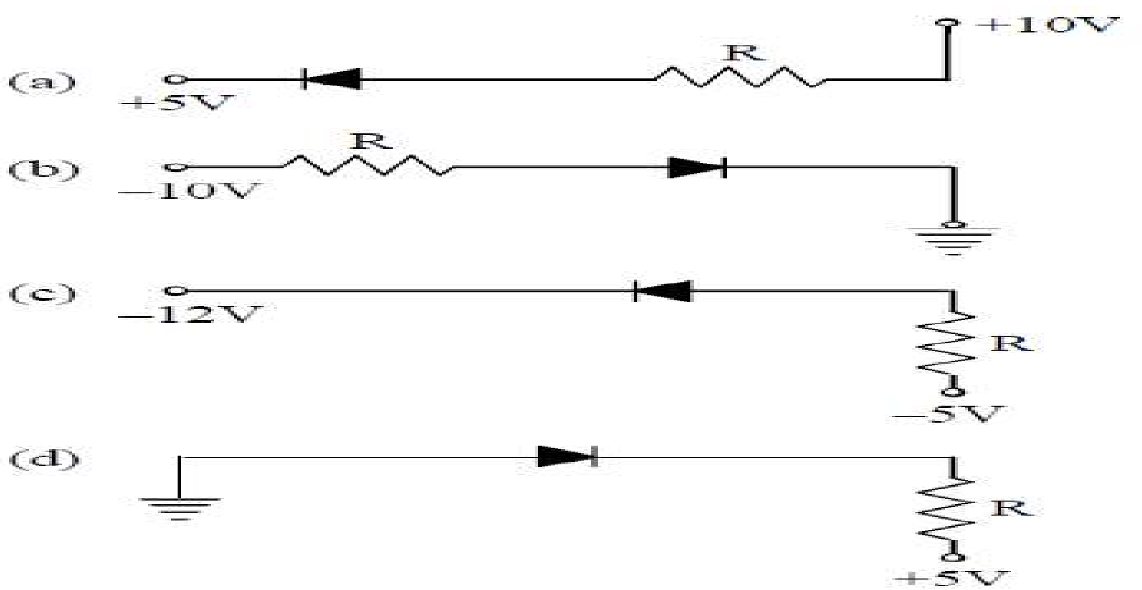
10**. Assertion**: When diode is used as a rectifier, its specified reverse breakdown voltage should not be exceeded.

Reason: When p-n junction diode crosses the reverse break down voltage, it gets destroyed

CASEBASED / SOURCE BASED QUESTIONS

11. When the diode is forward biased, it is found that beyond forward voltage $V = V_k$, called knee voltage, the conductivity is very high. At this value of battery biasing for p-n junction, the potential barrier is overcome and the current increases rapidly with an increase in forwarding voltage. When the diode is reverse biased, the reverse bias voltage produces a very small current about a few microamperes which almost remains constant with bias. This small current is reverse saturation current.

i) In which of the following figures, the p-n diode is forward biased



(a) a,b and d (b) c only (c) c and a (d) b and d

ii) Based on the V-I characteristics of the diode, we can classify diode as

(a) bi-directional device(b) ohmic device

(c) non-ohmic device(d) passive element

iii) In the case of forwarding biasing of a p-n junction diode, which one of the following statementis correct?

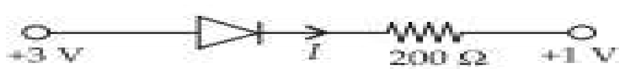
(a)effective barrier potential decreases

(b)majority charge carriers begins to flow away from junction

(c) width of depletion layer increases

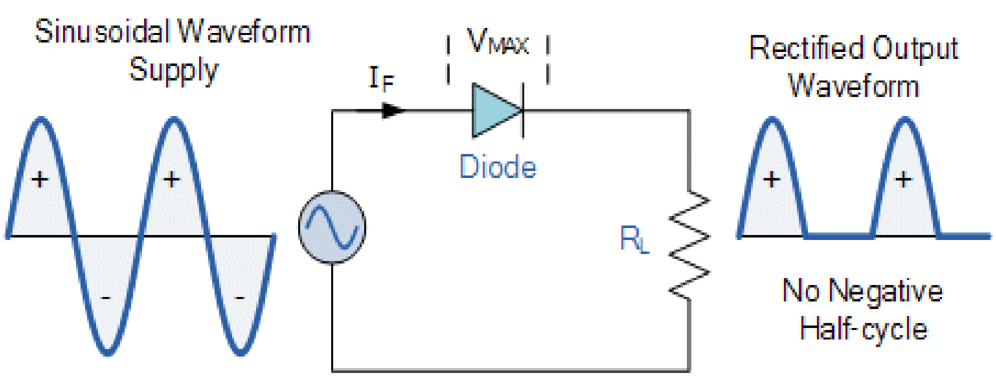
(d)effective resistance across the junction increases

iv) If an ideal junction diode is connected as shown, then the value of the current I is



(a) 0.005 A (b) 0.02 A (c) 0.01 A (d) 0.1A

12. If an alternating voltage is applied across a diode in series with a load and a pulsating voltage will appear across the load only during the half cycles of the ac input during which the diode is forward biased. Such rectifier circuit is called a half-wave rectifier. The reverse saturation current of a diode is negligible and can be considered equal to zero for practical purposes.



i)If input frequency of signal in half wave rectifier is 50 Hz then the output frequency will be

(a) 25 Hz (b) 50 Hz (c) 100 Hz (d) Uncertain

ii)In a half wave rectifier, the r.m.s. value of the a.c. component of the wave is

(a) equal to d.c. value (b) more than d.c. value (c) less than d.c. value (d) Zero

iii)Rectifier converts-

(a) AC to DC (b) DC to AC (c) AC to AC of different waveform

(d) All of these

iv)Full wave rectifier can be used over half wave rectifier because Full wave rectifier is-

(a) More energy efficient (b) More energy consuming

(c) More handy to use (d) More cost effective to manufacture

13. There are different techniques of fabrication of p-n junction. In one such technique, called fused junction techniques, an aluminium film is kept on the wafer of n-type semiconductor and the combination is then heated to a high temperature (about 600°C). As a result, aluminium fused into silicon and produces p-type semiconductor and in this way a p-n junction is formed.

i) When a p-n junction is reverse biased, then

a) No current flows. c) Height of potential barrier is decreased.

b) The depletion region is reduced. d) Height of potential barrier is increased.

ii) The cause of potential barrier in p-n junction is :

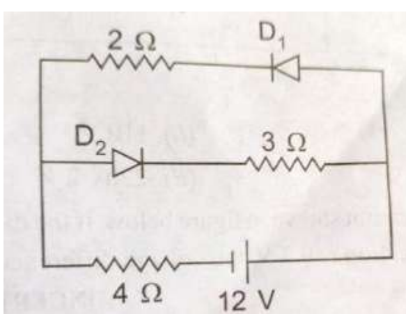
a) Depletion of positive charges near the junction.

b) Concentration of –ve charges near the junction.

c) Concentration of +ve charges near the junction.

d) Concentration of +ve and –ve charges near the junction.

iii) The circuit has two oppositely connected ideal diodes in parallel. What is the current flowing in the circuit ?



a) 1.17 A c) 2.0 A
b) 2.0 A d) 1.33 A

iv) When a pn junction is forward biased, then

a) Only diffusion current flows.

b) Both diffusion current and drift current flow but diffusion current is more than drift current.

c) Only drift current flows.

d) Both diffusion and drift current flow but drift current exceeds the diffusion current

.2 MARKS QUESTIONS

14.What are energy bands? Write any two distinguish features between conductors, semiconductors and insulators on the basis of energy band diagrams.

15.What is the result of doping germanium metal with a little quantity of indium?

16. Who are the major charge carriers in n-type and p-type semiconductors?

17. Explain with the help of a diagram how the depletion region and potential barrier are formedin a junction diode.

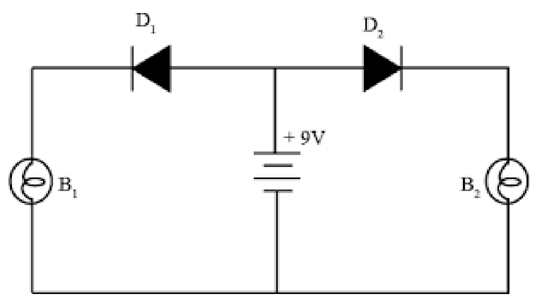
3 MARKS QUESTIONS

18. Draw V-I characteristics of a p-n junction diode. Answer the following questions, giving reasons:

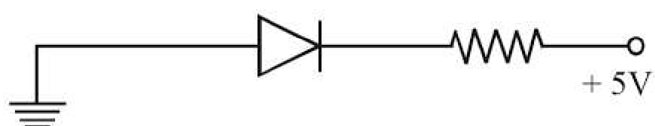
(i) Why is the current under reverse bias almost independent of the applied potential up to a critical voltage?

(ii) Why does the reverse current show a sudden increase at the criticalvoltage.

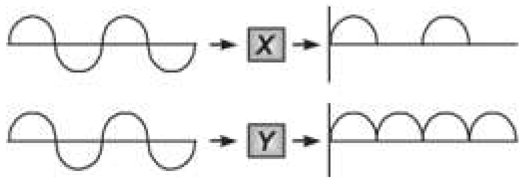
19. (i)In the following diagram, which bulb out of B_1 and B_2 will glow and why ?



(ii) In the following diagram,is the junction diode forward biased or reverse biased?



20. An a.c. signal is fed into two circuits X and Y and the corresponding output in the two cases have the wavefront shown in figure. Name the circuit X and Y. Also draw their detailed circuit diagram.



5 MARKS QUESTIONS

21.(a)Explain with the help of a diagram, how depletion region and potential barrier are formed in a junction diode.

(b)If a small voltage is applied to a p-n junction diode how will the barrier potential be affected when it is (i) forward biased, and (ii) reverse biased ?

22. Draw the circuit diagram of a full-wave rectifier using p-n junction diode. Explain its working and show the output and input waveforms.

****

SECTION-C ANSWERS

(1 MARK)

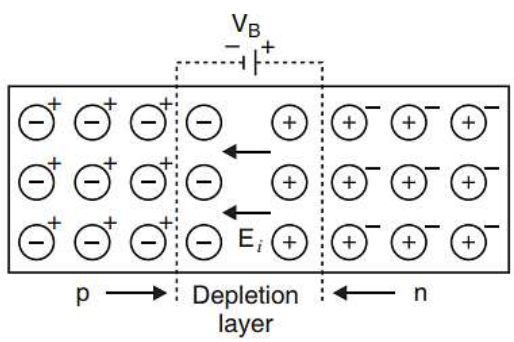
1. c
2. c
3. c
4. a
5. d
6. b
7. a
8. a
9. a
10. a
11. CASE BASED STUDY I:(I) b (II) c (III) a (IV) c
12. CASE BASED STUDY II:(I)b(II) c (III)a (IV) a

(2 MARKS)

13.In n-type semiconductors, electrons are the major charge carriers. In p-type semiconductors, holes are the major charge carriers.

14. P-type semiconductors are made from germanium impurities that include indium. Impurities of a trivalent nature can be added to germanium to generate the P-type material. They are called acceptor impurities because they are trivalent.

15. Because the n-type has more electrons and the p-type has more holes when a p-n junction is formed, the electrons from the n-side diffuse into the p-side & the holes from the p-side diffuse into the n-side.



Potential Barrier

A potential difference between the two regions is established by the buildup of electric charges of opposing polarities in the two regions across the junction. This is referred to as the potential or junction barrier. The potential barrier that has formed across the junction prevents charge carriers from moving from p to n and vice versa. There is a zone on each side of the intersection where mobile charges have depleted and only immobile charges remain. The depletion layer or zone is the area around the junction that is devoid of any mobile charge carriers.

16: Energy bands : In a solid , the energy of electrons lie within certain range. The energy levels of allowed energy are in the form of bands, these bands are separated by regions of forbidden energy called band gaps.

Distinguish features :

(a) In conductors : valence band and conduction band overlap each other.

In semiconductors : Valence band and conduction band are separated by a small energy gap.

In insulators : They are separated by a large energy gap.

(b) In conductors : Large number of free electrons are available in conduction band.

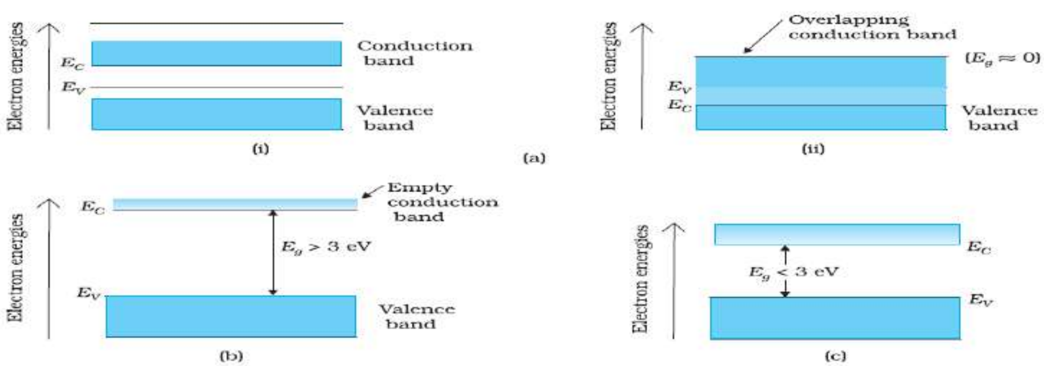
In semiconductor : A very small number of electrons are available for electrical conduction.

In insulators : Conduction band is almost empty i.e., no electron is available for conduction.

Effect of temperature : (i) In conductors : At high temperature , the collisions of electrons become more frequent with the atoms / molecules at lattice site in the metals as a result the conductivity decreases (or resistivity increases).

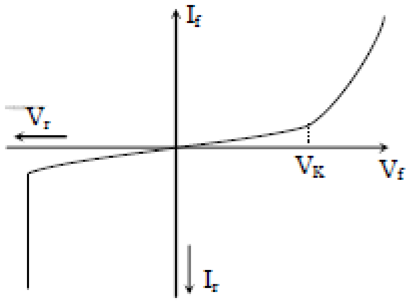
(ii) In semiconductors : As the temperature of the semiconducting material increases, more electrons hole pairs becomes available in the conduction band and valence band , and hence the conductivity increases or the resistivity decreases.

(ii) In insulators : The energy band between conduction band and valence band is very large , so it is unsurpassable for small temperature rise. So , there is no change in their behaviour.



(3 MARKS)

17. V-I Characteristics



(i) When p-n junction is reverse biased, the majority carriers in p and n region are repelled away from the junction. There is small current due to the minority carriers. This current attains its maximum or saturation value immediately and is independent of the applied reverse voltage.

(ii) As the reverse voltage is increased to a certain value, called break down voltage, large amount of covalent bonds in p and n regions are broken. As a result of this, large electron-hole pairs are produced which diffuse through the junction and hence there is a sudden rise in the reverse current. Once break down voltage is reached, the high reverse current may damage the ordinary junction diode.

18.(a) Bulb-B_1 will go as the diode $D_1$is forward biased

(b) Reversed biased.

(5 MARKS)

19.

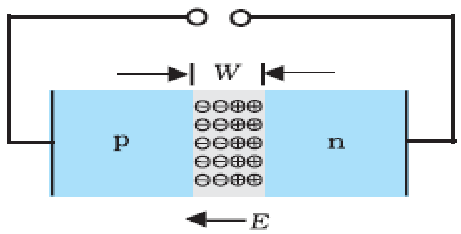
a) Two important processes involved during the formation of p-n junction are:

(i) Diffusion and (ii) drift.

As soon as p-type semiconductor comes in contact with n-type semiconductor due to the different concentration gradient to charge carries, the electrons start moving towards p-side and the holes start moving from p-side to n-side. This process is called drift.

Due to diffusion, the positive space charge region is created on the n-side of the junction and the negative space charge region is created on the p-side of the junction. Thios charge develops an electric field (junction field) from n-side to p-side. This field forces the free charges to move. This process is called drift.

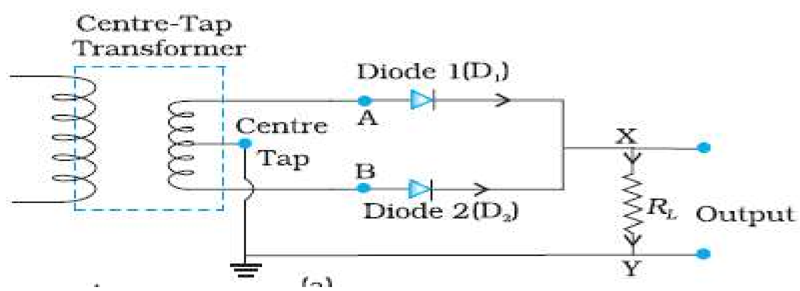
Formation of potential barrier : Electrons are the majority charge carries in n-type semiconductor. They move towards p-type semiconductor leaving behind the positive charged ions. Similarly, holes being in majority in the p-type semiconductor, move towards the n-type semiconductor. They leave behind the negatively charged ions. This way the accumulation of charges takes place near the junction. This stops further diffusion of the charges and the potential drop across the function due to these fixed charges is called potential barrier.



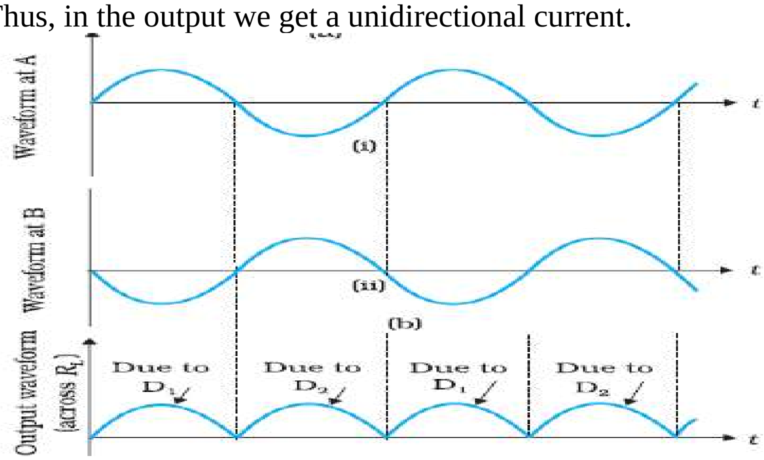
b) (i) In forward bias, the barrier potential decreases.

(ii) In reverse bias, the barrier potential increases.

20. During the first half of the cycle, if A is at higher potential with respect to centre-tap and B is at lower potential, the diode D_1 being forward biased conducts and the diodeD_2 being reverse biased does not conduct. The current flows through the load in thesense H to L.During the second half of the cycle, conditions get reversed and only diodeD_2 conducts Again, the current flows through the load in the sense H to L.



Thus, in the output we get a unidirectional current.



21.

i) (d) Reason : In reverse biased p-n junction, potential difference across a junction becomes $(V+V_B)$

ii) (c)

iii) (b) Reason : D_3 is in R.B. and D_1 is in F.B.

$\therefore$ 2 Ω and 4 Ω are in series and are connected to 12 V.

$$\therefore \quad I = \frac{12}{2+4} = 2\text{A}$$

iv) (d)

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Question Paper for 10 Years

CBSE Board Questions March 2020, March 2022

March 2020

Section A-1 Marks Questions

1) Define the term threshold frequency in photoelectric emission.

2) What is the impedance of a capacitor of capacitance C in an ac circuit using source of frequency n Hz?

3) What is the value of impedance of a resonant series LCR circuit?

4) The threshold frequencies of two photosensitive surfaces are v1 and v2, respectively. What is the ratio of the velocities of the photoelectrons emitted from these surfaces when light of frequency v is incident on them and photo emissions occurs?

5) Draw the graph showing variation of the value of the induced emf as a function of rate of change of current flowing through an ideal inductor.

Section B-2 Marks Questions

1) Which of the following electromagnetic waves has a) minimum wavelength and b) minimum frequency? Write one use of each of these two waves.

Infrared waves, Microwaves, y ray, X rays

2) A circular loop carrying a current 5A, produce a magnetic field of π mT, at its centre. Find the value of magnetic moment of the loop.

3) Draw V-I characteristics of PN junction diode. Explain why current under the reverse bias is almost independent of applied voltage up to the critical voltage.

4) Define the term mobility of charge carriers in a current carrying conductor. Obtain the relation for mobility in terms of relaxation time.

5) Define the term drift velocity of electron in a current carrying conductor. Obtain the relationship between the current density and drift velocity of electrons.

6) An object is placed in a front of convex mirror of focal length 15 cm. It produces an image that is half the size of the object. Find a) Position of the object, b) nature of the image and c) draw the ray diagram of image formation.

7) a) Explain the term 'sharpness of resonance ' in ac circuit.

b) In a series LCR circuit, Vl = Vc ≠ Vr. What is the value of power factor for this circuit?

8) An ac source of emf V = Vo sinwt is connected to a capacitor of capacitance C. Deduce the expression for current (I) flowing in it. Plot the graph of i) V vs wt ii) I vs wt.

Section C-3 marks questions

1) A capacitor of 4 uF is charged by a battery of 12 V. The battery is disconnected and a dielectric slab of dielectric constant 8 is inserted in between the plates of the capacitor to fill the space completely. Find the change in the a) charge store in the capacitor, b) potential difference between the plates of capacitor, and c) energy stored in the capacitor.

2) What is the difference in the construction of an astronomical telescope and a compound microscope? The focal lengths of the objective and eyepiece of a compound microscope are 1.25 cm and 5.0 cm, respectively. Find the position of the object relative to the objective in order to obtain an regular magnification of 30 when the final image is formed at the near point.

3) The maximum kinetic energy of the photoelectrons emitted I doubled when the wavelength of light incident on the photosensitive surface changes from $\lambda 1$ to $\lambda 2$. Deduce the expression for the threshold wavelength and work function for the metal surface in terms of $\lambda 1$and $\lambda 2$.

4) a) Draw the graph of radius of orbit (r_n) in hydrogen atom as a function of orbit number (n).

b) In a hydrogen atom, find the ratio of time taken by the electron to complete one revolution in the first excited and in the second excited states.

5) a) Derive the condition balance for Wheatstone meter bridge.

b) Draw the circuit diagram of a meter bridge to explain how it is based on Wheatstone bridge.

Section D-5 marks questions

1) a) Derived lens maker's formula for a biconvex lens.

b) A point object is placed at a distance of 12 cm on the principal axis of a convex lens of focal length 10 cm. A convex mirror is placed Coaxially on the other side of the lens at a distance of 10 cm. If the final image coincides with the object, sketch the ray diagram and find the focal length of the convex mirror.

2) a) What is the wavefront? How does it propagate? Using Huygens principle, explain the reflection of plane wavefront from a surface and verify the laws of reflection.

b) A parallel beam of light of wavelength 500 nm falls on a narrow slit and the resulting diffraction pattern is obtained on a screen 1 m away. If the first minimum is formed at a distance of 2.5 mm from the centre of the screen, find the i) width of the slit, and ii) distance of first secondary maximum from the centre of the screen.

3)a) Use gauss's law to show that due to a uniformly charge spherical shell of radius R, the electric field at any point situated outside the shell at a distance r from its centre is equal to the electric field at the same point, when the entire charge on the shell were concentrated at its centre. Also plot the graph showing the variation of electric field with r, for $r \leq R$ and $r \geq R$.

b) Two point charges of + 1 μ C and + 4 μ C are kept 30 cm apart. How far from the +1 μ C charges on the line joining the two charges, will the net electric field be zero?

4) a) A circular loop of radius R carries a current I. Obtain an expression for the magnetic field at a point on its axis at a distance x from its centre.

b) A conducting rod of length 2 m is placed on a horizontal table in north South direction. It carries a current of 5A from south to north. Find the direction and magnitude of magnetic force acting on the rod. Given that the Earth magnetic field at the place is 0.6 × 10 ^ -4 T and angle of dip is π/6.

5)a) Obtain the expression for the deflecting torque acting on the current carrying rectangular coil of a galvanometer in a uniform magnetic field. Why is radial magnetic field employed in the moving coil galvanometer?

b) Not In syllabus

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March 2022

Section A-1 marks questions

1) Give reason: The resistance of a pn junction is low when it is forward biased and is high when it is reversed biased.

2) Doping of intrinsic semiconductors is a necessity for making electronic devices.

Section B-2 marks questions

1) What is mean by energy band gap in solid? Draw the energy band diagrams for a conductor, an insulator and a semiconductor.

2) Name the spectral series for hydrogen atom which lies in the visible region. Find the ratio of maximum to the minimum wavelength of this series.

3) What are matter waves? A proton and an alpha particle are accelerated through a same potential difference. Find the ratio of the de Broglie wavelength associated with the portion to that with the alpha particle.

4) Not in syllabus

Section C-3 Marks Questions

1) Differentiate between nuclear fission and nuclear fusion.

2) a) In Geiger Marsden experiment calculate the distance of closest approach for an alpha particle with energy 2.56 × 10^ -12 joule. Consider that the particle approaches gold nucleus (Z= 79) in head on position.

b) In the above experiment is repeated with a proton of the same energy, then what will be the value the distance of closest approach?

3) Briefly explain how bright and dark fringes are formed on the screen in Young's double slit experiment. Hence derived the expression for the fringe width.

4) i) Draw a labelled ray diagram showing the formation of the image at infinity by an astronomical telescope.

ii) A telescope consists of an objective of focal length 150 cm and an eyepiece of focal length 6 cm. If the final image is formed at infinity, then calculate:

i) the length of the tube in this adjustment and

ii) the magnification produced.

5) i) Draw a labelled ray diagram showing the formation of the image at least distance of distinct vision by a compound microscope.

ii) A small object is placed at a distance of 3cm from a magnifier of focal length 4cm Find

I) the position of the image formed, and

II) the linear magnification produced.

6) a) Use Einstein's photoelectric equation to depict the variation of the maximum kinetic energy (Ek) of electrons emitted, with the frequency (v) of the incident radiation.

b) A photosensitive surface is illuminated with a beam of i) yellow light, and ii) red light both have the same intensity.

In which case will

I) photoelectrons have more Ek?

Ii) more numbers of electrons be emitted? Justify your answer in each case.

7) a) Identify electromagnetic waves which

i) are used in radar system

ii) affect a photographic plate

iii) are used in surgery.

Write their frequency range.

8) A plane wavefront is propagating from a rarer into a denser medium. Use Huygens principle to show the refracted wavefront and verify Snell's law.

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QUESTION PAPER MARCH 2018 AND 2019

Section A

1)A proton and electron travelling along parallel path enter a region of uniform magnetic field, acting perpendicular to their path. Which of them move in a circular Path with higher frequency?

2)Name the electromagnetic radiation, and frequency used for a) water purification b) eye surgery. c) radar.

3)Draw graph showing variation of photoelectric current with applied voltage for two incident radiation of equal frequency and different intensities. Mark the graph for the radiation of higher intensity. (2018)

4)Four nuclei of an element undergo fusion to form a heavier nucleus, with release of energy. Which of the two the parent or daughter nucleus would have higher binding energy per nucleon?

5) Two electric bulb P and Q have their resistance in the ratio of 1:2. They are connected in series across the battery. Find the ratio of the power dissipation in these bulbs? (2018)

6)Draw the pattern of electric field lines, when a point charge -Q is kept near an uncharged conducting plate. (2019)

7)How does mobility of electron in a conductor charge, if the potential difference applied across the conductor is doubled, keep the length and temperature of the conductor constant? (2019)

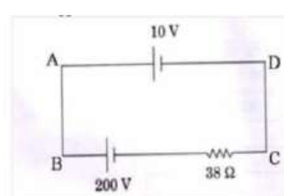
8) Define the term "Threshold frequency" in context of photoelectric emission. (2019)

9)State Bohr's quantization condition of angular momentum. Calculate the shortest wavelength of Bracket series and State to which pat of the electromagnetic spectrum does it belong. (2019)

10) Define the term wave front. Using Huygen's wave theory, verify the law of conservation.

11) Define mutual induction and write its SI unit. (2019)

Section B



Q1) A 10 V cells of negligible internal resistance is connected in parallel across a battery of emf 200 V and internal resistance 38 Q as shown in figure . Find the value of current in the circuit. (2M) (2018)

Q2) a) Why are infrared waves often called heat waves? Explain

b) What do you understand by the statement,'' Electromagnetic wave transport momentum?

(2M) (2018)

Q3) Four charges Q, q, Q and q are placed at the corner of a square of side ‘a’ as shown in figure. Find a) resultant electric force on a charge Q and b) potential energy of this system. (2018)

Q4) a) Define the term ‘conductivity’ of a metallic wire. Write its SI unit.

b) Using the concept of free electron in a conductor, derive the expression for conductivity of a wire in terms of number density and relaxation time hence obtain the relation between current density and applied electric field E. (2018)

Q5) a) The Bohr’s postulate to define stable orbits in hydrogen atom. How does De-Broglie’s hypothesis explain the stability of these orbit.

b) A hydrogen atom initially in the ground state absorbs photon which excites it to the n=4 level. Estimate the frequency of the photon. (2018)

Q6) a) A student wants to use two p-n junction diodes to convert alternating current into direct current. Draw the labelled diagram would use and explain how it work

b) Give the truth table and circuit symbol for NAND gate. (2018)

Q7) a) Define electric flux, Is it scalar or a vector quantity? A point charge q is at a distance of d/2 is directly above the center of a square of side ‘d’ use gauss law to explain the expression for electric flux through the square

b) If the point charge is now moved to a distance ‘d’ from the center of a square and the side of the square is doubled, explain how the electric flux will be affected? (2018)

Q8) Draw the ray diagram to show image formation when the concave mirror produces a real, inverted and magnified image of the object.

b) Obtain the mirror formula and write the expression for the linear magnification. (2018)

Q9) Two bulbs are rated (P1, V) and (P2, V). If they are connected i) in series and ii) in parallel across a supply V, find the power dissipated in two combination in terms P1 and P2.

Q10) Calculate the radius of curvature of an equi-concave lens of refractive index 1.5, when it is kept in a medium of refractive index 1.4, to have a power of -5D ? (2019)

Q11) An particle and a proton of the same kinetic energy are in turn allow to pass through a magnetic field B, acting normal to the direction of motion of the particle. Calculate the ratio of radii of circular paths describe by them. (2019)

Q12) a) Draw equipotential surface corresponding to a uniform electric field in the z- direction.

b) Derive an expression for the electric potential at any point along the axial line of an electric dipole. (2019)

Q13) a) State Gauss law for magnetism. Explain it's significance. b) write the four important properties of the magnetic field line due to a bar magnet. (2019)

Section C

Q1) A bar magnet of magnetic moment 6 J/T is aligned at 60^0 with uniform external magnetic field of 0.44 T Calculate

a) The work done in turning the magnet to align its magnetic moment
b) Normal to the magnetic field
c) Opposite the magnetic field

b) the torque on the magnet in the final orientation in case c (2018)

Q2) a) Show using proper diagram how unpolarized light can be linearly polarized by reflection from transparent glass surface. (2018)

Q3) a) If one of the two identical slit producing interference in Youngs experiment is covered with glass, so that the light intensity passing through it is reduce to 50% find the ratio of the maximum and minimum intensity of fringes in the interference pattern b) what kind of fringes do you expect to observe if white light is used instead of monochromatic light. (2018)

Q4) Why the wave theory of electromagnetic radiation not able to explain photoelectric effect? How does photon picture resolve this problem? (2019)

Q5) Plot the graph showing variation of de Broglie wavelength associated with a charge particle of masses m, versus 1/V, where V is potential difference through which the particle is accelerated. How does this graph give the information regarding the magnitude of the charge of the particle?

Q6) a) Derive the expression for the torque acting on a current carrying loop placed in a magnetic field. b) Explain the significance of radial magnetic field when a current carrying coil is kept in it. (2019)

Q7) a) Three photo diodes D1, D2, and D3 are made of semiconductor having band gapes of 2.5 eV, 2eV and 3eV resp. Which of them will not be able to detect the light of wavelength 600nm? b) Why Photodiodes are required to operate in reverse bias? Explain. (2019)

Q8) a) In a series LCR circuit connected across an ac source of variable frequency, obtain the expression for its impedance and draw a plot showing its variation with frequency of the ac source b) What is the phase difference between the voltage across the inductor and capacitor at resistance in the LCR circuit? (2019)

Q9) Describe briefly the process of transferring the charge between the two plates of a parallel plate capacitor when connected to a battery. Derive an expression for the energy stored in capacitor. b) A parallel plate capacitor is charge by a battery to a potential difference V, It is disconnected from battery and then connected to another uncharged capacitor of the same capacitane. Calculate the ratio of energy stored in the combination to the initial energy on the single capacitor. (2019)

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CBSE question paper March 2016 and March 2017

SECTION A

Q1) Define mutual inductance. (CBSE Delhi 2016) (1m)

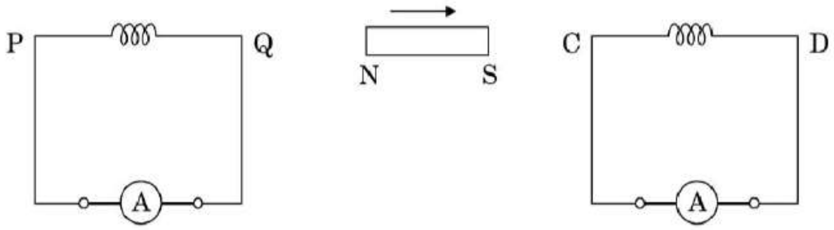
Q2) Define self inductance of a coil. Obtain the expression for the energy stored in an inductor L connected across a source of emf. (CBSE 55/1 2017) (3m)

Q3) Define mutual inductance between a pair of coils. Derive an expression for the mutual inductance of two long coaxial solenoids of same length wound one over the other

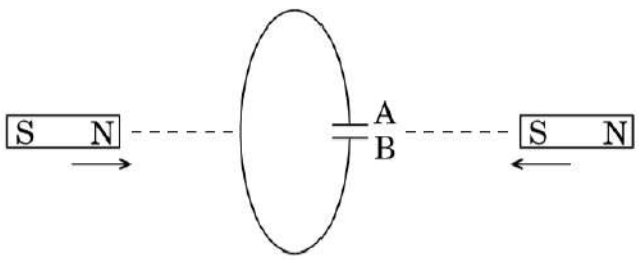
(CBSE 55/1 2017) (3m)

SECTION B

Q1) A bar magnet is moved in the direction indicated by the arrow between two coils PQ and CD. Predict the direction of the induced current in each coil (CBSE 55/2 2017) (1m)



Q2) Predict the polarity of the capacitor C connected to coil, which is situated between two bar magnets moving as shown in figure. (CBSE 55/1 2017) (1m)



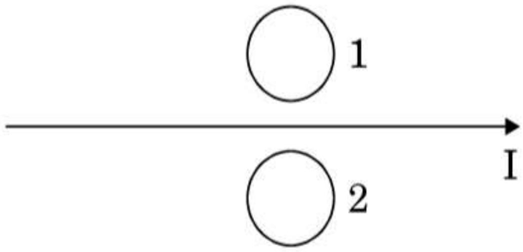
Q3) A pair of adjacent coils has a mutual inductance of 1.5 H. If the current in one coil changes from 0 to 20 A in 0.5 s, what is the change of flux linkage with the other coil?

(CBSE Delhi 2016) (2m)

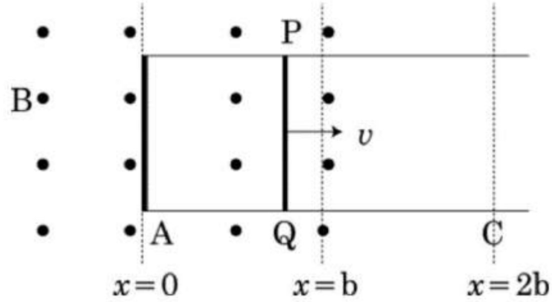
Q4) A rectangular coil of area A, having number of turns N is rotated at 'f' revolutions per second in a uniform magnetic field B, the field being perpendicular to the coil. Prove that maximum emf induced in the coil is $2\pi fNBA$. (CBSE 55/1/C 2016) (3m)

SECTION C

Q1) What is the direction of induced currents in metal rings 1and 2 when current I in the wire is increasing steadily? (CBSE 55/3 2017)(1m)



Q2) Sketch the change in flux, emf and force when a conducting rod PQ of resistance R and length L moves freely to and fro between A and C with speed v on a rectangular conductor place in uniform magnetic field as shown in the figure. (CBSE 55/1/N 2016) (3m)



Q3) When a bar magnet is pushed towards (or away) from the coil connected to a galvanometer, the pointer in the galvanometer deflects. Identify the phenomenon causing this deflection and write the factors on which the amount and direction of the deflection depends. State the laws describing this phenomenon. (CBSE 55/1/N 2016)(3m)

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ANSWER KEY:

SECTION A:

1.Mutual Inductance is the property of a pair of coils due to which an emf induce in one of the coils due to the change in the current in the other coil.

Mathematically, e_2= -M $\frac{di1}{dt}$

Therefore, M= -e_2/$\frac{di1}{dt}$

2.Self Inductance of a coil equals the flux linked with it when a unit current flows through it. The work done against induced emf is stored as magnetic potential energy.

The rate of work done, when a current I is passing through the coil, is

$\frac{dW}{dt}$= $|\varepsilon|$ i =(L$\frac{di}{dt}$)i

Therefore, W =$\int$ dW =$\int_0^I$ $LiDi$ =1/2 Li^2

3.Mutual inductance is numerically equal to the magnetic flux linked with one coil/secondary coil when unit current flows through the other coil/ primary coil.

Let a current i_2, flows in the secondary coil

Therefore, B_2 =$\frac{\mu_0 N_2 i_2}{l}$

∴ Flux linked with the primary coil = $N_1A_1B_2$ =$\frac{\mu_0 N_2 N_1 A_1 i_2}{l}$ =$M_{12}i_2$

Hence, M_{12} =$\frac{\mu_0 N_2 N_1 A_1}{l}$ = $\mu_0 n_2 n_1 A_1 l$ (n_1=N_1/l ; n_2= N_2/l)

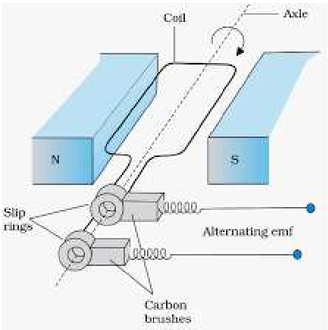
SECTION B

2.A is positive and B is negative

3. Change of flux for small change in current

dφ =MdI =1.5 (20-0) weber = 30 weber

4.



Flux at any time t,

Φ_B= BAcosθ = BA cosωt

Form Faraday's law, induced emf

e = -N$\frac{d\phi_B}{dt}$ = NBA $\frac{d}{dt}$ (cosωt)

Thus the instantaneous value of emf is

E = NBAωsinωt

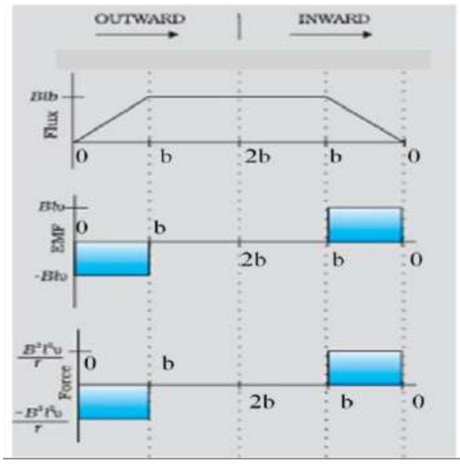
For maximum value of emf sinωt = ±1

i.e, e_0= NBAω = 2πfNAB

SECTION C

1. 1- clockwise, 2- anticlocwise

2.



3.The phenomenon involved is electromagnetic induction

For the deflection:

Amount depends upon the speed of movement of the magnet.

Direction depends on the sence (towards, or away) of the movement of the magnet.

The law describing the phenomenon is:

The magnitude of the induced emf, in a circuit, is equal to the time rate of change of the magnetic flux through the circuit.

ε = - $\frac{d\phi}{dt}$

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CBSE QUESTION PAPER MARCH 2016 AND 2017

SECTION A

Q1) Write the function of a transformer. State its principle of working with the help of a diagram. Mention various energy losses in this device. (CBSE 55/1/1/D 2016) (3m)

Q2) Draw a labelled diagram of an generator. Obtain the expression for the EMF induced in the rotating coil of N turns each of cross section area A, in the presence of a magnetic field B. (CBSE 55/1 2017)(3m)

Q3) Draw a labelled diagram of a step up transformer. Obtain the ratio of secondary to primary voltage in terms of number of turns and current in the two coils.

Q4) (i)Draw a labelled diagram of a step down transformer. State the principle of its working.

(ii)Express the turn ratio in terms of voltages.

(iii) Find the ratio of primary and secondary currents in terms of turn ratio in an ideal transformer. (CBSE 55/1/C 2016) (5m)

Q5) A power transmission line feeds input power at 2200V to a step-down transformer with its primary windings having 3000 turns. Find the number of turns in the secondary to get the power output at 220V. (CBSE 55/1/1 2017) (2m)

SECTION B

Q1) An a.c source of voltage V= $V_0 \sin \omega t$ is connected to an ideal inductor. Draw graphs of voltage V and current i versus omega t. (CBSE 55/1/E 2016) (1m)

Q2) An a.c source of voltage V = Vo sin ωt is connected to a series combination of L,C and R. Use the phasor diagram to obtain expressions for impedance of the circuit and phase angle between voltage and current. Find the condition when current will be in phase with the voltage. What is the circuit in this condition called? (3m) (CBSE 55/1/1/D 2016)

Q3) The primary coil of an ideal step up transformer has 100 turns and transformation ratio is also 100. The input voltage and power are respectively 220V and 1100W. Calculate

a) number of turns in secondary

b) current in primary

c) voltage across secondary

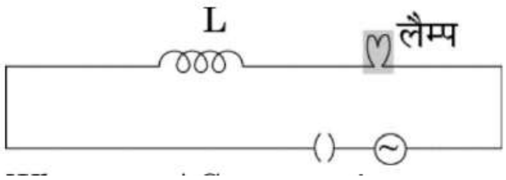
d) current in secondary

e) power in secondary. (CBSE 55/1/1/D 2016) (3m)

Q4) How much current is drawn by the primary of a transformer connected to 220 volt supply when it delivers power to a 110V - 550W refrigerator? (CBSE 55/1/C 2016)

Q5) The power factor of an AC circuit is 0.5. What is the phase difference between voltage and current in the circuit? (CBSE 55/1/S 2016) (1m)

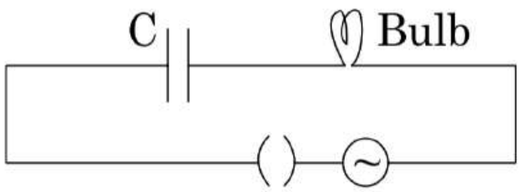
SECTION C



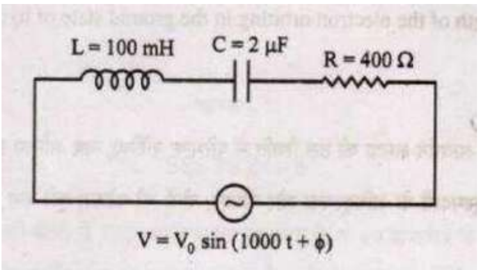
Q1) (i) When an AC source is connected to an ideal inductor show that the average power supplied by the source over a complete cycle is zero.

(ii)A lamp is connected in series with an inductor and an AC source. What happens to the brightness of the lamp when the key is plugged in and an iron rod is inserted inside the inductor? Explain. (CBSE 55/1/C 2016) (3m)

2.(i)When an AC source is connected to an ideal capacitor, show that the average power supplied by the source complete cycle is zero.



(ii)A bulb is connected in series with the variable capacitor and an AC source as shown. What happens to the brightness of the bulb when the key is plugged in and the capacitance of a capacitor is gradually reduced?(CBSE 55/1/N 2016) (3m)

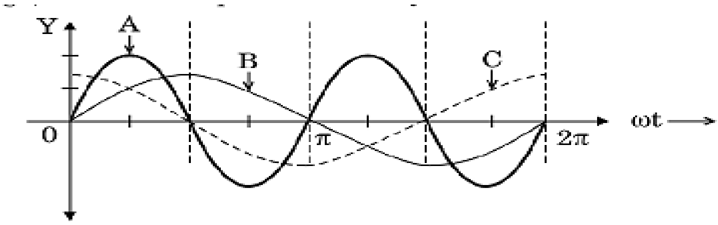


3.A capacitor of unknown capacitance, register of 100 ohm an inductor of self inductance L= $(4/\pi^2)$ henry are connected in series to an AC source of 200V and 50Hz. Calculate the value of the capacitance and impedance of the circuit when the current is in phase with the voltage. Calculate the power dissipated in the circuit. (CBSE 55/1/S 2016) (3m)

4.(i)Find the value of the phase difference between the current and the voltage in the series LCR circuit shown below. Which one lead in phase: current or voltage?

(ii)Without making any other change, find the value of the additional capacitor C1, to be connected in parallel with the capacitor C, in order to make the power factor of the circuit unity. (CBSE 55/1/1 2017) (3m)

5. A circular coil of cross-sectional area 200 m^2 and 20 turns is rotated about the vertical diameter with angular speed of 50 rad s^{-1} in a uniform magnetic field of magnitude 3.0x 10^{-2} T. Calculate the maximum value of the current in the coil. (CBSE 55/1/1 2017) (2m)



6.a) identify the device 'X'

b) which of the curves A,B and C represent the voltage, current and the power consumed in the circuit? Justify your answer

c) how does its impedance vary with frequency of the a.c source? Show graphically.

d) obtain an expression for the current in the circuit and its phase relation with a.c voltage. (CBSE 55/1 2017) (5m)

7. A horizontal conducting rod 10 m long extending from east to west is falling with the speed 5.0 m/s at right angle to the horizontal component of the Earth's magnetic field, 0.3 x 10^-4 Ab/m^-2 . Find the instantaneous value of the emf induced in the rod. (CBSE 55/1 2017) (2m)

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Answer Key

SECTION A

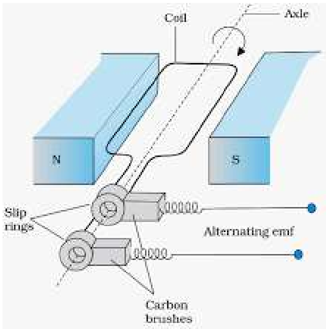
1.Function: A Transformer is an electrical device for converting an alternating current at low voltage into that at high voltage or vice versa.

Principle: It works on the principle of mutual induction i.e., when a changing current is passed through one of the two inductively coupled coils, an induced emf is set up in the other coil.

Energy losses in transformer:

i) Copper loss
ii) Eddy current loss
iii) Hysteresis loss
iv) Flux leakeage
v) Humming loss

2.Let ω be the angular speed of rotation of the coil. We then have



$$\Phi(t) = NBA \cos\omega t$$

$$\therefore\ E = \frac{d\emptyset}{dt} = NBA\omega \sin\omega t = E_0 \sin \omega t \qquad (E_0 = NBA\omega)$$

5. $\frac{N_S}{N_P} = \frac{V_s}{V_P}$

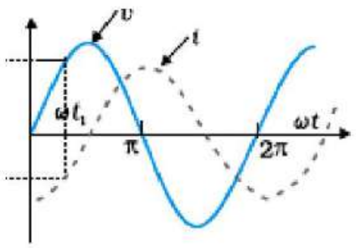
$\frac{N_S}{3000} = \frac{220}{2200}$

$\therefore N_S = 300$

SECTION B

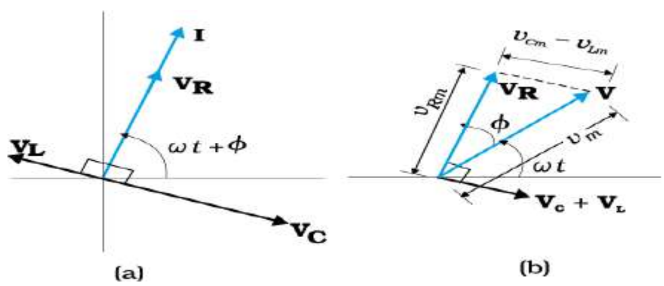
1.

.



Graph of V
Graph of I

From fig.



$\vec{V} = \vec{V_L} + \vec{V_R} + \vec{V_C}$

where $|\vec{V_R}| = i_m R$

$|\vec{V_L} + \vec{V_C}| = V_{Cm} - V_{Lm}$

$= i_m(X_C - X_L)$

$\Rightarrow V_m^2 = V_{Rm}^2 + (V_{Cm} - V_{Lm})^2$

$i_m^2 Z^2 = i_m^2 R^2 + i_m^2 (X_C - X_L)^2$

$\Rightarrow$ $Z=\sqrt{R^2 + (X_C - X_L)^2}$

From Figure

$$\tan\phi = \frac{V_{Cm}-V_{Lm}}{V_{Rm}} = \frac{i_m(X_C-X_L)}{i_m R}$$

$$\phi = tan^{-1}(\frac{X_C-X_L}{R})$$

Condition for current and voltage are in phase :

$$V_L = V_C \quad or \quad X_L = X_C$$

Circuit is called Resonant circuit.

3.N_P = 100 Transformation ratio = 100

a) No. of turns in secondary coil N_S = 100 x100 = 10000

b) Input Power = Input Voltage x current in primary

1100 = 220 x I_P

$\therefore$ I_P =5A

c) $\frac{N_S}{N_P} = \frac{V_s}{V_P}$

$\therefore$ $V_S = 2.2 \times 10^4$ V

d) $\frac{I_P}{I_S} = \frac{N_S}{N_P}$

$\therefore$ I_S = 0.05 A

e) Power in secondary = Power in primary

= 1100 W

4.We have, $i_P V_P = i_S V_S$ = 550 W

V_P = 220 V

I_P = 550/220 = 2.5 A

5. given power factor is 0.5

Cosφ = 0.5 = 1/2

phase angle φ = $\cos^{-1}$ (1/2) = 60°

SECTION C

1.(i) $P_{av} = I_{av} \times e_{av} \cos\varphi$

For an ideal inductor , φ =π/2

$\therefore$ P_{av} = Iav x eav $\cos\frac{\pi}{2}$

P_{av} =0

(ii) Brightness decreases because as iron rod is inserted inductance increases. Thus, current decreases and brightness decreases.

2.(i) Let the applied voltage be $V = V_0 \sin\omega t$

The current through an ideal capacitor, would be

$I = I_0 \sin(\omega t + \pi/2) = I_0 \cos\omega t$

$\therefore P_{i\,nst} = VI$

$\therefore P_{AV} = 1/T \int_0^T \quad VIdt$

$\therefore P_{AV} = V_0I_0/2 \sin(2\omega t) = 0$

(ii) The brightness of the bulb would also reduce gradually.

$X_C = 1/\omega C$

$\therefore$ X_C increases as C decreases. Hence, with decreasing C, the brighness of the bulb would decreases.

3.Capacitance C = $\frac{1}{L\omega^2} = \frac{1}{\frac{4}{\pi^2}(2\pi\ x\ 50)^2}$ F = 2.5 x 10^{-5} F

Impedence = resistance (since V and I are in phase)

$\therefore$Impedence =100Ω

Power dicipated = $\frac{Erms^2}{R} = \frac{200^2}{100}$ = 400 watt

4.(i) $X_L = \omega L$ = (1000x100 x 10^{-3}) Ω = 100 Ω

$X_C = \frac{1}{\omega C} = (\frac{1}{1000\ x2\ x\ 10^{-6}})\Omega = 500\Omega$

Phase angle =tan φ = $\frac{X_L - X_C}{R} = \frac{100-500}{400}$ = -1

$\Phi = -\frac{\pi}{4}$

As $X_C > X_L$ (phase angle is negative), hence current leads voltage

(ii) To make power factor unity

$X_{C'} = X_L$

$\frac{1}{\omega c}$ = 100

C' = 10 μF

C' = C + C_1

10 = 2 + C_1

C_1 = 8 μF

5.Maximum induced current $i_0 = \frac{e_0}{R} = \frac{600}{R}$ mA

Since, R is not given value of max. current cannot be calculated

6.a) the device name is a capacitor

b) curve B = voltage, curve C= current, curve A = power

Reason: The current lead the voltage in phase, by π/2, for capacitor.

c) $X_c = 1/\omega c$

d) $V = V_0 \sin\omega t$

$Q = CV = C V0 \sin\omega t$

$I = \frac{dq}{dt} = \omega C V0 \cos\omega t = I_0 \sin(\omega t + \pi/2)$

Current leads the voltage, in phase by π/2

7.Induced emf = BIV

$\therefore E = 0.3 x 10^{-4} x 10 x 5$ volt

$E = 1.5 x 10^{-3} V = 1.5mV$

March 2014 and March 2015 Question Papers

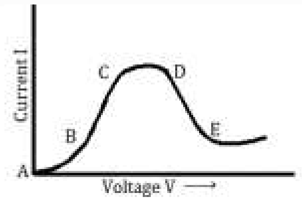
SECTION – A

Q1) What is the electric flux through a cube of side 1 cm which encloses an electric dipole?

Q2) A concave lens of refractive index 1.5 is immersed in a medium of refractive index 1.65. What is the nature of the lens?

Q3) How are side bands produced?

Q4) Graph showing the variation of current versus voltage for a material GaAs is shown in the figure. Identify the region of



a) Negative resistance

b) Where Ohm's law is obeyed

Q5) Define capacitor reactance. Write its S.I. units.

Section – B

Q6) Show that the radius of the orbit in hydrogen atom varies as n2 , where n is the principal quantum number of the atom.

Q7) Distinguish between 'intrinsic' and 'extrinsic' semiconductors.

Q8) Use the mirror equation to show that an object placed between f and 2f of a concave mirror produces a real image beyond 2f.

OR

Find the expression for intensity of transmitted light when a polaroid sheet is rotated between two crossed polaroids. In which position of the polaroid sheet will the transmitted intensity be maximum?

Q9) Use Kirchhoff's rules to obtain conditions for the balanced condition in a Wheatstone bridge.

Q10) A proton and an α -particle have the same de-Broglie wavelength. Determine the ration of (i) their accelerating potentials (ii) their speeds.

Section – C

Q11) Draw a block diagram of a detector for AM signal and show, using necessary processes and the waveforms, how the original message signal is detected from the input AM wave.

Q12) A cell of emf 'E' and internal resistance 'r' is connected across a variable load resistor R. draw the plots of the terminal voltage V versus (i) R and (ii) the current I.

It is found that when R = Ω 4 , the current is 1 A and when R is increased to 9Ω , the current reduces to 0.5 A. Find the values of the emf E and internal resistance r.

Q13) Two capacitors of unknown capacitances C_1 and C_2 are connected first in series and then in parallel across a battery of 100 V. If the energy stored in the two combinations is 0.045 J and 0.25 J respectively, determine the value of C_1 and C_2. Also calculate the charge on each capacitor in parallel combination.

Q14) State the principle of working of a galvanometer.

A galvanometer of resistance G is converted into a voltmeter to measure upto V volts by connecting a resistance R_1 in series with the coil. If a resistance R_2; is connected in series with it, then it can measure upto V/2 volts. Find the resistance, in terms of R_1 and R_2, required be connected to convert it into a voltmeter that can read upto 2 V. Also find the resistance G of the galvanometer in terms of R_1 and R_2.

Q15) With what considerations in view, a photodiode is fabricated? State its working with the help of a suitable diagram.

Even though the current in the forward bias is known to be more than in the reverse bias, yet the photodiode works in reverse bias. What is the reason?

Q16) Draw a circuit diagram of a transistor amplifier in CE configuration.

Define the terms: (i) Input resistance and (ii) Current amplification factor. How are these determined using typical input and output characteristics?

Q17) Answer the following questions:

a) In a double slit experiment using light of wavelength 600 nm, the angular width of the fringe formed on a distant screen is 0.1°. Find the spacing between the two slits.

b) Light of wavelength 5000 $\mathring{A}$ propagating is air gets partly reflected from the surface of water. How will the wavelength and frequencies of the reflected and refracted light be affected?

Q18) An inductor L of inductance X_L is connected in series with a bulb B and an ac source. How would brightness of the bulb change when (i) number of turn in the inductor is reduced, (ii) an iron rod is inserted in the inductor and (iii) a capacitor of reactance $X_c=X_L$ is inserted in series in the circuit. Justify your answer in each case.

Q19) Name the parts of the electromagnetic spectrum which is

a) Suitable for radar system used in aircraft navigation.

b) Used to treat muscular strain.

c) Used as a diagnostic tool in medicine.

Write in brief, how these waves can be produced.

Q20) a) A giant refracting telescope has an objective lens of focal length 15 m. If an eye piece of focal length 1.0 cm is used, what is the angular magnification of the telescope?

b) If this telescope is used to view the moon, what is the diameter of the image of the moon formed by the objective lens? The diameter of the moon is 3.48×10^6m and the radius of lunar orbit is 3.8×10^8m.

Q21) Write Einstein's photoelectric equation and mention which important features in photoelectric effect can be explained with the help of this equation.

The maximum kinetic energy of the photoelectrons gets doubled when the wavelength of light incident on the surface changes from λ_1 to λ_2 to. Derive the expressions for the threshold wavelength λ_0 and work function for the metal surface.

Q22) In the study of Geiger-Marsdon experiment on scattering of α particles by a thin foil of gold, draw the trajectory of α -particles in the coulomb field of target nucleus. Explain briefly how one gets the information on the size of the nucleus from this study. From the relation $R = R_0 A^{1/3}$, R_0 is constant and A is the mass number of the nucleus, show that nuclear matter density is independent of A.

OR

Distinguish between nuclear fission and fusion. Show how in both these processes energy is released.

Calculate the energy release in MeV in the deuterium-tritium fusion reaction:

$${}_1^2\mathrm{H}+{}_1^3\mathrm{H} \rightarrow {}_2^4\mathrm{He}+\mathrm{n}$$

Using the data:

$$m\left({}_1^2H\right) = 2.014102u$$

$$m\left({}_1^3H\right) = 3.016049u$$

$$m\left({}_2^4He\right) = 4.002603u$$

$$m_n = 1.008665u$$

$$1u = 931.5MeV/c^2$$

Section – D

Q23) A group of students while coming from the school noticed a box marked "Danger H.T. 2200 V" at a substation in the main street. They did not understand the utility of a such a high voltage, while they argued, the supply was only 220 V. They asked their teacher this question the next day. The teacher thought it to be an important question and therefore explained to the whole class.

Answer the following questions:

a) What device is used to bring the high voltage down to low voltage of a.c. current and what is the principle of its working?

b) Is it possible to use this device for bringing down the high dc voltage to the low voltage? Explain.

c) Write the values displayed by the students and the teacher.

Section – E

Q24. a) Using Huygen's construction of secondary wavelets explain how a diffraction pattern is obtained on a screen due to a narrow slit on which a monochromatic beam of light is incident normally.

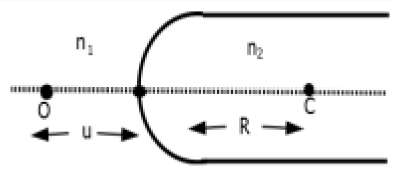
b) Show that the angular width of the first diffraction fringe is half that of the central fringe.

c) Explain why the maxima at $\theta = n + \frac{1}{2}\frac{\lambda}{a}$ become weaker with increasing n.

OR

a) A point object 'O' is kept in a medium of refractive index n1 in front of a convex spherical surface of radius of curvature R which separates the second medium of refractive index n_2 from the first one, as shown in the figure.

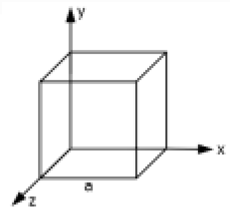
Draw the ray diagram showing the image formation and deduce the relationship between the object distance and the image distance in term of n_1, n_2 and R.



b) When the image formed above acts as a virtual object for a concave spherical surface separating the medium n_2 from n_1 ($n_2 > n_1$), draw this ray diagram and write the similar (similar to (a)) relation. Hence obtain the expression for the lens maker's formula.

Q25. a) An electric dipole of dipole moment $\overline{p}$ consists of point charges +q and –q separated by a distance 2a apart. Deduce the expression for the electric field $\overline{E}$ due to the dipole at a distance x from the centre of the dipole on its axial lien in terms of the dipole moment $\overline{p}$. Hence show that in the limit x>>a, $\overline{E} \rightarrow 2\overline{p} / \left(4\pi\varepsilon_0 x^3\right)$.

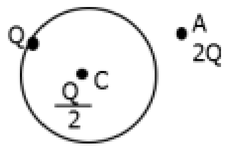
b) Given the electric field in the region $\overline{E} = 2x\hat{i}$, find the net electric flux through the cube and the charge enclosed by it.



OR

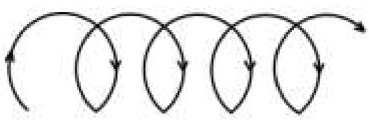
a) Explain, using suitable diagrams, the difference in the behavior of a (i) conductor and (ii) dielectric in the presence of external electric field. Define the terms polarization of the dielectric and write its relation with susceptibility.

b) A thin metallic spherical shell of radius R carries a charge Q on its surface. A point charge $\frac{Q}{2}$ is placed at its centre C and an other charge +2Q is placed outside the shell at a distance x from the centre as shown in the figure. Find (i) the force on the charge at the centre of shell and at the point A, (ii) the electric flux through the shell.



Q26. a) State Ampere's circuital law. Use this law to obtain the expression for the magnetic field inside an air cored toroid of average radius 'r', having 'n' turns per unit length and carrying a steady current I.

b) An observer to the left of a solenoid of N turns each of cross section area 'A' observes that a steady current I in it flows in the clockwise direction. Depict the magnetic field lines due to the solenoid specifying its polarity and show that it acts as a bar magnet of magnetic moment m = NIA.



OR

a) Define mutual inductance and write its S.I. units.

b) Derive an expression for the mutual inductance of two long co-axial solenoids of same length wound one over the other.

c) In an experiment, two coils c_1 and c_2 are placed close to each other. Find out the expression for the emf induced in the coil c_1 due to a change in the current through the coil c_2.

CBSE Question Paper 2015

SECTION – A

Q1) A concave lens of refractive index 1.5 is immersed in a medium of refractive index 1.65. What is the nature of the lens?

Q2) How are side bands produced?

Q3) Graph showing the variation of current versus voltage for a material GaAs is shown in the figure. Identify the region of

(i) negative resistance (ii) where Ohm's law is obeyed.

Q4) Define capacitor reactance. Write its S.I. units.

Q5) What is the electric flux through a cube of side 1 cm which encloses an electric dipole?

SECTION B

Q6) Distinguish between 'intrinsic' and 'extrinsic' semiconductors.

Q7) Use the mirror equation to show that an object placed between f and 2f of a concave mirror produces a real image beyond 2f.

OR

Find an expression for intensity of transmitted light when a polaroid sheet is rotated between two crossed polaroids. In which position of the polaroid sheet will the transmitted intensity be maximum? Note: Not in syllabus

Q8) Use Kirchhoff's rules to obtain conditions for the balance condition in a Wheatstone bridge.

Q9) A proton and an α-particle have the same de-Broglie wavelength. Determine the ratio of (i) their accelerating potentials (ii) their speeds.

Q10) Show that the radius of the orbit in hydrogen atom varies as n2, where n is the principal quantum number of the atom.

SECTION C

Q11) State the principle of working of a galvanometer.

A galvanometer of resistance G is converted into a voltmeter to measure upto V volts by connecting a resistance R_1 in series with the coil. If a resistance R_2 is connected in series with it, then it can measure upto V/2 volts. Find the resistance, in terms of R_1 and R_2, required to be connected to convert it into a voltmeter that can read upto 2 V. Also find the resistance G of the galvanometer in terms of R_1 and R_2.

Q12) With what considerations in view, a photodiode is fabricated? State its working with the help of a suitable diagram.

Even though the current in the forward bias is known to be more than in the reverse bias, yet the photodiode works in reverse bias. What is the reason? Note: Not in syllabus

Q13) Not in syllabus

Q14) Answer the following questions:

(a) In a double slit experiment using light of wavelength 600 nm, the angular width of the fringe formed on a distant screen is 0.1°. Find the spacing between the two slits.

(b) Light of wavelength 5000 Å propagating in air gets partly reflected from the surface of water. How will the wavelengths and frequencies of the reflected and refracted light be affected?

Q15) An inductor L of inductance X_L is connected in series with a bulb B and an ac source. How would brightness of the bulb change when (i) number of turn in the inductor is reduced, (ii) an iron rod is inserted in the inductor and (iii) a capacitor of reactance $X_C = X_L$ is inserted in series in the circuit. Justify your answer in each case.

Q16) Name the parts of the electromagnetic spectrum which is

(a) suitable for radar systems used in aircraft navigation.

(b) used to treat muscular strain.

(c) used as a diagnostic tool in medicine.

Write in brief, how these waves can be produced.

Q17) (i) A giant refracting telescope has an objective lens of focal length 15 m. If an eye piece of focal length 1.0 cm is used, what is the angular magnification of the telescope?
(ii) If this telescope is used to view the moon, what is the diameter of the image of the moon formed by the objective lens ? The diameter of the moon is 3.48×10^6 m and the radius of lunar orbit is 3.8×10^8 m.

Q18) Write Einstein's photoelectric equation and mention which important features in photoelectric effect can be explained with the help of this equation.
The maximum kinetic energy of the photoelectrons gets doubled when the wavelength of light incident on the surface changes from λ_1 to λ_2. Derive the expressions for the threshold wavelength λ_0 and work function for the metal surface.

Q19) In the study of Geiger-Marsdon experiment on scattering of α particles by a thin foil of gold, draw the trajectory of α-particles in the coulomb field of target nucleus. Explain briefly how one gets the information on the size of the nucleus from this study.

From the relation $R = R_0 A^{1/3}$, where R_0 is constant and A is the mass number of the nucleus, show that nuclear matter density is independent of A.

OR

Distinguish between nuclear fission and fusion. Show how in both these processes energy is released.

Calculate the energy release in MeV in the deuterium-tritium fusion reaction: ${}_1^2H + {}_1^3H \rightarrow {}_2^4He + n$

Using the data:

$m({}_1^2H) = 2.014102u$

$m({}_1^3H) = 3.016049u$

$m({}_2^4He) = 4.002603u$

$M_n = 1.008665u$

$1u = 931.5\ MeV/c^2$

Q20) Not in syllabus

Q21) A cell of emf 'E' and internal resistance 'r' is connected across a variable load resistor R. Draw the plots of the terminal voltage V versus (i) R and (ii) the current I. It is found that when R = 4 Ω, the current is 1 A and when R is increased to 9 Ω, the current reduces to 0.5 A. Find the values of the emf E and internal resistance r.

Q22) Two capacitors of unknown capacitances C_1 and C_2 are connected first in series and then in parallel across a battery of 100 V. If the energy stored in the two combinations is 0.045 J and 0.25 J respectively, determine the value of C_1 and C_2. Also calculate the charge on each capacitor in parallel combination.

SECTION D

Q23) A group of students while coming from the school noticed a box marked "Danger H.T. 2200 V" at a substation in the main street. They did not understand the utility of a such a high voltage, while they argued, the supply was only 220 V. They asked their teacher this question the next day. The teacher thought it to be an important question and therefore explained to the whole class.

Answer the following questions:

(i) What device is used to bring the high voltage down to low voltage of a.c. current and what is the principle of its working?

(ii) Is it possible to use this device for bringing down the high dc voltage to the low voltage?

Explain.

(iii) Write the values displayed by the students and the teacher.

SECTION E

Q24) (a) An electric dipole of dipole moment $\vec{p}$ consists of point charges +q and –q separated by a distance 2a apart. Deduce the expression for the electric field $\vec{E}$ due to the dipole at a distance x from the centre of the dipole on its axial line in terms of he dipole moment → p. Hence show that in the limit x >> a, $\vec{E} \rightarrow 2\vec{p}\,/\,(4\pi\varepsilon_0 x^3)$.

(b) Given the electric field in the region $\vec{E} = 2x\hat{i}$, find the net electric flux through the cube and the charge enclosed by it.

OR

(a) Explain, using suitable diagrams, the difference in the behaviour of a (i) conductor and (ii) dielectric in the presence of external electric field. Define the terms polarization of a dielectric and write its relation with susceptibility.

(b) A thin metallic spherical shell of radius R carries a charge Q on its surface. A point charge $\frac{Q}{2}$ is placed at its centre C and an other charge +2Q is placed outside the shell at a distance x from the centre as shown in the figure. Find (i) the force on the charge at the centre of shell and at the point A, (ii) the electric flux through the shell.

Q25) (a) State Ampere's circuital law. Use this law to obtain the expression for the magnetic field inside an air cored toroid of average radius 'r', having 'n' turns per unit length and carrying a steady current I.

(b) An observer to the left of a solenoid of N turns each of cross section area 'A' observes that a steady current I in it flows in the clockwise direction. Depict the magnetic field lines due to the solenoid specifying its polarity and show that it acts as a bar magnet of magnetic moment m = NIA.

OR

(a)Define mutual inductance and write its S.I. units.

(b) Derive an expression for the mutual inductance of two long co-axial solenoids of same length wound one over the other.

(c) In an experiment, two coils c_1 and c_2 are placed close to each other. Find out the expression for the emf induced in the coil c_1 due to a change in the current through the coil c_2.

Q26) (a) Using Huygens's construction of secondary wavelets explain how a diffraction pattern is obtained on a screen due to a narrow slit on which a monochromatic beam of light is incident normally.

(b) Show that the angular width of the first diffraction fringe is half that of the central fringe.

(c) Explain why the maxima at $\theta = \left(n + \frac{1}{2}\right)\frac{\lambda}{a}$ become weaker and weaker with increasing n.

OR

(a) A point object 'O' is kept in a medium of refractive index n_1 in front of a convex spherical surface of radius of curvature R which separates the second medium of refractive index n_2 from the first one, as shown in the figure.

Draw the ray diagram showing the image formation and deduce the relationship between the object distance and the image distance in terms of n_1, n_2 and R.

(b) When the image formed above acts as a virtual object for a concave spherical surface separating the medium n_2 from n_1 ($n_2 > n_1$), draw this ray diagram and write the similar (similar to (a)) relation. Hence obtain the expression for the lens maker's formula.

SECTION A

Q1) What are permanent magnets? Give one example. 1

Q2) What is the geometrical shape of equipotential surfaces due to a single isolated charge?1

Q3) (a) Write the necessary conditions for the phenomenon of total internal reflections to occur.

(c) Write the relation between the refractive index and critical angle for a given pair of optical media.2

Q4) (a) Why photoelectric effect cannot be explained on the basis of wave nature of light? Give reasons.

(d) write the basis features of photon picture of electromagnetic radiation on which Einstein's photoelectric equation is based.3

Q5) (a) Draw a ray diagram showing the image formation by a compound microscope. Hence obtain expression for total magnification when the image is formed at infinity.

(e) Not in syllabus

OR

(a) State Huygen's principle. Using this principle draw a diagram to show how a plane wave front incident at the interface of the two media gets refracted when it propagates from a rarer to a denser medium. Hence verify Snell's law of refraction.

(b) When monochromatic light travels from a rarer to a denser medium, explain the following, giving reasons:

(i) Is the frequency of reflected and reflected light same as the frequency of incident light?

(ii) Does the decrease in speed imply a reduction in the energy carried by light wave?

SECTION B

Q1) A capacitor has been charged by a dc source. What are the magnitudes of conduction and displacement currents, when it is fully charged? 1

Q2) Write the relationship between angle of incidence 'i', prism 'A' and angle of minimum deviation for a triangular prism. 1

Q3) State Lenz's Law. A metallic rod held horizontally along east-west direction, is allowed to fall under gravity. Will there be an emf induced at its ends? Justify your answer. 2

Q4) A convex lens of focal length 25 cm is placed coaxially in contact with a concave lens of focal length 20 cm. Determine the power of the combination. Will the system be converging or diverging in nature? 2

Q5) (a) An em wave is travelling in a medium with a velocity . Draw a sketch showing the propagation of the em wave, indicating the direction of the oscillating electric and magnetic fields.

(b) How are the magnitudes of the electric and magnetic fields related to the velocity of the em wave? 2

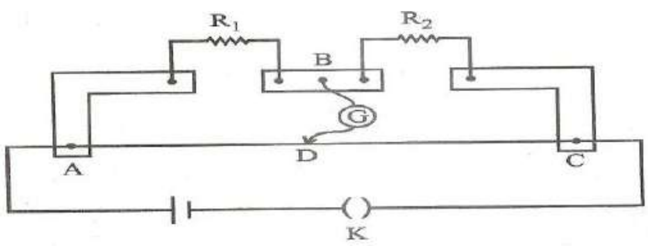
Q6) A metallic rod of length 'l' is rotated with a frequency v with one end hinged at the centre and the other end at the circumference of a circular metallic ring of radius r, about an axis passing through the centre and perpendicular to the plane of the ring. A constant uniform magnetic field B parallel to the axis is present everywhere. Using Lorentz force, explain how emf is induced between the centre and the metallic ring and hence obtain the expression for it.3

Q7) (a) & b) Not in syllabus

OR

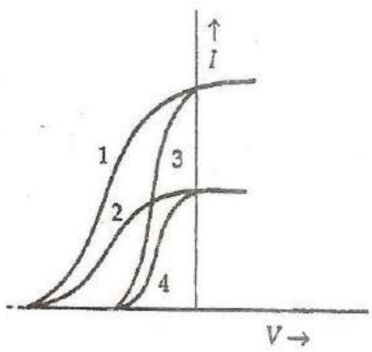
(a) State Kirchhoff's rules for an electric network. Using Kirchhoff's rules, obtain the balance condition in terms of the resistances of four arms of Wheatstone bridge.

(b) In the meter bridge experimental set up, shown in the figure, the null point 'D' is obtained at a distance of 40 cm from end A of the meter bridge wire. If a resistance of 10 Ω is connected in series with R1, null point is obtained at AD=60 cm. Calculated the values of R1 and R2. 5

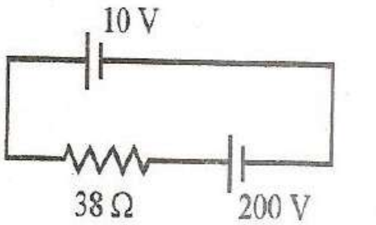


SECTION C

Q1) The given graph shows the variation of photo-electric current (I) versus applied voltage (V) for two different photosensitive materials and for two different intensities of the incident radiation. Identify the pairs of curves that correspond to different materials but same intensity of incident radiation. 1



Q2) A 10 V battery of negligible internal resistance is connected across a 200 V battery and a resistance of 38Ω as shown in the figure. Find the value of the current in circuit. 1



Q3) The emf of a cell is always greater than its terminal voltage. Why? Give reason. 1

Q4) An ammeter of resistance 0.80 Ω can measure current upto 1.0A.

(f) What must be the value of shunt resistance to enable the ammeter to measure current upto 5.0A?

(ii) What is the combined resistance of the ammeter and the shunt? 2

Q5) A capacitor of unknown capacitance is connected across a battery of V volts. The charge stored in it is360C. When potential across the capacitor is reduced by 120 V, the charge stored in it becomes120μC.

Calculate:

(g) The potential V and the unknown capacitance C.

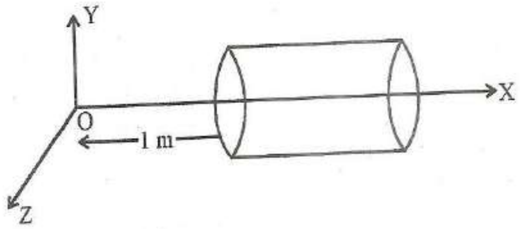
(ii) What will be the charge stored in the capacitor, if the voltage applied had increased by 120V?

OR

A hollow cylindrical box of length 1m and area of cross-section $25 cm^2$ is placed in a three-dimensional coordinate system as shown in the figure. The electric field in the region is given by, where E is in $NC^{-1}$and x is in metres. Find:

(h) Net flux through the cylinder.

(ii) Charge enclosed by the cylinder.



Q6) (a) In a typical nuclear reaction, e.g.

$$ {}_{1}^{2}H + {}_{1}^{2}H \longrightarrow {}_{2}^{3}He + n + 3.27 \text{ MeV}, $$

Although number of nucleons is conserved, yet energy is released. How? Explain.

(b) Show that nuclear density in a given nucleus is independent of mass number A.3

Q7) Using Bohr's postulates, obtain the expression for the total energy of the electron in the stationary states of the hydrogen atom. Hence draw the energy level diagram showing how the line spectra corresponding to Balmer series occur due to transition between energy levels.3

Q8) (a) In what way is diffraction from each slit related to the interference pattern in a double slit experiment?

(b) Two wavelength of sodium light 590 nm and 596 nm are used, in turn, to study the diffraction taking place at a single slit of aperture 2 x10^{-4} m. The distance between the slit and the screen is 1.5.m. Calculate the separation between the positions of the first maxima of the diffraction pattern obtained in the two cases. 3

Q9) In a series LCR circuit connected to an ac source of variable frequency and voltage draw a plot showing the variation of current (I) with angular frequency for two different values of resistance R1 and R2 (R1>R2). Write the condition under which the phenomenon of resonance occurs. For which values of the resistance out of the two curves, a sharper resonance is produced? Define Q-factor of the circuit and give its significance. 3

Q10) (a) Derive the expression for the torque on a rectangular current carrying loop suspended in a uniform magnetic field.

(i) A proton and a deuteron having equal momenta enter in a region of uniform magnetic field at right angle to the direction of the field. Depict their trajectories in the field.

OR

(a) A small compass needle of magnetic moment 'm' is free to turn about an axis perpendicular to the direction of uniform magnetic field 'B'. The moment of inertia of the needle about the axis is 'I'. The needle is slightly disturbed from its stable position and then released. Prove that it executes simple harmonic motion. Hence deduce the expression for its time period.

(b) A compass needle, free to turn in a vertical-plane orients itself with its axis vertical at a certain place on the earth. Find out the values of (i) horizontal component of earth's magnetic field and (ii) angle of dip at the place.

VALUE BASED QUESTION

Q1) While travelling back to his residence in the car, Dr. Pathak was caught up in a thunderstorm. It became very dark. He stopped driving the car and waited for thunderstorm to stop. Suddenly he noticed a child walking alone on the road. He asked the boy at his residence. The boy insisted that Dr. Pathak should meet his parents. The parents expressed their gratitude to Dr. Pathak for his concern for safety of the child. Answer the following questions based on the above information:

(a) Why is it safer to sit inside a car during a thunderstorm?

(b) Which two values are displayed by Dr. Pathak in his actions?

© Which values are reflected in parents' response to Dr. Pathak?

(d) Give an example of a similar action on your part in the past from everyday life.

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CBSE Question Paper 2012

SECTION A

Q1) Show on a graph, the variation of resistivity with temperature for a typical semiconductor. 1

Q2) Why should electrostatic field be zero inside a conductor? 1

Q3) Name the physical quantity which remains same for microwaves of wavelength 1 mm and UV radiations of 1600 Å in vacuum. 1

Q4) State de-Broglie hypothesis. 1

Q5) When an ideal capacitor is charged by a de battery, no current flows. However, when an ac source is used, the current flows continuously. How does one explain this, based on the concept of displacement current? 2

Q6) Draw a plot showing the variation of (i) electric field (E) and (ii) electric potential (V) with distance r due to a point charge Q. 2

Q7) Draw the circuit diagram of a full wave rectifier using p-n junction diode. Explain its working and show the output, input waveforms. 3

Q8) Write Einstein's photoelectric equation. State clearly how this equation is obtained using the photon picture of electromagnetic radiation. Write the three salient features observed in photoelectric effect which can be explained using this equation. 3

Q9) Use Huygens's principle to explain the formation of diffraction pattern due to a single slit illuminated by a monochromatic source of light. When the width of the slit is made double the original width, how would this affect the size and intensity of the central diffraction band? 3

Q10) (a) Define electric flux. Write its S.I. units.

(b) Using Gauss's law, prove that the electric field at a point due to a uniformly charged infinite plane sheet is independent of the distance from it. (c) How is the field directed if (i) the sheet is positively charged, (ii) negatively charged? 5

SECTION B

Q1) Under what condition docs a biconvex lens of glass having a certain refractive index act as a plane glass sheet when immersed in a liquid? 1

Q2) When electrons drift in a metal from lower to higher potential, does it mean that all the free electrons of the metal are moving in the same direction? 1

Q3) The susceptibility of a magnetic material is – 2.6 x 10^{-5}. Identify the type of magnetic material and state its two properties. 2

Q4) Define self-inductance of a coil. Show that magnetic energy required to build up the current I in a coil of self inductance L is given by 1/2 LI^2. 2

Q5) (i) What characteristic property of nuclear force explains the constancy of binding energy per nucleon (BE/A) in the range of mass number 'A' lying $30 < A < 170$?

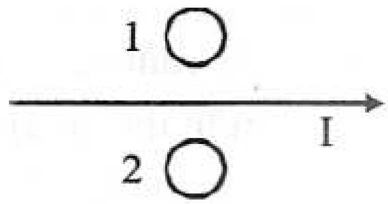
ii) Show that the density of nucleus over a wide range of nuclei is constant independent of mass number A. 3

Q6) (a) Why are coherent sources necessary to produce a sustained interference pattern?

(b) In Young's double slit experiment using monochromatic light of wavelength λ ,the intensity of light at a point on the screen where path difference is λ, is K units. Find out the intensity of light at a point where path difference is $\lambda/3$. 3

SECTION C

Q1) Predict the directions of induced currents in metal rings 1 and 2 lying in the same plane where current I in the wire is increasing steadily. 1



Q2) A ray of light, incident on an equilateral glass prism ($\mu_g = \sqrt{3}$) moves parallel to the base line of the prism inside it. Find the angle of incidence for this ray. 1

Q3) A cell of emf E and internal resistance r is connected to two external resistances R1and R2 and a perfect ammeter. The current in the circuit is measured in four different situations: 2

(i) without any external resistance in the circuit

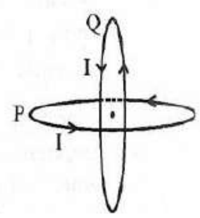
(ii) with resistance R1 only

(iii) with R1 and R2 in series combination

(iv) with R1 and R2 in parallel combination

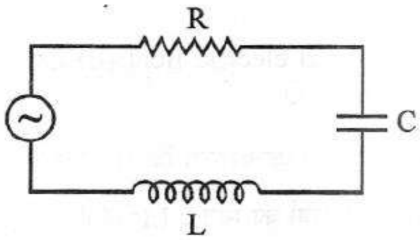
The currents measured in the four cases are 0.42 A 1.05 A, 1.4 A and 4.2 A, but not necessarily in that order. Identify the currents corresponding to the four cases mentioned above. 2

Q4) Two identical circular wires P and Q each of radius R and carrying current 'l' are kept in perpendicular planes such that they have a common centre as shown in the figure. Find the magnitude and direction of the net magnetic field at the common centre of the two coils. 2



Q5) A metallic rod of 'L' length is rotated with angular frequency of 'w' with one end hinged at the centre and the other end at the circumference of a circular metallic ring of radius L, about an axis passing through the centre and perpendicular to the plane of the ring. A constant and uniform magnetic field B parallel to the axis is present everywhere. Deduce the expression for the emf between the centre and the metallic ring. 2

Q6) The figure shows a series LCR circuit with L = 5.0 H, C= 80 uF, R = 40Ω connected to a variable frequency 240 V source. Calculate

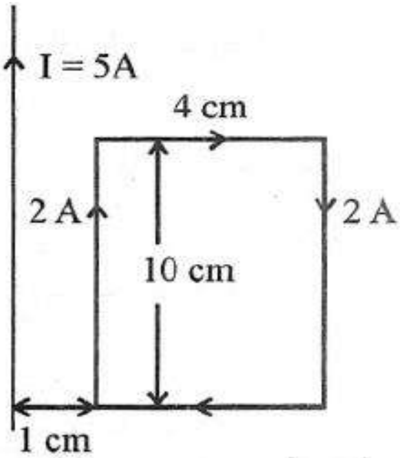


(i) The angular frequency of the source which drives the circuit at resonance.

(ii) The current at the resonating frequency.

(iii) The rms potential drop across the capacitor at resonance. 3

Q7) A rectangular loop of wire of size 4 cm x 10 cm carries a steady current of 2 A. A straight long wire carrying 5 A current is kept near the loop as shown. If the loop and the wire are coplanar, find



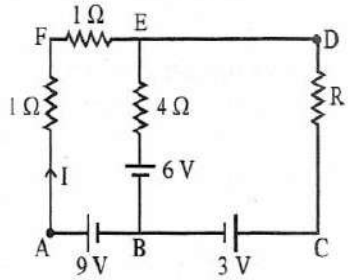
(1) the torque acting on the loop and

(ii) the magnitude and direction of the force on the loop due to the current carrying wire. 3

Q8) (a) Using Bohr's second postulate of quantization of orbital angular momentum show that the circumference of the electron in the n" orbital state in hydrogen atom is n times the de Broglie wavelength associated with it.

(b) The electron in hydrogen atom is initially in the third excited state. What is the maximum number of spectral lines which can be emitted when it finally moves to the ground state? 3

Q9) Using Kirchoff's rules determine the value of unknown resistance R in the circuit so that no current flows through 4Ω resistance. Also find the potential difference between A and D. 3



Q10) Define magnifying power of a telescope. Write its expression. A small telescope has an objective lens of focal length 150 cm and an eye piece of focal length 5 cm. If this telescope is used to view a 100 m high tower 3 km away. find the height of the final image when it is formed 25 cm away from the eye piece.

OR

How is the working of a telescope different from that of a microscope? The focal lengths of the objective and eyepiece of a microscope are 1.25 cm and 5 cm respectively. Find the position of the object relative to the objective in order to obtain an angular magnification of 30 in normal adjustment.

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