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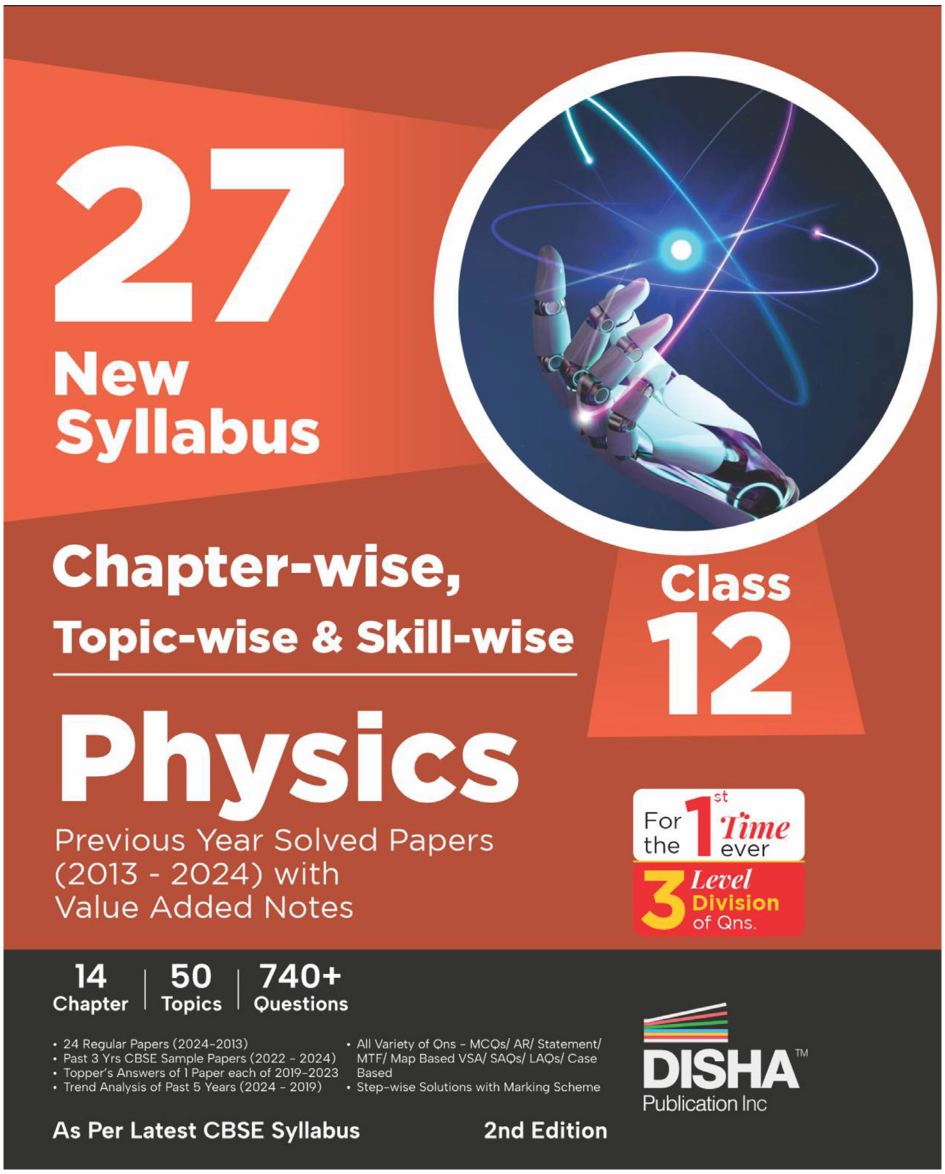
All India 2024 Solved Paper

This sample is taken from the **"27 New Syllabus Chapter-wise, Topic-wise & Skill-wise CBSE Class 12 Physics Previous Year Solved Papers (2013 - 2024) with Value Added Notes 2nd Edition"**



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Chapterwise Topicwise CBSE 2024
All India and Delhi Solved Paper

Chapter 1 : Electric Charges and Fields

Topic-2: ***Coulomb's Law, Forces between Multiple Charges, Electric Field, Electric Field Lines***

1 ***Multiple Choice Questions (1 Mark)***

1. An infinite long straight wire having a charge density λ is kept along y′y axis in x - y plane. The Coulomb force on a point charge q at a point P(x, 0) will be **[Delhi 2024, A]**

(a) attractive and $\frac{q\lambda}{2\pi\varepsilon_0 x}$

(b) repulsive and $\frac{q\lambda}{2\pi\varepsilon_0 x}$

(c) attractive and $\frac{q\lambda}{\pi\varepsilon_0 x}$

(d) repulsive and $\frac{q\lambda}{\pi\varepsilon_0 x}$

5 ***Short Answer Questions (2 or 3 Marks)***

2. (a) Four points charges of 1 μC, –2 μC, 1 μC and –2 μC are placed at the corners A, B, C and D respectively, of a square of side 30 cm. Find the net force acting on a charge of 4μC placed at the centre of the square.

[All India 2024, Ap]

OR

(b) Three point charges, 1 pC each are kept at the vertices of an equilateral triangle of side 10 cm. Find the net electric field at the centroid of triangle.

[All India 2024, Ap]

Topic-3: ***Electric Flux, Electric Dipole, Dipole in a Uniform External Field, Continuous Charge Distribution***

5 ***Short Answer Questions (2 or 3 Marks)***

3. (a) Define the term 'electric flux' and write its dimensions. **[All India 2024, K]**

(b) A plane surface, in shape of a square of side 1 cm is placed in an electric field $\vec{E} = \left(100\frac{N}{C}\right)\hat{i}$ such that the unit vector normal to the surface is given by $\hat{n} = 0.8\hat{i} + 0.6\hat{k}$. Find the electric flux through the surface. **[All India 2024, Ap]**

Topic-4: ***Gauss's Law and its Applications***

6 ***Long Answer Questions (5 Marks)***

4. (i) A thin spherical shell of radius R has a uniform surface charge density σ. Using Gauss' law, deduce an expression for electric field (i) outside and (ii) inside the shell.

[All India 2024, U]

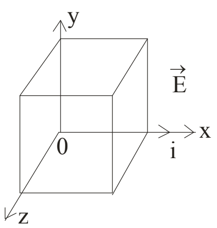
(ii) Two long straight thin wires AB and CD have linear charge densities 10 μC/m and – 20 μC/m, respectively. They are kept parallel to each other at a distance 1 m. Find magnitude and direction of the net electric field at a point midway between them.

[All India 2024, Ap]

5. (i) Using Gauss's law, show that the electric field $\vec{E}$ at a point due to a uniformly charged infinite plane sheet is given by $\vec{E} = \frac{\sigma}{2\varepsilon_0}\hat{n}$ where symbols have their usual meanings. **[Delhi 2024, U]**

(ii) Electric field $\vec{E}$ in a region is given by $\vec{E} = (5x^2 + 2)\hat{i}$ where E is in N/C and x is in meters.

A cube of side 10 cm is placed in the region as shown in figure.



Calculate (1) the electric flux through the cube, and (2) the net charge enclosed by the cube.

[Delhi 2024, A]

Chapter 2 : Electrostatic Potential and Capacitance

Topic-1: ***Electrostatic Potential, Potential due to a Point Charge, Potential due to an Electric Dipole, Potential due to a System of Charges, Equipotential Surfaces***

3 *Assertion Reason/Two Statement Type Questions (1 Mark)*

Note : For questions number 13 to 16, two statements are given – one labelled **Assertion** (A) and the other labelled **Reason** (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below:

(a) If both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
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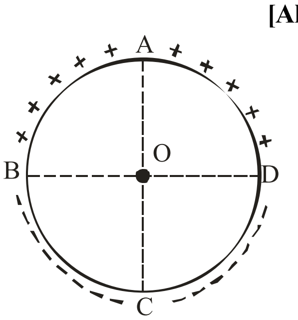
(c) If Assertion (A) is true and Reason (R) is false.
(d) If both Assertion (A) and Reason (R) are false.

6. **Assertion (A) :** Equal amount of positive and negative charges are distributed uniformly on two halves of a thin circular ring as shown in figure. The resultant electric field at the centre O of the ring is along OC.
Reason (R) : It is so because the net potential at O is not zero. **[All India 2024, K]**



Topic-2: ***Potential Energy of a System of Charges, Potential Energy in an External Field, Electrostatics of Conductors, Dielectrics and Polarisation***

1 *Multiple Choice Questions (1 Mark)*

7. An electric dipole of dipole moment $\vec{p}$ is kept in a uniform electric field $\vec{E}$. The amount of work done to rotate it from the position of stable equilibrium to that of unstable equilibrium will be **[Delhi 2024, U]**

(a) 2 pE (b) –2 pE
(c) p E (d) zero

5 *Short Answer Questions (2 or 3 Marks)*

8. Two conducting spherical shells A and B of radii R and 2R are kept far apart and charged to the same charge density σ. They are connected by a wire. Obtain an expression for final potential of shell A. **[Delhi 2024, U]**

6 *Long Answer Questions (5 Marks)*

9. (i) Draw equipotential surfaces for an electricle dipole. **[All India 2024, K]**

(ii) Two point charges q_1 and q_2 are located at $\vec{r}_1$ and $\vec{r}_2$ respectively in an external electric field $\vec{E}$. Obtain an expression for the potential energy of the system. **[All India 2024, U]**

(iii) The diple moment of a molecule is 10^{-30} Cm. It is placed in an electric field $\vec{E}$ of 10^5 V/m such that its axis is along the electric field. The direction of $\vec{E}$ is suddenly changed by 60° at an instant. Find the change in the potential energy of the dipole, at that instant. **[All India 2024, Ap]**

Topic-3: ***Capacitors and Capacitance, The Parallel Plate Capacitor, Effect of Dielectric on Capacitance, Combination of Capacitors, Energy Stored in a Capacitor***

6 *Long Answer Questions (5 Marks)*

10. (a) (i) A dielectric slab of dielectric constant 'K' and thickness 't' is inserted between plates of a parallel plate capacitor of plate separation d and plate area A. Obtain an expression for its capacitance. **[Delhi 2024, K]**

(ii) Two capacitors of different capacitances are connected first (1) in series and then (2) in parallel across a dc source of 100 V. If the total energy stored in the combination in the two cases are 40 mJ and 250 mJ respectively, find the capacitance of the capacitors. **[Delhi 2024, U]**

7 *Case Based Questions*

11. Dielectrics play an important role in design of capacitors. The molecules of a dielectric may be polar or non - polar. When a dielectronic slab is placed in an external electric field, opposite charges appear on the two surfaces of the slab perpendicular to electric field. Due to this an electric field is established inside the dielectric.

The capacitance of a capacitor is determined by the dielectric constant of the material that fills the space between the plates. Consequently, the energy storage capacity of a capacitor is also affected. Like resistors, capacitors can also be arranged in series and / or parallel. **[All India 2024, A]**

(i) Which of the following is a polar molecule?
(a) O_2 (b) H_2
(c) N_2 (d) HCl

(ii) Which of the following statements about dielectrics is correct?
(a) A polar dielectric has a net dipole moment in absence of an external electric field which gets modified due to the induced dipoles.

(b) The net dipole moments of induced is along the direction of the applied electric field.
(c) Dielectrics contain free charges.
(d) The electric field produced due to induced surface charges inside a dielectric is along the external electric field.

(iii) When a dielectric slab is inserted between the plates of an isolated charged capacitor, the energy stored in it:
(a) increases and the electric field inside it also increases.
(b) decreases and the electric field also decreases.
(c) decreases and the electric field increases.
(d) increases and the electric field decreases.

(iv) (a) An air - filled capacitor with plate area A and plate separation d has capacitance C_0. A slab of dielectric constant K, area A and thickness $\left(\frac{d}{5}\right)$ is inserted between the plates. The capacitance of the capacitor will become

(a) $\left[\frac{4K}{5K+1}\right]C_0$ (b) $\left[\frac{K+5}{4}\right]C_0$
(c) $\left[\frac{5K}{4K+1}\right]C_0$ (d) $\left[\frac{K+4}{5K}\right]C_0\frac{1}{2}$

OR

(iv) (b) Two capacitors of capacitances 2 C_0 and $6C_0$ are first connected in series and then in parallel across the same battery. The ratio of energies stored in series combination to that in parallel is

(a) $\frac{1}{4}$ (b) $\frac{1}{6}$
(c) $\frac{2}{15}$ (d) $\frac{3}{16}$

Chapter 3 : Current Electricity

Topic-1: ***Electric Current, Electric Currents in Conductors, Ohm's Law, Drift of Electrons and the Origin of Resistivity, Limitations of Ohm's Law***

3 *Assertion Reason/Two Statement Type Questions (1 Mark)*

Note : For questions number 13 to 16, two statements are given – one labelled **Assertion** (A) and the other labelled **Reason** (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below:
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(c) If Assertion (A) is true and Reason (R) is false.
(d) If both Assertion (A) and Reason (R) are false.

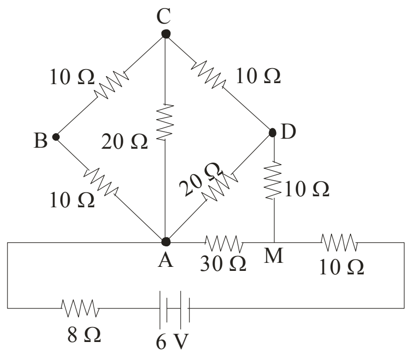
12. **Assertion (A) :** When electrons drift in a conductor, it does not mean that all free electrons in the conductor are moving in the same direction. **[Delhi 2024, U]**
Reason (R) : The drift velocity is superposed over large random velocities of electrons

Topic-2: ***Resistivity of Various Materials, Temperature Dependence of Resistivity, Electrical Energy, Power***

5 *Short Answer Questions (2 or 3 Marks)*

13. Find the temperature at which the resistance of a conductor increases by 25% of its value at 27°C. The temperature coefficient of resistance of the conductor is 2.0×10^{-4} °C^{-1}. **[Delhi 2024, Ap]**

14. In the given network, calculate:
(i) effective resistance between points A and M, and
(ii) power supplied by the battery. **[Delhi 2024, Ap]**



Topic-3: ***Cells, EMF, Internal Resistance, Cells in Series and in Parallel, Wheatstone Bridge***

1 *Multiple Choice Questions (1 Mark)*

15. A battery supplies 0.9 A current through a 2Ω resistor and 0.3 A current through a 7Ω resistor when connected one by one. The internal resistance of the battery is: **[All India 2024, K]**
(a) 2Ω (b) 1.2Ω
(c) 1 Ω (d) 0. 5Ω

Chapter 4 : Moving Charges and Magnetism

Topic-1: ***Magnetic Force, Motion in a Magnetic Field***

1 *Multiple Choice Questions (1 Mark)*

16. A particle of mass m and charge q describes a circular path of radius R in a magnetic field. It is mass and charge were 2 m and $\frac{q}{2}$ respectively, the radius of its path would be **[All India 2024, K]**

(a) $\frac{R}{4}$ (b) $\frac{R}{2}$

(c) $2R$ (d) $4R$

3 *Assertion Reason/Two Statement Type Questions (1 Mark)*

Note : For questions number 13 to 16, two statements are given – one labelled **Assertion** (A) and the other labelled **Reason** (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below:

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(b) If both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanations of Assertion (A).

(c) If Assertion (A) is true and Reason (R) is false.

(d) If both Assertion (A) and Reason (R) are false.

17. **Assertion (A) :** The energy of a charged particle moving in a magnetic field does not change.

Reason (R) : It is because the work done by the magnetic force on the charge moving in a magnetic field is zero.

[All India 2024, U]

5 *Short Answer Questions (2 or 3 Marks)*

18. Derive an expression for magnetic force $\vec{F}$ acting on a straight conductor of length L carrying I in an external magnetic field $\vec{B}$. Is it valid when the conductor is in zig - zag form? Justify. **[All India 2024, A]**

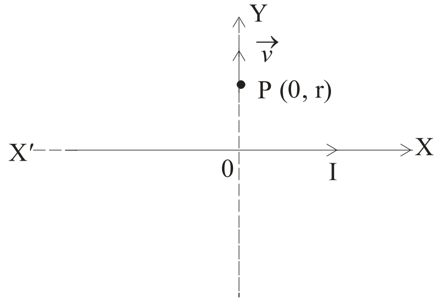
19. An electron moving with a velocity $\vec{v} = (1.0 \times 10^7 \, m/s)\hat{i} + (0.5 \times 10^7 \, m/s)\hat{j}$ enters a region of uniform magnetic field $\vec{B} = (0.5mT)\hat{j}$. Find the radius of the circular path described by it. While rotating; does the electron trace a liner part too? If so, calculate the linear distance covered by it during the period of one revolution.

[All India 2024, Ap]

Topic-2: Magnetic Field due to a Current Carrying Element, Biot-Savart's Law, Magnetic Field on the Axis of a Circular Current Loop

5 *Short Answer Questions (2 or 3 Marks)*

20. An infinite straight conductor is kept along X'X axis and carries a current I. A charge q at point P(0, r) starts moving with velocity $\vec{v} = v_0\hat{j}$ as shown in figure. Find the direction and magnitude of force initially experienced by the charge **[Delhi 2024, U]**



Topic-3: Ampere's Circuital Law, The Solenoid and the Toroid, Force between Two Parallel Currents, the Ampere

1 *Multiple Choice Questions (1 Mark)*

21. Two long straight parallel conductors A and B, kept at a distance r, carry current I in opposite directions. A third identical conductor C, kept at a distance $\left(\frac{r}{3}\right)$ from A carry current I_1 in the same direction as in A. The net magnetic force on unit length of C is **[Delhi 2024, U]**

(a) $\frac{3\mu_0 II_1}{2\pi r}$, towards A (b) $\frac{3\mu_0 II_1}{2\pi r}$, towards B

(c) $\frac{3\mu_0 II_1}{4\pi r}$, towards A (d) $\frac{3\mu_0 II_1}{4\pi r}$, towards B

5 *Short Answer Questions (2 or 3 Marks)*

22. (b) (i) State and explain Ampere's circuital law.

(ii) Two long straight parallel wires separated by 20 cm, carry 5A and 10 A current respectively, in the same direction. Find the magnitude and direction of the net magnetic field at a point midway between them.

[Delhi 2024, K + Ap]

Topic-4: Torque on Current Loop, Magnetic Dipole, The Moving Coil Galvanometer

1 *Multiple Choice Questions (1 Mark)*

23. A galvanometer of resistance 50Ω is converted into a voltmeter of range (0–2V) using a resistor of 1.0 kΩ. If it is to be converted into a voltmeter of range (0 –10 V), the resistance required will be **[All India 2024, AP]**

(a) 4.8kΩ (b) 5.0 kΩ

(c) 5.2 kΩ (d) 5.4 kΩ

24. A galvanometer of resistance 100 Ω is converted into an ammeter of range (0 – 1 A) using a resistance of 0.1 Ω. The ammeter will show full scale deflection for a current of about **[Delhi 2024, AP]**

(a) 0.1 mA (b) 1 mA
(c) 10 mA (d) 0.1 A

Chapter 5 : Magnetism and Matter

Topic-2: Magnetisation and Magnetic Intensity, Magnetic Properties of Materials

1 *Multiple Choice Questions (1 Mark)*

25. Which of the following pairs is that of paramagnetic materials? **[All India 2024, K]**

(a) Copper and Aluminium (b) Sodium and Calcium
(c) Lead and Iron (d) Nickel and Cobalt

26. The magnetic susceptibility for a diamagnetic material is **[Delhi 2024, K]**

(a) small and negative (b) small and positive
(c) large and negative (d) large and positive

5 *Short Answer Questions (2 or 3 Marks)*

27. What are ferromagnetic materials? Explain ferromagnetism with the help of suitable diagrams, using the concept of magnetic domain. **[Delhi 2024, K]**

Chapter 6 : Electromagnetic Induction

Topic-1: The Experiments of Faraday and Henry, Magnetic Flux, Faraday's Law of Induction, Lenz's Law and Conservation to Energy, Motional Electromotive Force

1 *Multiple Choice Questions (1 Mark)*

28. A coil of N turns is placed in a magnetic field $\vec{B}$ such that $\vec{B}$ is perpendicular to the plane of the coil. $\vec{B}$ changes with time as $B = B_0 \cos\left(\frac{2\pi}{T}t\right)$ where T is time period. The magnitude of emf induced in the coil will be maximum at **[Delhi 2024, Ap]**

(a) $t = \frac{nT}{8}$ (b) $t = \frac{nT}{4}$

(c) $t = \frac{nT}{2}$ (d) $t = nT$

Here, n = 1, 2, 3, 4, ...

29. A circular loop A of radius R carries a current I. Another circular loop B of radius $r\left(=\frac{R}{20}\right)$ is placed concentrically in the plane of A. The magnetic flux linked with loop B is proportional to **[Delhi 2024, Ap]**

(a) R (b) $\sqrt{R}$

(c) $R^{\frac{3}{2}}$ (d) R^2

5 *Short Answer Questions (2 or 3 Marks)*

30. (i) State Lenz's Law. In a closed circuit, the induced current opposes the change in magnetic flux that produced it as per the law of conservation of energy. Justify. **[All India 2024, K]**

(ii) A metal rod of length 2 m is rotated wit a frequency 60 rev/s about an axis passing through its centre and perpendicular to its length. A uniform magnetic field of 2T perpendicular to its plane of rotation is switched - on in the region. Calculate the e. m. f. induced between the centre and the end of the rod. **[All India 2024, Ap]**

Topic-2: Inductance, AC Generator

1 *Multiple Choice Questions (1 Mark)*

31. Two coils are placed near each other. When the current in one coil is changed at the rate of 5 A/s, an emf 2mV is induced in the other. The mutual inductance of the two coils is **[All India 2024, Ap]**

(a) 0.4 mH (b) 2.5 mH
(c) 10 mH (d) 2.5 H

5 *Short Answer Questions (2 or 3 Marks)*

32. (i) Define mutual inductance. Write its SI unit. **[Delhi 2024, K]**

(ii) Derive an expression for the mutual inductance of a system of two long coaxial solenoids of same length *l*, having turns N_1 and N_2 and of radii r_1 and r_2 ($> r_1$). **[Delhi 2024, U]**

6 *Long Answer Questions (5 Marks)*

33. (i) With the help of a diagram, briefly explain the construction and working of ac generator. **[Delhi 2024, K]**

(ii) An electron is revolving around a proton in an orbit of radius r with a speed *v*. Obtain expression for magnetic moment associated with the electron.

[Delhi 2024, U]

Chapter 7 : Alternating Current

Topic-1: *AC Voltage Applied to a Resistor, Representation of AC Current and Voltage by Rotating Vectors-Phasors*

1 *Multiple Choice Questions (1 Mark)*

34. The r. m. s. value of a current given by $i = (i_1 \cos \omega t + i_2 \sin \omega t)$ is – **[Delhi 2024, U]**

(a) $\frac{1}{\sqrt{2}}(i_1 + i_2)$ (b) $\frac{1}{\sqrt{2}}(i_1 - i_2)$

(c) $\frac{1}{\sqrt{2}}\sqrt{(i_1^2 + i_2^2)}$ (d) $\frac{1}{\sqrt{2}}(i_1^2 + i_2^2)$

Topic-2: *AC Voltage Applied to an Inductor, AC Voltage Applied to a Capacitor, AC Voltage Applied to a Series LCR Circuit, Power in AC Circuit: The Power Factor*

6 *Long Answer Questions (5 Marks)*

35. (i) You are given three circuit elements X, Y, Z. They are connected one by one across a given ac source. It is found that V and I are in phase for element X, V lead I by $\left(\frac{\pi}{4}\right)$ for element Y while I lead V by $\left(\frac{\pi}{4}\right)$ for element Z. Identify elements X, Y and Z.

(ii) Establish the expression for impedance of circuit when elements X, Y and Z are connected in series to an ac source. Show the variation of current in the circuit with the frequency of the applied ac source.

(iii) In a series LCR circuit, obtain the conditions under which (i) impedance is minimum and (ii) wattless current flows in the circuit. **[All India 2024, A + U]**

Topic-3: *Transformers*

6 *Long Answer Questions (5 Marks)*

36. (i) Describe the construction and working of a transformer and hence obtain the relation for $\left(\frac{V_s}{V_p}\right)$ in terms of number of turns of primary and secondary.

(ii) Discuss four main causes or energy loss in a real transformers. **[All India 2024, K + U]**

37. (i) Mention the factors on which the resonant frequency of a series LCR circuit depends. Plot a graph showing variation of impedance of a series LCR circuit with the frequency of the applied a. c. source.

(ii) With the help of a suitable diagram, explain the working of a step - up transformer.

(iii) Write two causes of energy loss in a real transformer.

[Delhi 2024, K]

Chapter 8 : Electromagnetic Waves

Topic-1: *Displacement Current, Electromagnetic Waves*

1 *Multiple Choice Questions (1 Mark)*

38. The phase difference between electric field $\vec{E}$ and magnetic field $\vec{B}$ in an electromagnetic wave propagating along z - axis is – **[Delhi 2024, U]**

(a) zero (b) π

(c) $\frac{\pi}{2}$ (d) $\frac{\pi}{4}$

Topic-2: *Electromagnetic Spectrum*

1 *Multiple Choice Questions (1 Mark)*

39. The electromagnetic waves used to purify water are **[All India 2024, K]**

(a) Infraded rays (b) Ultraviolet rays

(c) X - rays (d) Gamma rays

5 *Short Answer Questions (2 or 3 Marks)*

40. (a) Name the parts of the electromagnetic spectrum which are (i) also known as 'heat waves' and (ii) absorbed by ozone layer in the atmosphere.

(b) Write briefly one method each, of the production and detection of these radiations. **[All India 2024, K]**

41. Explain the following giving reasons:

(i) 'Electromagnetic waves differ considerably in their mode of interaction with matter'.

(ii) 'Food items to be heated in microwave oven must contain water'.

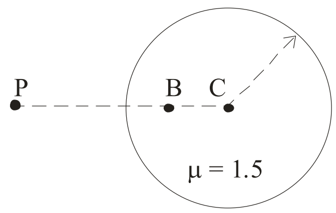
(iii) 'Welders wear face mask with glasses during welding'. **[Delhi 2024, U + A]**

Chapter 9 : Ray Optics and Optical Instruments

Topic-2: Refraction, Total Internal Reflection, Refraction at Spherical Surfaces and by Lenses

5 Short Answer Questions (2 or 3 Marks)

42. (a) An air bubble is trapped at point B(CB = 20 cm) in a glass sphere of radius 40 cm and refractive index 1.5 as shown in figure. Find the nature and position of the image of the bubble as seen by an observer at point P. **[Delhi 2024, U]**



7 Case Based Questions

43. A lens is a transparent optical medium bounded by two surfaces ; at least one of which should be spherical. Applying the formula of image formation by a single spherical suface successively at the two surfaces of a thin lens, a formula known as lens maker's formula and hence the basic lens formula can be obtained. The focal length (or power) of a lens depends on the radii of its surfaces and the refractive index of its material with respect to the surrounding medium. The refractive index of a material depends on the wavelength of light used. Combination of lenses helps us to obtain diverging or converging lenses of desired power and magnification **[Delhi 2024, A + Ap]**

(i) A thin converging lens of focal length 20 cm and a thin diverging lens of focal length 15 cm are placed coaxially in contact. The power of the combination is

(a) $\frac{-5}{6}$D (b) $\frac{-5}{3}$D

(c) $\frac{4}{3}$D (d) $\frac{3}{2}$D

(ii) The radii of curvature of two surfaces of a convex lens are R and 2R. If the focal length of this lens is $\left(\frac{4}{3}\right)R$, the refractive index of the material of the lens is:

(a) $\frac{5}{3}$ (b) $\frac{4}{3}$

(c) $\frac{3}{2}$ (d) $\frac{7}{5}$

(iii) The focal length of an equiconvex lens

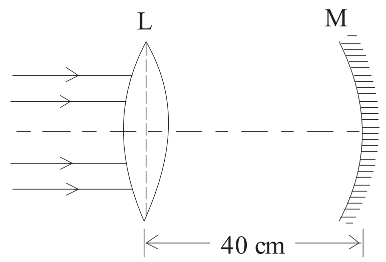
(a) increases when the lens is dipped in water.

(b) increases when the wavelength of incident light decreases.

(c) increases with decease in radius of curvature of its surface.

(d) decreases when the lens is cut into two identical parts along its principal axis.

(iv) (A) A thin convex lens L of focal length 10 cm and a concave mirror M of focal length 15 cm are placed coaxially 40 cm apart as shown in figure. A beam of light coming parallel to the principal axis is incident on the lens. The final image will be formed at a distance of



(a) 10 cm, left of lens (b) 10 cm, right of lens

(c) 20 cm, left of lens (d) 20 cm, right of lens

OR

(iv) (B) A beam of light coming parallel to the principal axis of a convex lens L_1 of focal length 16cm is incident on it. Another convex lens L_2 of focal length 12cm is placed coaxially at a distance 40 cm from L_1. The nature and distance of the final image from L_2 will be

(a) real, 24 cm (b) virtual, 12cm

(c) real, 32 cm (d) virtual, 18cm

Topic-3: Refraction through a Prism, Dispersion by a Prism

5 Short Answer Questions (2 or 3 Marks)

44. A ray of light is incident normally on one face of an equilateral glass prism of refractive index μ. When the prism is completely immersed in a transparent medium, it is observed that the emergent ray just grazes the adjacent face. Find the refractive index of the medium.

[Delhi 2024, U]

7 Case Based Questions

45. A prism is an optical medium bounded by three refracting plane surfaces. A ray of light suffers successive refractions on passing through its two surfaces and deviates by a certain angle from its original path. The refractive index of the material of the prism is given by $\nu = \dfrac{\sin\left(\dfrac{A+\delta m}{2}\right)}{\sin\dfrac{A}{2}}$.

If the angle of incidence on the second surface is greater than an angle called critical angle, the ray will not be refracted from the second surface and is totally internally reflected. **[All India 2024, A + U]**

(i) The critical angle for glass is θ_1 and that for water is θ_2. The critical angle for glass - water surface would be (given ${}_a\mu_g = 1.5$, ${}_a\mu_w = 1.33$)

(a) less than θ_2 (b) between θ_1 and θ_2

(c) greater than θ_2 (d) less than θ_1

(ii) When a ray of light of wavelength λ and frequency v is refracted into a denser medium

(a) λ and v both increase.

(b) λ increase but v is unchanged.

(c) λ decreases but v is unchanged.

(d) λ and v both decrease.

(iii) (a) The critical angle for a ray of light passing from glass to water is minimum for

(a) red colour (b) blue color

(c) yellow colour (d) violet colour

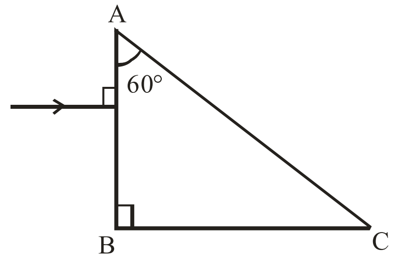
OR

(iii) (b) Three beams of red, yellow and violet colours are passed through a prism, one by one under the same condition. When the prism is in the position of minimum deviation, the angles of refraction from the second surface are r_R, r_Y and r_V respectively. Then **[All India 2024, U]**

(a) $r_V < r_Y < r_R$ (b) $r_Y < r_R < r_V$

(c) $r_R < r_Y < r_V$ (d) $r_R = r_Y = r_V$

(iv) A ray of light is incident normally on a prism ABC of refractive index $\sqrt{2}$, as shown in figure. After it strikes face AC, it will **[All India 2024, A]**



(a) go straight undeviated

(b) just graze along the face AC

(c) refract and go out of the prism

(d) undergo total internal reflection

Topic-4: Optical Instruments

1 Multiple Choice Questions (1 Mark)

46. The focal length of the objective and the eyepiece of a compound microscope are 1 cm and 2 cm respectively. If the tube length of the microscope is 10 cm, the magnification obtained by the microscope for most suitable viewing by relaxed eye is: **[All India 2024, Ap]**

(a) 250 (b) 200

(c) 150 (d) 125

5 Short Answer Questions (2 or 3 Marks)

47. A telescope has an objective lens of focal length 150 cm and an eyepiece of focal length 5 cm. Calculate its magnifying power in normal adjustment and the distance of the image formed by the objective. **[All India 2024, Ap]**

48. In normal adjustment, for a refracting telescope, the distance between objective and eye piece lens is 1.00 m. If the magnifying power of the telescope is 19, find the focal length of the objective and the eyepiece lens. **[Delhi 2024, Ap]**

6 Long Answer Questions (5 Marks)

49. (a) (i) Draw a ray diagram for the formation of the image of an object by a convex mirror. Hence, obtain the mirror equation. **[Delhi 2024, K]**

(ii) Why are multi - component lenses used for both the objective and the eyepiece in optical instruments? **[Delhi 2024, A]**

(iii) The magnification of a small object produced by a compound microscope is 200. The focal length of the eyepiece is 2 cm and the final image is formed at infinity. Find the magnification produced by the objective. **[Delhi 2024, Ap]**

Chapter 10 : Wave Optics

Topic-2: ***Coherent and Incoherent Addition of Waves, Interference of Light Waves and Young's Experiment***

1 *Multiple Choice Questions (1 Mark)*

50. A Young's double - slit experimental set up is kept in a medium of refractive index $\left(\frac{4}{3}\right)$. Which maximum in this case will coincide with the 6th maximum obtained if the medium is replaced by air? **[All India 2024, U]**

(a) 4th (b) 6th

(c) 8th (d) 10th

3 *Assertion Reason/Two Statement Type Questions (1 Mark)*

Note : For questions number 13 to 16, two statements are given – one labelled **Assertion** (A) and the other labelled **Reason** (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below:

(a) If both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

(b) If both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanations of Assertion (A).

(c) If Assertion (A) is true and Reason (R) is false.

(d) If both Assertion (A) and Reason (R) are false.

51. **Assertion (A) :** In a Young's double - slit experiment, interference pattern is not observed when two coherent sources are infinitely close to each other.

Reason (R) : The fringe width is proportional to the separation between the two sources.

[All India 2024, A]

6 *Long Answer Questions (5 Marks)*

52. (i) A plane light wave propagating from a rarer into a denser medium, is incident at an angle i on the surface separating two media. Using Huygen's principle, draw the refracted wave and hence verify Snell's law of refraction. **[All India 2024, K + U]**

(ii) In a Young's double slit experiment, the slits are separated by 0.30 mm and the screen is kept 1.5 m away. The wavelength of light used is 600 nm. Calculate the distance between the central bright fringe and the 4th dark fringe. **[All India 2024, Ap]**

53. (i) Differentiate between a wavefront and a ray.

[Delhi 2024, K]

(ii) State Hugen's principle and verify laws reflection using suitable diagram. **[Delhi 2024, K]**

(iii) In Young's double slit experiment, the slits S_1 and S_2 are 3 mm apart and the screen is placed 1.0 m away from the slits. It is observed that the fourth bright fringe is at a distance of 5 mm from the second dark fringe. Find the wavelength of light used .

[Delhi 2024, Ap]

Topic-3: ***Diffraction***

3 *Assertion Reason/Two Statement Type Questions (1 Mark)*

Note : For questions number 13 to 16, two statements are given – one labelled **Assertion** (A) and the other labelled **Reason** (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below:

(a) If both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

(b) If both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanations of Assertion (A).

(c) If Assertion (A) is true and Reason (R) is false.

(d) If both Assertion (A) and Reason (R) are false.

54. **Assertion (A):** In interference and di ffraction of light, light energy reduces in one region producing a dark fringe. It increases in another region and produces a bright fringe.

Reason (R) : This happens because energy is not conserved in the phenomena of interference and diffraction. **[Delhi 2024, U]**

6 *Long Answer Questions (5 Marks)*

55. (i) Discuss briefly diffraction of light from a single slit and draw the shape of the diffraction pattern.

[All India 2024, K]

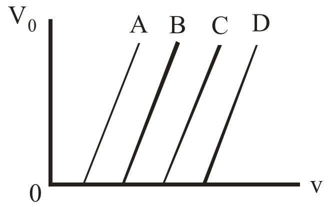
(ii) An object is placed between the pole and the focus of a concave mirror. Using mirror formula, prove mathematically that it produces a virtual and an enlarged image. **[All India 2024, U]**

Chapter 11 : Dual Nature of Radiation and Matter

Topic-1: ***Electron Emission, Photoelectric Effect, Experimental Study of Photoelectric Effect, Photoelectric Effect and Wave Theory of Light, Einstein's Photoelectric Equation: Energy Quantum of Radiation, Particle Nature of Light: The Photon***

1 *Multiple Choice Questions (1 Mark)*

56. The variation of the stopping potential (V_0) with the frequency (v) of the incident radiation for four metals A, B, C and D is shown in the figure. For the same frequency of incident radiation producing photo - electrons in all metals, the kinetic energy of photo - electrons will be maximum for metal **[All India 2024, U]**



(a) A (b) B
(c) C (d) D

57. The quantum nature of light explains the observations on photoelectric effect as – **[Delhi 2024, U]**
(a) there is a minimum frequency of incident radiation below which no electrons are emitted.
(b) the maximum kinetic energy of photoelectrons dep ends only on the frequency of incident radiation.
(c) when the metal surface is illuminated, electrons are ejected from the surface after some time.
(d) the photoelectric current is independent of the intensity of incident radiation.

3 *Assertion Reason/Two Statement Type Questions (1 Mark)*

Note : For questions number 13 to 16, two statements are given – one labelled **Assertion** (A) and the other labelled **Reason** (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below:
(a) If both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(b) If both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanations of Assertion (A).
(c) If Assertion (A) is true and Reason (R) is false.
(d) If both Assertion (A) and Reason (R) are false.

58. **Assertion (A) :** Electrons are ejected from the surface of zinc when it is irradiated by yellow light.
Reason (R) : Energy associated with a photon of yellow light is more than the work function of zinc.
[Delhi 2024, U]

5 *Short Answer Questions (2 or 3 Marks)*

59. (a) Write Einstein's photoelectric equation. How did Millikan prove the validity of this equation? **[All India 2024, K]**
(b) Explain the existence of threshold frequency of incident radiation for photoelectric emission from a given surface. **[All India 2024, U]**

Topic-2: ***Wave Nature of Matter***

5 *Short Answer Questions (2 or 3 Marks)*

60. The ratio of de Broglie wavelengths of a proton and a deuteron accelerated by potential V_p and V_d respectively, $\left(\frac{\lambda_p}{\lambda_d}\right)$ is $\frac{1}{2}$. Find $\frac{V_p}{V_d}$. **[Delhi 2024, U]**

Chapter 12 : Atoms

Topic-1: ***Alpha-particle Scattering and Rutherford's Nuclear Model of Atom, Atomic Spectra***

3 *Assertion Reason/Two Statement Type Questions (1 Mark)*

Note : For questions number 13 to 16, two statements are given – one labelled **Assertion** (A) and the other labelled **Reason** (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below:
(a) If both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(b) If both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanations of Assertion (A).
(c) If Assertion (A) is true and Reason (R) is false.
(d) If both Assertion (A) and Reason (R) are false.

61. **Assertion (A) :** An alpha particle is moving towards a gold nucleus. The impact parameter is maximum for the scattering angle of 180°.

Reason (R) : The impact parameter in an alpha particle scattering experiment does not depent upon the atomic number of the target nucleus. **[All India 2024, U]**

5 *Short Answer Questions (2 or 3 Marks)*

62. Draw the graph showing variation of scattered particles detected (N) with the scattering angle (θ) in Geiger - Marsden experiment. Write two conclusions that you can draw from this graph. Obtain the expression for the distance of closest approach in this experiment. **[Delhi 2024, U]**

Topic-2:* *Bohr Model of the Hydrogen Atom, The Line Spectra of the Hydrogen Atom and De Broglie's Explanation of Bohr's Second Postulate of Quantisation

1 *Multiple Choice Questions (1 Mark)*

63. The energy of an electron in the ground state of hydrogen atom is –13.6 eV. The kinetic and potential energy of the electron in the first excited state will be **[All India 2024, Ap]**

(a) –13.6 eV, 27.2 eV (b) – 6.8 eV, 13.6 eV
(c) 3.4 eV, –6.8 eV (d) 6.8 eV, –3.4 eV

64. In Balmar series of hydrogen atom, as the wavelength of spectral lines decreases, they appear **[Delhi 2024, U]**

(a) equally spaced and equally intense.
(b) further apart and stronger in intensity.
(c) closer together and stronger in intensity.
(d) closer together and weaker in intensity.

65. The radius (r_n) of n^{th} orbit in Bohr model of hydrogen atom varies with as **[Delhi 2024, K]**

(a) $r_n \propto n$ (b) $r_n \propto \frac{1}{n}$
(c) $r_n \propto n^2$ (d) $r_n \propto \frac{1}{n^2}$

5 *Short Answer Questions (2 or 3 Marks)*

66. (a) Two energy levels of an electron in hydrogen atom are separated by 2.55 eV. Find the wavelength of radiation emitted when the electron makes transition from the higher energy level to the lower energy level. **[All India 2024, Ap]**

(b) In which series of hydrogen spectrum this line shall fall? **[All India 2024, U]**

67. The earth revolved around the sun in an orbit of radius 1.5×10^{11} c m with orbital speed 30 km/s. Find the quantum number that characteristics its revolution using Bohr's model in this case (mass of earth = 6.0×10^{24} kg). **[All India 2024, Ap]**

Chapter 13 : Nuclei

Topic-2:* *Mass-Energy and Nuclear Binding Energy, Nuclear Force, Nuclear Energy

1 *Multiple Choice Questions (1 Mark)*

68. The potential energy between two nucleons inside a nucleus is minimum at a distance of about **[All India 2024, K]**

(a) 0.8 fm (b) 1.6 fm
(c) 2.0 fm (d) 2. 8 fm

5 *Short Answer Questions (2 or 3 Marks)*

69. (a) Differentiate between nuclear fission and fusion. **[Delhi 2024, K]**

(b) The fission properties of $_{94}Pu^{239}$ are very similar to those of $_{92}U^{235}$. How much energy (in MeV), is released if all the atoms in 1 g of pure $_{94}Pu^{239}$ undergo fission? The average energy released per fission is 180 MeV. **[Delhi 2024, Ap]**

Chapter 14 : Semiconductor Electronics: Material Devices and Simple Ciruits

Topic-2:* *Intrinsic Semiconductor, Extrinsic Semiconductor

1 *Multiple Choice Questions (1 Mark)*

70. A pure Si crystal having 5×10^{28} atoms m^{-3} is dopped with 1 ppm concentration of antimony. If the concentration of holes in the doped crystal is found to be 4.5×10^9 m^{-3}, the concentration (in m^{-3}) of intrinsic charge carriers in Si crystal is about **[All India 2024, K]**

(a) 1.2×10^{15} (b) 1.5×10^{16}
(c) 3.0×10^{15} (d) 2.0×10^{16}

3 *Assertion Reason/Two Statement Type Questions (1 Mark)*

Note : For questions number 13 to 16, two statements are given – one labelled **Assertion** (A) and the other labelled **Reason** (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below:

71. **Assertion (A) :** The temperature coefficient of resistance is positive for metals and negative for p - type semiconductors.

Reason (R) : The charge carriers in metals are negatively charged, whereas the majority charge carriers in p - type semiconductors are positively charged. **[Delhi 2024, U]**

(a) If both Assertion (A) and Reason (R) are true and Reason (R) is correct explanation of Assertion (A).

(b) If both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanation of Assertion (A).

(c) If Assertion (A) is true but Reason (R) is false.

(d) If both Assertion (A) and Reason (R) are false.

Topic-3: *p-n Junction, Semiconductor Diode, Application of Junction Diode as a Rectifier*

5 *Short Answer Questions (2 or 3 Marks)*

72. (a) Explain the characteristics of a p - n junction diode that makes it suitable for its use as a rectifier. **All India 2024, U]**

(b) With the help of a circuit diagram, explain the working of a full wave rectifier. **[All India 2024, K]**

73. Explain the following, giving reasons:

(a) A doped semiconductors is electrically neutral.

(b) In a p - n junction under equilibrium, there is no net current.

(c) In a diode, the reverse current is practically not dependent on the applied voltage.

[All India 2024, U]

74. Draw the circuit diagram of a p - n junction diode in (i) forward biasing and (ii) reverse biasing. Also draw its I - V characteristics in the two cases. **[Delhi 2024, K]**

7 *Case Based Questions*

75. A pure semiconductor like Ge or Si, when doped with a small amount of suitable impurity, becomes an extrinsic semiconductor. In thermal equilibrium, the electron and hole concentration in it are related to the concentration of intrinsic charge carriers. A p-type or n-type semiconductor can be converted into a p-n junction by doing it with suitable impurity. Two processes, diffusion and drift take place during formation of a p - n junction. A semiconductor diode is basically a p - n junction with metallic contacts provided at the ends for the application of an external voltage. A p - n junction diode allows currents to pass only in one direction when it is forward biased. Due to this property, a diode is widely used to rectify alternating voltages, in half - wave or full wave configuration.

[Delhi 2024, A + U]

(i) When Ge is doped with pentavalent impurity, the energy required to free the weakly bound electron from the dopant is about **[Delhi 2024, A]**

(a) 0.001 eV (b) 0.01 eV

(c) 0.72 eV (d) 1.1 eV

(ii) At a given temperature, the number of intrinsic charge carriers in a semiconductor is 2.0×10^{10} cm^{-3}. It is doped with pentavalent impurity atoms. As a result, the number of holes in it becomes 8×10^{3} cm^{-3}. The number of electrons in the semiconductors is

[Delhi 2024, AP]

(a) 2×10^{24} m^{-3} (b) 4×10^{23}m^{-3}

(c) 1×10^{22} m^{-3} (d) 5×10^{22}m^{-3}

(iii) (A) During the formation of a p - n junction –

[Delhi 2024, K]

(a) electrons diffuse from p - region into m - region and holes diffuse from n - region into p - region.

(b) both electrons and holes diffuse from n - region into p - region.

(c) electrons diffuse from n - region into p - region and holes diffuse from p - region into n - region.

(d) both electrons and holes diffuse from p - region into n - region.

OR

(iii) (B) Initially during the formation of a p - n junction –

[Delhi 2024, U]

(a) diffusion current is large and drift current is small.

(b) diffusion current is small and drift current is large.

(c) both the diffusion and the drift currents are large.

(d) both the diffusion and the drift current are small.

(iv) An ac voltage V = 0.5 sin (100πt) volt is applied, in turn, across a half -wave rectifier and a full - wave rectifier. The frequency of the output voltage across them respectively will be **[Delhi 2024, Ap]**

(a) 25 Hz, 50 Hz (b) 25 Hz, 100 Hz

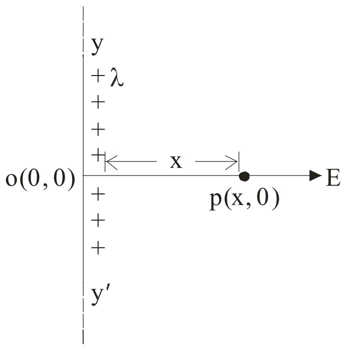
(c) 50 Hz, 50 Hz (d) 50 Hz, 100 Hz

Solutions

Chapter 1 : Electrostatic Potential and Capacitance

***Topic-2:* Coulomb's Law, Forces between Multiple Charges, Electric Field, Electric Field Lines**

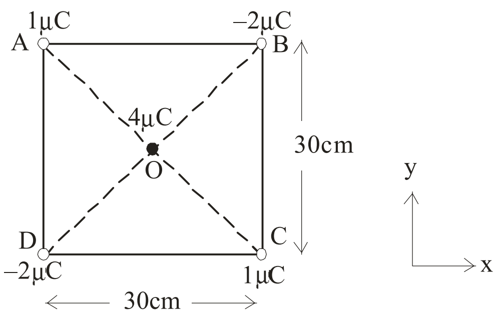
1. **(b)** The electric field at point P is $E = \dfrac{\lambda}{2\pi\varepsilon_0 x}$



$\therefore$ The force on point charge q at point P is

$F = qE = \dfrac{q\lambda}{2\pi\varepsilon_0 x}$ (repulsive) **[1 Mark]**

2. **(a)** Net force acting on charge 4 μC is given by; **[1 Mark]**



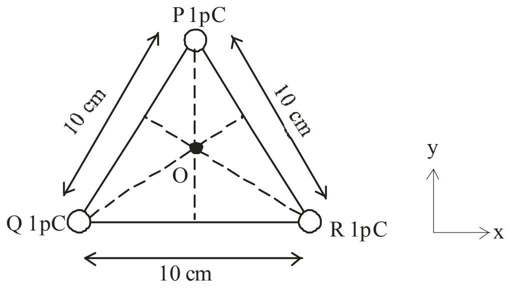
$\vec{F}_{net} = \vec{F}_{OA} + \vec{F}_{OB} + \vec{F}_{OC} + \vec{F}_{OD} =$

$$\frac{K(1\mu C)(4\mu C)}{(15cm)^2}(\hat{i}-\hat{j}) + \frac{K(-2\mu C)(4\mu C)}{(15cm)^2}(\hat{i}+\hat{j})$$

$$+\frac{K(1\mu C)(4\mu C)}{(15cm)^2}(-\hat{i}-\hat{j}) + \frac{K(-2\mu C)(4\mu C)}{(15cm)^2}(-\hat{i}-\hat{j})$$

$\Rightarrow \quad \vec{F}_{net} = 0$ **[1 Mark]**

(b) Net Electric field at point 'O' (centroid of the triangle) is given by;



[1 Mark]

$F_{net} = \vec{E}_{OP} + \vec{E}_{OQ} + \vec{E}_{OR}$

$$= \frac{K.(1pC)}{(OP)^2}(-\hat{j}) + \frac{K(1pC)}{(OQ)}\left(+\frac{\sqrt{3}}{2}\hat{i} + \frac{1}{2}\hat{j}\right) + \frac{K(1pC)}{(OR)^2}\left(\frac{\sqrt{3}}{2}\hat{i} + \frac{1}{2}\hat{j}\right)$$

where, $OP = OQ = OR = 5\sqrt{3}$cm

Hence, $\vec{E}_{net} = 0$ **[1 Mark]**

***Topic-3:* Electric Flux, Electric Dipole, Dipole in a Uniform External Field, Continuous Charge Distribution**

3. **(a)** Electric flux is defined as the number of electric field lines crossing per unit area.

Dimension of electric flux is $[ML^3 T^{-3} I^{-1}]$

[1½ Marks]

(b) $\vec{E} = 100\dfrac{N}{C}\hat{i}, \vec{S} = 1cm^2(0.8\hat{i} + 0.6\hat{k})$

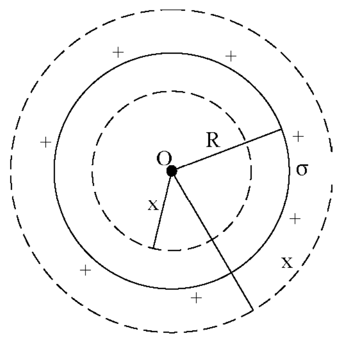
electric flux is given by;

$\phi_E = \vec{E}.\vec{S} = \left(100\dfrac{N}{C}\hat{i}\right).[1cm^2\ (0.8\ \hat{i} + 0.6\hat{k})]$

$\Rightarrow \quad \phi_E = 80\ N\ cm^2\ C^{-1}$

***Topic-4:* Gauss's Law and its Applications**

4. **(i)**



$0 < x < R$

As x lies inside the shell, the charge enclosed by the gaussian surface is zero

$q = 0$

Flux through the Gaussian surface

$\phi = E \times 4\pi x^2$

Applying Gauss's theorem,

$$\phi = \frac{q}{\varepsilon_0}$$

$E \times 4\pi x^2 = 0$

$\therefore \quad E = 0$

$x > R$

The total charge q inside the gaussian surface is the charge on the shell of radius R and area $4\pi R^2$.

$\therefore \quad q = 4\pi R^2 \sigma$

Flux through gaussian surface

$$\phi = E \times 4\pi x^2$$

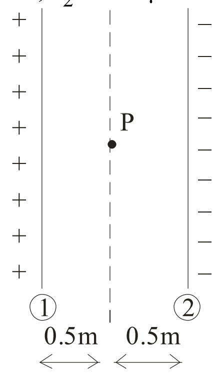
Applying gauss theorem,

$$\phi = \frac{q}{\varepsilon_0}$$

$$E \times 4\pi x^2 = \frac{4\pi R^2 \sigma}{\varepsilon_0}$$

$$E = \frac{\sigma R^2}{\varepsilon_0 x^2}$$ **[2 Marks]**

(ii) $\lambda_1 = 10\ \mu c/m,\ \lambda_2 = -20\ \mu c/m$



Electric field due to linear charge distribution is given by.

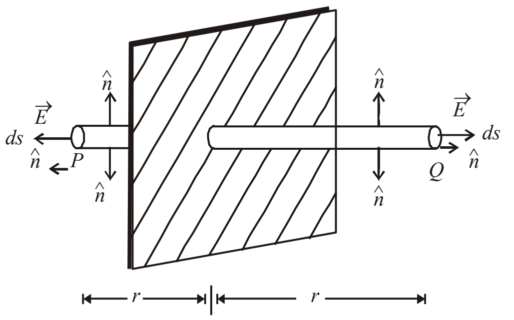
$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$ **[1 Mark]**

So, Electric field at point P is,

$$E_{net} = \frac{10 \times 10^{-6}}{2 \times 3.14 \times 8.85 \times 10^{-12} \times 0.5} + \frac{(-20) \times 10^{-6}}{2 \times 3.14 \times 8.85 \times 10^{-12} \times 0.5}$$

$E_{net} = 35.95 \times 10^{-4}$ N/C **[2 Marks]**

5. **(b)** (i) Electric fields due to a uniformly charged infinite plane sheet: Suppose a thin non-conducting infinite sheet of uniform surface, charge density σ. **[3 Marks]**



Electric field intensity $\vec{E}$ on either side of the sheet must be perpendicular to the plane of sheet having same magnitude at all points from sheets.

Let P be any point at a distance r from the sheet. Let the small area element $\vec{ds} = ds\hat{n}$.

$\vec{E}$ and $\hat{n}$ are parallel on the two cylinderical edges P and Q, which contributes electric flux.

$\therefore$ Electric flux over the edges P and Q of the cylinder is 2ϕ

$$\Rightarrow \quad 2\oint \vec{E} \cdot \vec{ds} = \frac{q}{\epsilon_0} \quad \Rightarrow \quad 2E\pi r^2 = \frac{q}{\epsilon_0}$$

$$E = \frac{q}{2\pi \epsilon_0 r^2}$$

Charge density, $\sigma = \frac{q}{s} \Rightarrow q = \pi r^2 \sigma$

[Where S – area of circle]

$$E = \frac{\pi r^2 \sigma}{2\pi \epsilon_0 r^2}$$

$$E = \frac{\sigma}{2\epsilon_0}, \text{ Vectorically } \vec{E} = \frac{\sigma}{2\epsilon_0}\hat{n}$$

where $\hat{n}$ is a unit vector normal to the plane and going away from it.

When $\sigma > 0$, E is directed away from both sides. Hence electric field intensity is independent of r.

The direction of an electric field for positive charge density is in outward direction and perpendicular to the plane infinite sheet. And for the negative charge density the direction of the field is in inward direction and perpendicular to the sheet.

(ii) $\vec{E} = (5x^2 + 2)\hat{i}$

(1) The net electric flux through the cube is

$\phi = \phi_1 + \phi_2$

$= -(5 \times 0 + 2)\ \hat{i} \cdot (100 \times 10^{-4})\ \hat{i} + (5 \times 100 \times 10^{-4} + 2)\ \hat{i} \cdot (100 \times 10^{-4})\ \hat{i}$

$= -200 \times 10^{-4} + 5 \times 10^4 \times 10^{-8} + 200 \times 10^{-4}$

$= 5 \times 10^{-4}\ \text{Nm}^2\ \text{C}^{-1}$

(2) By Gauss' theorem,

$$\phi = \frac{q_{in}}{\varepsilon_o} \Rightarrow q_{in} = \phi\varepsilon_o$$

$= 5 \times 10^{-4} \times 8.85 \times 10^{-12}$

$= 44.25 \times 10^{-14}$ C **[2 Marks]**

Chapter 2 : Electrostatic Potential and Capacitance

***Topic-1:* Electrostatic Potential, Potential due to a Point Charge, Potential due to an Electric Dipole, Potential due to a System of Charges, Equipotential Surfaces**

6. **(c)** The net electric field at O is along OC.
The net potential at O is zero **[1 Mark]**

7. **(a)** The amount of work done to rotate an electric dipole from angle θ_1 to θ_2 is

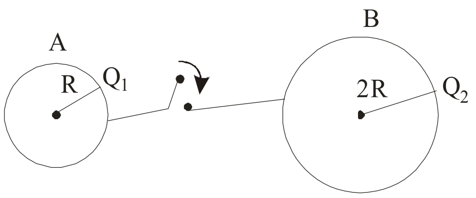
$W = pE(\cos\theta_1 - \cos\theta_2)$

For stable equilibrium, $\theta_1 = 0°$

For unstable equilibrium, $\theta_2 = 180°$

$\therefore$ W = pE (cos 0° – cos 180°) = pE [1–(–1)] = 2 pE **[1 Mark]**

8.



$\sigma_1 = \sigma_2$

$$\Rightarrow \frac{Q_1}{4\pi R^2} = \frac{Q_2}{4\pi(2R)^2} \Rightarrow Q_2 = 4Q_1$$

After connecting wire, $V_1 = V_2$

$$\frac{kQ_1'}{R} = \frac{k(5Q_1 - Q_1')}{2R}$$

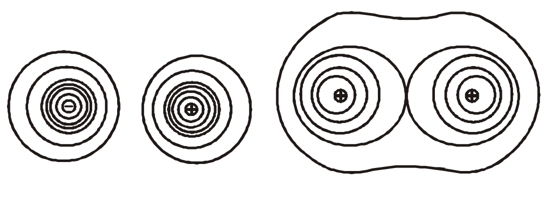
$$\therefore \; Q_1' = \frac{5Q_1}{3}$$ **[2 Marks]**

$\therefore$ Common potential, $V = \frac{kQ_1'}{R} + \frac{k(5Q_1 - Q_1')}{2R}$

$= 0$ **[1 Marks]**

***Topic-2:* Potential Energy of a System of Charges, Potential Energy in an External Field, Electrostatics of Conductors, Dielectrics and Polarisation**

9. (i)



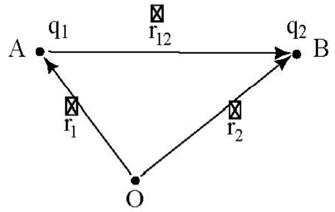
(a) (b)

Figure: Some equipotential surfaces for (a) a dipole, (b) two identical positive charges.

Here, A = 6 × 10^{-3} m^2, d = 3mm = 3 × 10^{-3}m **[1 Mark]**

(ii) – Work done to bring q_1 from ∞ in external electric field $\vec{E}$

$w_1 = q_1 V(\vec{r}_1)$



Work done to bring q_2 in external electric field and of field of q_2

$$w_2 = q_2 V(\vec{r}_2) + \frac{Kq_1q_2}{r_{12}}$$

Potential energy of system

$U = w_1 + w_2$

$$= q_1V(\vec{r}_1) + q_2V(\vec{r}_2) + \frac{Kq_1q_2}{r_{12}}$$ **[2 Marks]**

(iii) – p = 10^{-30}cm, E = 10^5c/m, θ_1 = o°, θ_2 = 60° **[2 Marks]**

$U_1 = pE\cos\theta_1$

$U_2 = pE\cos\theta_2$

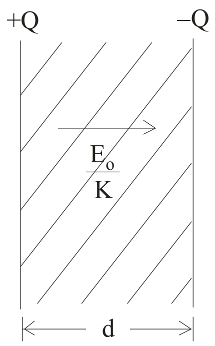
$$\Delta U = U_2 - U_1 = pE[\cos\theta_2 - \cos\theta_1] = 10^{-30} \times 10^5 \left[\frac{1}{2} - 1\right]$$

$= 0.5 \times 10^{-25}$J

***Topic-3:* Capacitors Capacitance, The Parallel Plate Capacitor, Effect of Dielectric on Capacitance, Combination of Capacitors, Energy Stored in a Capacitor**

10. **(a)** (i) The electric field inside the plates of capacitors is

$$E = \frac{E_o}{K} = \frac{1}{K}\left(\frac{Q}{A\varepsilon_0}\right)$$



$\therefore$ Potential difference,

$$V = Ed = \left(\frac{Q}{KA\varepsilon_0}\right)d$$

$\therefore$ Capacitance of parallel plate capacitor is

$$C = \frac{Q}{V} = \frac{Q}{\left(\frac{Qd}{KA\varepsilon_0}\right)} = \frac{KA\varepsilon_0}{d}$$ **[2 Marks]**

(ii) For series combination of capacitors

$$U = \frac{1}{2}C_{eq}V^2$$

$$\Rightarrow \quad 0.04 = \frac{1}{2}\left(\frac{C_1C_2}{C_1+C_2}\right)(100)^2 \quad \text{...... (i)}$$

For parallel combination of capacitors,

$$0.25 = \frac{1}{2}(C_1+C_2)(100)^2$$

$\Rightarrow \quad (C_1+C_2) = 0.5 \times 10^{-4}$ .... (ii)

From eq (i), we get

$C_1 C_2 = 0.04 \times 10^{-8}$

Now, $(C_1 - C_2)^2 = (C_1+C_2)^2 - 4C_1 C_2$

$= (0.5 \times 10^{-4})^2 - 4 \times 0.04 \times 10^{-8}$

$\therefore \quad (C_1 - C_2) = (0.3 \times 10^{-4}$ .... (iii)

From eq (i) and (iii), we get

$C_1 = 0.4 \times 10^{-4} = 40\ \mu F$

$C_2 = 10\ \mu F$ **[3 Marks]**

11. (i) (d) (ii) (b)

(iii) (b) For isolated capacitor, Q = constant

$$E' = \frac{E}{K},\ U = \frac{Q^2}{2C'} = \frac{Q^2}{2KC}$$

$\therefore$ Electric field as well as energy stored in capacitor decreases.

(iv) (c) $C_o = \frac{\varepsilon_0 A}{d},\ t = \frac{d}{5}$

$$C' = \frac{\varepsilon_0 A}{d - t + \frac{t}{k}} = \frac{\varepsilon_0 A}{d - \frac{d}{5} + \frac{d}{5k}} = \frac{\varepsilon_0 A}{\frac{4d}{5} + \frac{d}{5k}}$$

$$= \frac{\varepsilon_0 A(5k)}{d(4k+1)} = \left(\frac{5k}{4k+1}\right)C_o$$

OR

(iv) (d) $C_1 = \frac{(2C_o)(6C_o)}{2C_o + 6C_o} = \frac{12C_o^2}{8C_o} = \frac{3}{2}C_o$

$C_2 = 2C_o + 6C_o = 8C_o$

$$\therefore \quad \frac{U_1}{U_2} = \frac{\frac{1}{2}C_1V^2}{\frac{1}{2}C_2V^2} = \frac{C_1}{C_2} = \frac{3}{16}$$ **[1 × 4 = 4 Marks]**

Chapter 3 : Current Electricity

Topic-1: ***Electric Current, Electric Currents in Conductors, Ohm's Law, Drift of Electrons and the Origin of Resistivity, Limitations of Ohm's Law***

12. **(a)** The drift velocity of electrons in a conductor is average velocity of large radom velocities of electrons and drifting of electron doesn't mean that they are moving in same directions **[1 Mark]**

Topic-2: ***Resistivity of Various Materials, Temperature Dependence of Resistivity, Electrical Energy, Power***

13. $T_1 = 27°C, R_2 = 1.25\,R_1,\ \alpha = 2.0 \times 10^{-4}\ °C^{-1}$

For conductor, $R_2 = R_1\,(1 + \alpha\,\Delta T)$

$\Rightarrow \quad 1.25\,R_1 = R_1\,(1 + 2 \times 10^{-4} \times \Delta T)$

$$\Rightarrow \quad \Delta T = \frac{0.25}{2 \times 10^{-4}} = 1250$$

$\Rightarrow \quad T_2 - T_1 = 1250$

$\Rightarrow \quad T_2 = 1250 + T_1 = 1250 + 27 = 1277°C$ **[2 Marks]**

14. (i) The effective resistance between points A and M is given by

$$R_{AC} = \frac{20 \times 20}{20 + 20} = 10\Omega$$

$$R_{AD} = \frac{20 \times 20}{20 + 20} = 10\Omega$$

$$R_{AM} = \frac{20 \times 30}{20 + 30} = 12\Omega$$ **[1½ Marks]**

(ii) Power supplied by the battery is given by

$$P = \frac{V^2}{R_{net}} = \frac{6 \times 6}{12 + 10 + 8} = 1.2\ W$$ **[1½ Marks]**

Topic-3: ***Cells, EMF, Internal Resistance, Cells in Series and in Parallel, Kirchhoff's Rules, Wheatstone Bridge***

15. **(d)** In first case, $I_1 = \frac{E}{R_1 + r} \Rightarrow 0.9 = \frac{E}{2 + r}$ .... (i)

In second case, $I_2 = \frac{E}{R_2 + r} \Rightarrow 0.3 = \frac{E}{7 + r}$ .... (ii)

Dividing eq (i) by eq (ii), we get

$$3 = \frac{7 + r}{2 + r} \Rightarrow r = 0.5\Omega$$ **[1 Mark]**

Chapter 4 : Moving Charges and Magnetism

Topic-1: Magnetic Force and Motion in a Magnetic Field

16. **(d)** The radius of circular path in magnetic field is

$$r = \frac{mv}{Bq} \Rightarrow r \propto \frac{m}{q}$$

$$\therefore \quad \frac{r_2}{r_1} = \left(\frac{m_2}{m_1}\right)\left(\frac{q_1}{q_2}\right)$$

$$\Rightarrow \quad \frac{r_2}{R} = \left(\frac{2m}{m}\right)\left(\frac{q_1}{q/2}\right) = 4$$

$$\therefore \quad r_2 = 4R$$

[1 Mark]

17. **(a)** The energy of charged particle moving in a magnetic field does not change, because no work is done by magnetic force on the charged particle. **[1 Mark]**

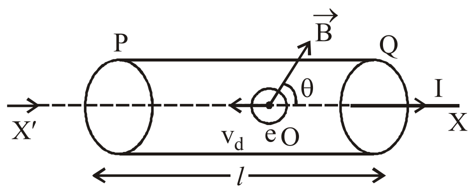
18. Let PQ be a conductor of length ℓ.

I be the current through the conductor.

$\vec{B}$ is the magnetic field intensity. $\vec{v_d}$ is the drift speed of electrons. θ is the angle between $\vec{B}$ and I.

n be the no. of electrons per unit volume of the conductor.

A is the cross-sectional area of the conductor.



Total no. of free electrons in the conductor $N = nA\ell$

Magnetic Lorentz force on each electron $\vec{f} = -e\left(\vec{v_d} \times \vec{B}\right)$

$\therefore$ Total force of all free electrons

$$\vec{F} = N\vec{f} = -nA\ell e\left(\vec{v_d} \times \vec{B}\right)$$

But $I = nAev_d$

$$\therefore \quad I\ell = nA\ell ev_d$$

$I\vec{\ell}$ is called current element vector and is opposite to $\vec{v_d}$

$$\therefore \quad I\vec{\ell} = -nA\ell e\vec{v_d}$$

$$\therefore \quad \vec{F} = I\vec{\ell} \times \vec{B}$$

$$\therefore \quad |\vec{F}| = I|\vec{\ell} \times \vec{B}| \Rightarrow F = I\ell B \sin\theta$$

Yes it is valid for the conductor in zig-zag form also but we have to take effective length in place of actual length

$$\therefore \quad F = I\left(\vec{l}_{eff} \times \vec{B}\right)$$ **[1 Mark]**

19. $\vec{v} = (1.0 \times 10^7 \text{ m/s})\,\hat{i} + (0.5 \times 10^7 \text{ m/s})\,\hat{j}$, $\vec{B} = 0.5 \text{ mT } \hat{j}$

$q = -1.6 \times 10^{-19}$ J, $m_e = 9.1 \times 10^{-31}$ kg

$$F = \left|q\left(\vec{V} \times \vec{B}\right)\right| = 1.6 \times 10^{-19} \times 0.5 \times 10^4 \text{ N} = 8.0\ 10^{-9} \text{ N}$$

[1 Mark]

$$\text{also, } F = \frac{mv^2}{r}, \text{ So, } r = \frac{mv^2}{F} = \frac{9.1 \times 10^{-31} \times 1.25 \times 10^{14}}{8.0 \times 10^{-9}}$$

$\Rightarrow \quad r = 1.42 \times 10^{-8}$m **[1 Mark]**

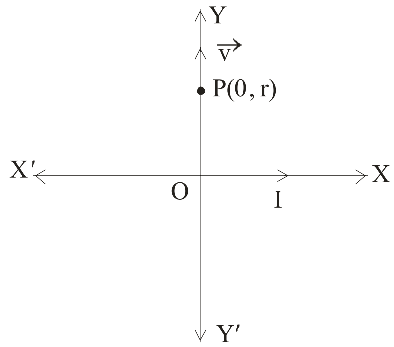
Pitch of the hellical path is given by;

$$p = \left(V_{parellel}\right)\left(\frac{2\pi m}{qB}\right) = \frac{0.5 \times 10^7 \times 2 \times 3.14 \times 9.1 \times 10^{-31}}{1.6 \times 10^{-19} \times 0.5 \times 10^{-3}}$$

$p = 0.36$m **[1 Mark]**

Topic-2: Magnetic Field due to a Current Carrying Element, Biot-Savart's Law, Magnetic Field on the Axis of a Circular Current Loop

20. The magnetic field at point P(0, r) due to current I is



$$\vec{B} = \frac{\mu_o I}{2\pi r}(-\hat{k})$$

$$\vec{v} = v_o\hat{j}$$

$\therefore$ The force acting on charge q is

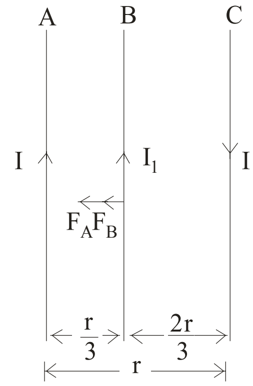
$$\vec{F} = q\left(\vec{v} \times \vec{B}\right)$$ **[1 Mark]**

$$= q\left[v_o\hat{j} \times \frac{\mu_o I}{2\pi r}(-\hat{k})\right] = \frac{q_o v_o \mu_o I}{2\pi r}(-\hat{i})$$

$\therefore$ Force, $F = \dfrac{q_o v_o \mu_o I}{2\pi r}$ along x' axis **[2 Marks]**

Topic-3: Ampere's Circuital Law, The Solenoid & the Toroid, Force between Two Parallel Currents and the Ampere

21. **(c)** The net magnetic force on unit length of C is $F_{net} = F_A + F_B$



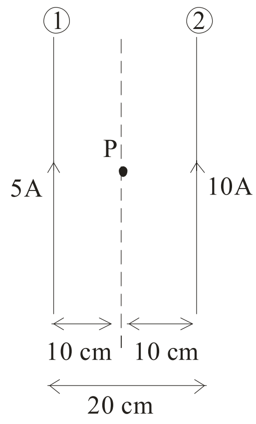
$$= \frac{\mu_0 I I_1}{2\pi\left(\frac{2r}{3}\right)} + \frac{\mu_0 I I_1}{2\pi\left(\frac{r}{3}\right)}$$ **[1 Mark]**

$$= \frac{\mu_0 I I_1}{2\pi r}\left(\frac{3}{2}+3\right) = \frac{9\mu_0 I I_1}{4\pi r} \text{ towards A}$$

22. (b) (i) Ampere's circuital law states that the line integral of the magnetic field $\vec{B}$ around any closed circuit is equal to μ_0 times the total current I passing through this closed circuit. **[1½ Marks]**

$$\oint \vec{B}\cdot d\vec{l} = \mu_0 I]$$

(ii) Magnetic field at point P due to wire (1) is inward and due to wire (2) is outward. net magnetic field at point 'P' is given by; **[1½ Marks]**



$$B_{net} = \frac{-\mu_o I_1}{2\pi d} + \frac{\mu_o I_2}{2\pi d} \text{ (out ward)}$$

$$= \frac{-4\pi\times10^{-7}\times5}{2\pi\times0.1} + \frac{4\pi\times10^{-7}\times10}{2\pi\times0.1}$$

$B_{net} = 2\times10^{-5}$ T **[1 Mark]**

Topic-4: Torque on Current Loop, Magnetic Dipole and The Moving Coil Galvanometer

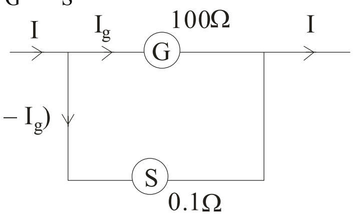
23. **(c)** $G = 50\Omega, R_1 = 1000\Omega, V_1 = 2V, V_2 = 10V$

For voltmeter,

$$\frac{V_1}{V_2} = \frac{G+R_1}{G+R_2} \Rightarrow \frac{2}{10} = \frac{50+1000}{50+R_2}$$

$\therefore \quad R_2 = 5.2\,\Omega$ **[1 Mark]**

24. **(b)** As, $V_G = V_S$



$\Rightarrow \quad I_g . G = (I - I_g)S$

$$\Rightarrow \quad I_g = \left(\frac{S}{G+S}\right)I$$

$$= \left(\frac{0.1}{100+0.1}\right)\times 1 \approx 1\text{mA}$$ **[1 Mark]**

Chapter 5 : Magnetism and Matter

Topic-2: Magnetisation & Magnetic Intensity and Magnetic Properties of Materials

25. **(b)** **[1 Mark]**

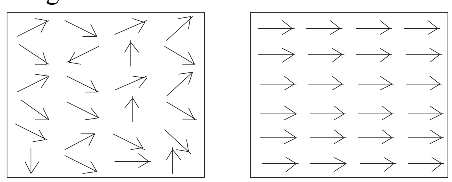
26. **(a)** For diamagnetic materials,

Magnetic susceptibility, $-1 \le \chi < 0$ **[1 Mark]**

27. **(b)** Ferromagnetic materials are those which gets strongly magnetised when placed in an external magnetic field.

The atoms in ferromagnetic material possess a dipole moment and they interact with one another such that they align themselves in a common direction over a microscopic volume called domain. In external field, the domains of ferromagnetic materials grow in size and oriented in the direction of external magnetic field. **[1½ Marks]**

The domain of ferromagnetic material in absence of magnetic field and in presence of magnetic field are shown in figure below



(Without external magnetic field) (With external magnetic field)

[1½ Marks]

Chapter 6 : Electromagnetic Induction

Topic-1: ***The Experiments of Faraday & Henry, Magnetic Flux, Faraday's Law of Induction, Lenz's Law and Motional Electromotive Force***

28. **(b)** $B = B_o \cos\left(\frac{2\pi}{T}t\right)$

The magnitude of induced emf,

$$e = \left|-N\frac{d\phi}{dt}\right| = \left|NA.\frac{dB}{dt}\right|$$

$$\left|NA\frac{d}{dt}\left(B_o\cos\left(\frac{2\pi}{T}.t\right)\right)\right|$$

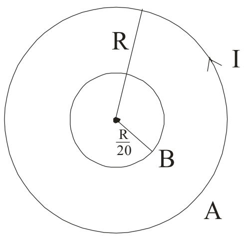
$$= \left|-N\,A\,B_o.\frac{2\pi}{T}\sin\left(\frac{2\pi}{T}.t\right)\right|$$

For e to be maximum, $\frac{2\pi}{T}t = n.\frac{\pi}{2}$, where n = 1, 3, 5

$\therefore t = \frac{nT}{4}$ **[1 Mark]**

29. **(a)** The flux linked with loop B due to loop A is

$\phi_{BA} = \vec{B}.\vec{A}$



$= \left(\frac{\mu_0 I}{2R}\right).\pi\left(\frac{R}{20}\right)^2 = \left(\frac{\mu_0 \pi I}{800}\right)R$ **[1 Mark]**

$\therefore \quad \phi_{BA} \propto R$

30. **(a)**

(i) **Lenz's law and conservation of energy:** Lenz's law is according to law of conservation of energy because when N-pole of a magnet is moved towards the coil, the upper face of the coil acquires north polarity. So work has to be done against the force of repulsion in bringing the magnet closer to the coil.

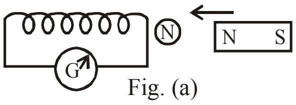


Fig. (a)

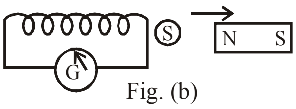


Fig. (b)

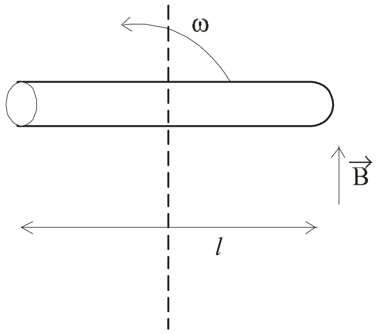
When the N-pole is moved away, south polarity is developed on the upper face of the coil. Therefore, work has to be done against the force of attraction in taking the magnet away from the coil.

$\therefore$ Mechanical work done is converted into electrical energy of the coil.

When the magnet does not move work done is zero, so no electrical energy is produced.

Lenz's law : Whenever the magnetic flux linked with a circuit changes, an induced emf is produced and the direction of the induced current is such that it opposes the cause which produces it. **[1½ Marks]**

(ii) $l = 2m$, $\omega = 60$ rev/sec, $B = 2T$ **[1½ Marks]**



induced emf is given by;

$$e = B\omega\left(\frac{l}{2}\right)^2 + B\omega\left(\frac{l}{2}\right)^2$$

$$= \frac{B\omega l^2}{2} = \frac{2\times 60\times(2)^2}{2}$$

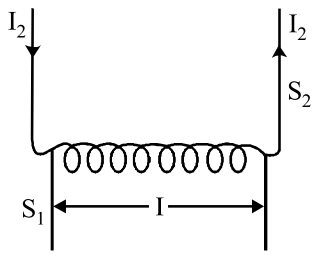
$e = 240\,V$

Topic-2: ***Inductance and AC Generator***

31. **(a)** $e = 2mV, \frac{dI}{dt} = 5A/s$

$\therefore \quad e = M.\frac{dI}{dt} \Rightarrow M = \frac{e}{dI/dt} = \frac{2}{5}$ **[1 Mark]**

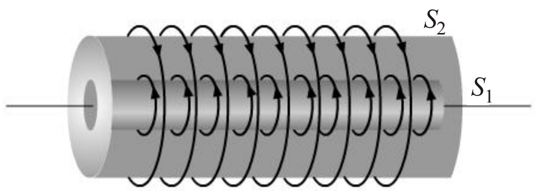
32. (i) Mutual inductance is the property of two coils by the virtue of which each opposes any change in the strength of current flowing through the other by developing an induced emf. **[1½ Mark]**



1½

(ii) Production of induced e.m.f. in a coil due to the change of current in a neighbouring coil, is called mutual induction.

[1½ Mark]



Suppose a current i is passed through the inner solenoid S_1.
A magnetic field $B = \mu_0 n_1 i$ is produced inside S_1, whereas the field outside it is zero.
The flux through each turn S_2 is

$$B\pi r_1^2 = \mu_0 n_1 i\pi r_1^2$$

The total flux through all the turns in a length l of S_2 is

$$\phi = (\mu_0 n_1 i\pi r_1^2) n_2 l = (\mu_0 n_1 n_2 \pi r_1^2 l) i$$

$$\Rightarrow M = \mu_0 n_1 n_2 \pi r_1^2 l$$

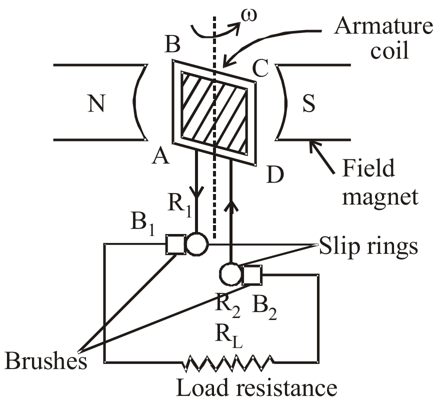
Note

Between the two solenoid if a medium of relative permeability μ_r has been present, the mutual inductance would be

$M = \mu_r v_0 n_1 n_1 \pi r_1^2 l$.

Mutual inductance of a pair of coils, solenoids etc, depends on their separation as well as relative orientation.

33. (i) **Principle:** A dynamo or an ac generator is a device which converts mechanical energy into electrical energy. It is based on the principle of electromagnetic induction.



Construction: It consists of four main parts-

(i) **Field magnet:** It produces the magnetic field. For a low power dynamo, the magnetic field in generated by a permanent magnet but for a large power dynamo, the magnetic field is produced by an electromagnet.

(ii) **Armature:** It consists of a large number of turns of insulated copper wire on a soft iron core. It can revolve round the axis between the two poles of the field magnet. The soft iron core provides support to the coils and increases the magnetic field through the coil.

(iii) **Slip rings:** The slip rings R_1 and R_2 are two metal rings to which the ends of the 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.

(iv) **Brushes (B_1 and B_2):** These are flexible metal plates or carbon rods which are fixed and constantly touch the revolving rings. The output current in external load resistance R_1 is taken through these brushes.

Working: When the armature coil is rotated in the strong magnetic field, the magnetic flux linked the coil changes and the current is induced in the coil. The direction of current is given by Flemming's left hand rule. It remains same during the first half turn of the armature. During the second half revolution, the direction of current is reversed.

If N is the number in the coil, f is the frequency of rotation, A is the area of the coil and B is the magnetic field intensity then induced emf. **[3 Marks]**

(ii) Magnetic moment is

$$m = IA$$

where I is current and A = area
When electron of charge 'e', revolve around nucleus, with time period T, then current I is

$$I = \frac{e}{T}$$

If r = orbital radius
and v = orbital speed

Then $T = \frac{\text{Distance}}{\text{speed}} = \frac{2\pi r}{v}$

$\therefore$ $I = \frac{ev}{2\pi r}$

Area of orbit $A = \pi r^2$

So magnetic moment m will be $m = \frac{ev}{2\pi r} \times \pi r^2$

as $\boxed{m = \frac{evr}{2}}$

[1½ Marks]

Chapter 7 : Alternating Current

Topic-1: ***AC Voltage Applied to a Resistor, Representation of AC Current and Voltage by Rotating Vectors-Phasors***

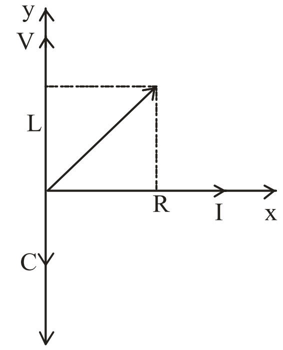
34. **(c)** The rms value of current is

$$I_{rms} = \frac{I_o}{\sqrt{2}} = \frac{1}{\sqrt{2}}\left(\sqrt{i_1^2 + i_2^2}\right)$$ **[1 Mark]**

Topic-3: *Transformers*

35. (i) Element X is resistor, element Y is a inductor and element Z is a conductance.

(ii)



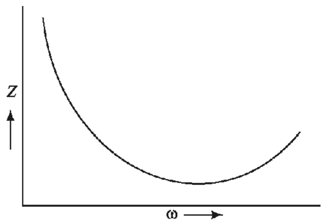
$$V^2 = V_R^2 + (V_L - V_C)^2$$

$$= R^2 I_0^2 + (X_L I_0 - X_C I_0)^2$$

$$= I_0^2 \left[R^2 + (X_L - X_C)^2 \right]$$

$\Rightarrow$ impedence $(Z) = \frac{V}{I_0} = \sqrt{R^2 + (X_L - X_C)^2}$

[1 Mark]



[1 Mark]

(iii) for impedence to be minimum,

$Z^2 = R^2 + (X_L - X_C)^2$

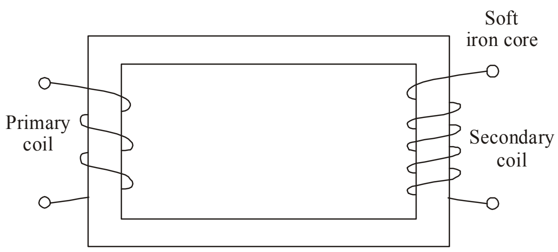
$\Rightarrow$ $Z^2 - R^2 = 0 \Rightarrow (X_L - X_C)^2$

$\Rightarrow$ $X_L = X_C$ (minimum impedence)

Condition for wattless current flow in the circuit is that the phase difference between the voltage and current should be $\frac{\pi}{2}$. **[2 Marks]**

i.e., circuit should be purely inductive or purely conductive. **[1 Mark]**

36. (i)



Consider the situation, input emf is ε_p (emf in primary). This incuced emf is]

$$\varepsilon_p = -NP \frac{d\phi}{dt}$$

where ϕ = magnetic flux linked with each turn of the primary or secondary coil.

emf induced in secondary coil, ε_s is

$$\varepsilon_s = -N_S \frac{d\phi}{dt}$$

Here N_S and N_P = no. of turns in secondary and primary coil respectively.

$$\therefore \quad \frac{\varepsilon_S}{\varepsilon_p} = \frac{N_S}{N_p} \qquad ...(1)$$

Assuming transformer to be ideal one so that there is no energy losses, then

Input power = Output power

$$\varepsilon_P I_P = \varepsilon_S I_S$$

$$\frac{\varepsilon_S}{\varepsilon_p} = \frac{I_p}{I_S} \qquad ...(2)$$

[3 Marks]

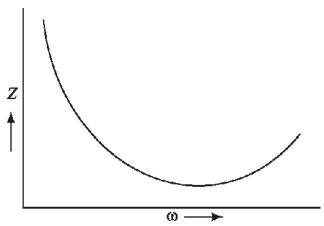
(ii) Causes of energy loss in transformer :-

- Copper loss - It occurs in the form of heat energy lost due to the resistance of the copper coils used in the winding of a transformer. **[½ Mark]**
- Hysteresis loss - loss of energy due to continuous magnetization and demagnetization of the transformer **[½ Mark]**
- Flux Loss – It occurs when coupling of the primary and secondary coil is not good. **[½ Mark]**
- Eddy current coss - Energy loss in the metallic plate when kept in time varying magnetic field. **[½ Mark]**

37. (i) The resonant frequency of a series LCR circuit depends on following factors:

(1) The self inductance of the coil.

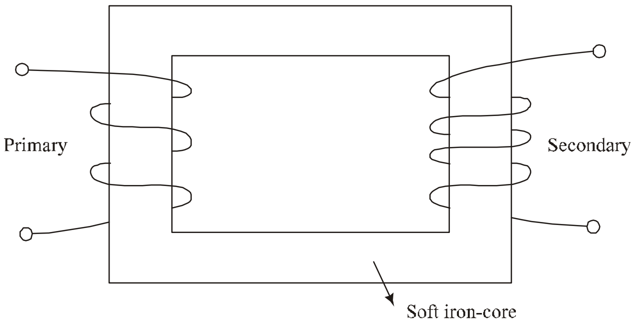
(2) The capacitance of the capacitor.



[2 Marks]

(ii) **7.** *Working of a step-up transformer:*

As the alternating current flows through the primary, it generates an alternating magnetic flux in the core which also passes through the secondary. This changing flux sets up an induced emf in the secondary, also a self-induced emf in the primary. If there is no leakage of magnetic flux, then flux linked with each turn of the primary will be equal to that linked with each turn of the secondary.



STEP-UP TRANSFORMER

[2 Marks]

(iii) The following two causes of energy loss in transformer are given below:

(1) Flux leakage

(2) Eddy current **[1 Mark]**

Chapter 8 : Electromagnetic Waves

Topic-1: Displacement Current & Electromagnetic Waves

38. **(a)** The electric field and magnetic field of electromagnetic wave become peak and zero at same time, but they propagate in different direction.

$\therefore$ Phase difference = 0 **[1 Mark]**

Topic-2: Electromagnetic Spectrum

39. **(b)** **[1 Mark]**

40. **(a)** (i) – Infrared waves **[1 Mark]**

(ii) – Ultravoilet waves

(b) Infrared waves are produced by hot bodies and molecules. Ultravoilet waves are produced by heating a body to incandescent temperature. Sunlight is also a major source of ultravoilet waves. **[2 Marks]**

41. (i) As, the wavelength of matter waves have smaller than electromagnetic wave. So, electromagnetic waves differ in their mode of interaction with matter.

(ii) The natural frequency of water molecules in food matches with microwave

frequency which causes resonance, due to which temperature of food items increases rapidly.

(iii) Welders wear face mask with glasses during welding to protect their eyes from ultraviolet rays (UV rays), which is harmful for their eyes. **[3 Marks]**

Chapter 9 : Ray Optics and Optical Instruments

Topic-2: Refraction, Total Internal Reflection, Refraction at Spherical Surfaces and by Lenses

42. **(a)** $u = -20\text{cm}, R = -40\text{cm}$

$\mu_1 = 1.5, \mu_2 = 1$

From refraction through curved surface,

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$ **[1 Mark]**

$$\Rightarrow \frac{1}{v} - \frac{1.5}{-20} = \frac{1-1.5}{-40}$$

$\therefore$ $v = -16\text{cm}$

Hence, the observer P see the virtual image of B at a distance 16cm right to the curve surface. **[1 Mark]**

43. (i) (b) $f_1 = 20\text{cm}, f_2 = -15$ cm

The focal length of combination of lens is

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{20} + \frac{1}{-15} = \frac{-1}{60}$$

$\therefore$ $f = -60\text{cm}$

$$\therefore \text{ Power, } P = \frac{100}{f(\text{in cm})} = \frac{100}{-60} = -\frac{5}{3}D$$

(ii) (c) $R_1 = R,\ R_2 = -2R,\ f = \frac{4R}{3}$

$\therefore$ By lens maker's formula,

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = (\mu - 1)\left(\frac{1}{R} - \frac{1}{-2R}\right)$$

$$\Rightarrow \frac{3}{4R} = (\mu - 1)\frac{3}{2R} \Rightarrow \mu = \frac{3}{2}$$

(iii) (a) The focal length of equiconvex lens is

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R} - \frac{1}{-R}\right) = \frac{2(\mu - 1)}{R}$$

$$\therefore f = \frac{R}{2(\mu - 1)}$$

If the lens is dipped in water, then μ decreases $\Rightarrow$ f increases.

(iv) (A) (b) For lens,

$$\frac{1}{v_1} - \frac{1}{u_1} = \frac{1}{f_1} \Rightarrow \frac{1}{v_1} - \frac{1}{-\infty} = \frac{1}{10} \Rightarrow v_1 = 10\text{cm}$$

for mirror, $$\frac{1}{v_2} + \frac{1}{u_2} = \frac{1}{f_2} \Rightarrow \frac{1}{v_2} + \frac{1}{-30} = \frac{1}{-15}$$

$\therefore$ $v_2 = -30\text{cm}$

$\therefore$ Final image is formed at 10cm of right of lens.

OR

(iv). (B) (a) For lens L_1, $u_1 = -\infty$, $f_1 = 16$ cm

$\therefore$ By lens formula,

$$\frac{1}{v_1} - \frac{1}{u_1} = \frac{1}{f_1} \Rightarrow \frac{1}{v_1} - \frac{1}{-\infty} = \frac{1}{16}$$

$\therefore$ $v_1 = 16$ cm

For lens L_2, $u_2 = -(40-16) = -24$ cm

$f_2 = 12$ cm

∴ By lens formula,

$$\frac{1}{v_2}-\frac{1}{u_2}=\frac{1}{f_2} \Rightarrow \frac{1}{v_2}-\frac{1}{-24}=\frac{1}{12}$$

∴ $v_2 = 24$ cm

Hence final image is formed at a distance 24 cm right of the lens L_2. **[4 Marks]**

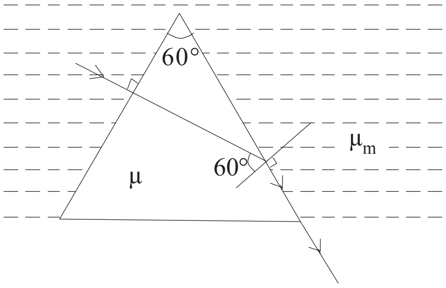
Topic-3: Refraction through a Prism & Dispersion by a Prism

44. For prism,

$r_1 + r_2 = A$

$\Rightarrow$ $0 + r_2 = 60°$

∴ $r_2 = 60°$



By Snell's law

$\mu \sin 60° = \mu_m \sin 90°$

∴ $\mu_m = \frac{\sqrt{3}\mu}{2}$ **[2 Marks]**

45. (i) (c) Critical angle, $\sin\theta = \frac{\mu_r}{\mu_d}$

For glass, $\sin\theta_1 = \frac{1}{1.5} \Rightarrow \theta_1 = \sin^{-1}\left(\frac{2}{3}\right)$

For water, $\sin\theta_2 = \frac{1}{1.33} \Rightarrow \theta_2 = \sin^{-1}\left(\frac{3}{4}\right)$

∴ For glass - water surface

$$\sin\theta_3 = \frac{\mu_w}{\mu_g} = \frac{1.33}{1.5} = \frac{4\times 2}{3\times 3} = \frac{8}{9}$$

∴ $\theta_3 = \sin^{-1}\left(\frac{8}{9}\right)$

∴ $\theta_3 > \theta_2 > \theta_1$

(ii) (c) When ray of light passes from rarer to denser medium, then

Frequency, ν = constant

Wavelength, $\lambda' = \frac{\lambda}{\mu}$

(iii) (d) Critical angle for glass- water surface,

$$\sin\theta = \frac{\mu_w}{\mu_g} = \frac{1}{{}_w\mu_g}$$

Also, ${}_w\mu_g \propto \frac{1}{\lambda}$

$\Rightarrow$ $\theta \propto \lambda$

As $\lambda_R > \lambda_Y > \lambda_B > \lambda_V$

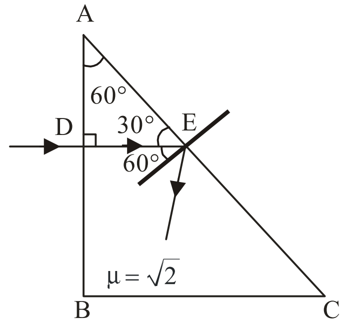
$\Rightarrow$ $\theta_R > \theta_Y > \theta_B > \theta_V$

OR

(iii) (c) The angle of refraction from second surface of prism is the angle of emergence.

∴ $r_V > r_Y > r_R$

(iv) (d) Critical angle at E,



$\sin\theta_C = \frac{1}{\sqrt{2}} = \sin 45°$ ∴ $\theta_C = 45°$

At the surface AC, $i = 60°$

∴ $i > \theta_C$

So, the ray of light undergo total internal reflection after it strikes face AC. **[1 × 4 = 4 Marks]**

Topic-4: Optical Instruments

46. **(d)** For compound microscope,

$f_0 = 1$ cm, $f_e = 2$cm, $L = 10$cm

For eye, image is formed at infinity

$$m = \frac{L}{f_0}\left(\frac{D}{fe}\right) = \left(\frac{10}{1}\right)\left(\frac{25}{2}\right) = 125$$ **[1 Mark]**

47. For telescope,

$f_0 = 150$ cm, $f_e = 5$cm

For normal adjustment, final image is formed at infinity

∴ $m = \frac{f_0}{f_e} = \frac{150}{5} = 30$ **[1 Mark]**

For objective lens,

$u_o = \infty$, $f_o = 150$ cm

∴ By lens formula,

$$\frac{1}{v_o}-\frac{1}{u_o}=\frac{1}{f_o} \Rightarrow \frac{1}{v_o}-\frac{1}{-\infty}=\frac{1}{150}$$

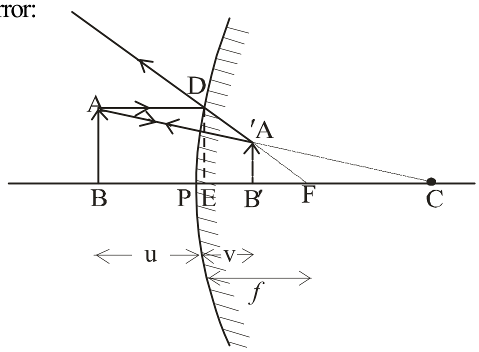
∴ $v_o = 150$ cm **[1 Mark]**

48. **(b)** In telescope, for normal adjustment,

$L = f_o + f_e = 100$ and $m = \frac{f_o}{f_e} = 19$

By solving, $f_o = 95$ cm, $f_e = 5$cm **[2 Marks]**

49. (a) (i) The ray diagram for image formation by a convex mirror:



$\Delta ABC \sim \Delta A'B'C$

$$\frac{AB}{A'B'} = \frac{BC}{B'C} = \frac{BE + EC}{EC - EB'} \quad .... (i)$$

$\Delta DEF \sim \Delta A'B'F$

$$\frac{DE}{A'B'} = \frac{AB}{A'B'} = \frac{EF}{B'F} = \frac{EF}{EF - EB'} \quad .... (ii)$$

From eqs (i) and (ii), we get

$$\frac{BE + EC}{EC - EB'} = \frac{EF}{EF - EB'}$$

$$\Rightarrow \frac{-u + 2f}{2f - v} = \frac{f}{f - v}$$

$$\Rightarrow \frac{1}{f} = \frac{1}{u} + \frac{1}{v}, \text{ which is mirror formula.}$$ **[2 Marks]**

(ii) To increase magnifying power of optical instruments, we generally use multi - component lenses for both the objective and the eyepiece. **[1 Mark]**

(iii) $m = -200, f_e = 2cm$

For compound microscope, $m = m_o \times m_e$ .... (i)

When final image is formed at infinity,

$$m_e = \frac{D}{f_e} = \frac{25}{2}$$

$\therefore$ From eq (i), we get

$$-200 = m_o \times \frac{25}{2}$$

$\therefore$ $m_o = -16$ **[2 Marks]**

Chapter 10 : Wave Optics

Topic-2: Coherent and Incoherent Addition of Waves, Interference of Light Waves and Young's Experiment

50. (c) In YDSE,

In air, position of maximum, $x_n = \frac{n\lambda D}{d}$

$\therefore$ For 6[th] maximum, $x_6 = \frac{6\lambda D}{d}$ .... (i)

In medium, position of maximum, $x'_n = \frac{n\lambda D}{\mu d}$ .... (ii)

$\therefore$ From eqs (i) and (ii), we get

$x_6 = x'_n$

$$\Rightarrow \frac{6\lambda D}{d} = \frac{n\lambda D}{(4/3)d} \Rightarrow n = 8$$ **[1 Mark]**

51. (c) In YDSE, $\beta = \frac{\lambda D}{d} \Rightarrow \beta \propto \frac{1}{d}$

As, $d \to O \Rightarrow \beta \to \infty \Rightarrow$ no interference pattern is observed. **[1 Mark]**

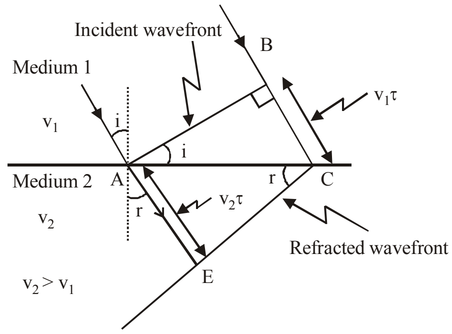
52. (i) Let v_1 and v_2 be the speed of light in medium 1 and medium 2 $v_2 < v_1$ Suppose a plane wavefront AB is incident on PP' at an angle i.

Let t be the time taken by the wavefront to travel distance BC in medium 1. Thus, $BC = v_1t$

In the same time the wavefront travels distance AE in medium 2. Thus, $AE = v_2t$ and CE would represent the refracted wavefront.

In ΔABC, $\sin i = \frac{BC}{AC} = \frac{v_1 t}{AC}$;

In ΔAEC, $\sin r = \frac{AE}{AC} = \frac{v_2 t}{AC}$



(1 Mark)

where *i* and *r* are the angle of incidence and of refraction respectively.

$$\therefore \frac{\sin i}{\sin r} = \frac{v_1}{v_2} \quad ...(i)$$

Now, $n_1 = \frac{c}{v_1}$ and $n_2 = \frac{c}{v_2}$

$$\therefore \frac{n_2}{n_1} = \frac{v_1}{v_2} \text{ or } n_{21} = \frac{v_1}{v_2} \quad ...(ii)$$

From eqs. (i) and (ii), $\frac{\sin i}{\sin r} = n_{21}$ **(2 Marks)**

This is the Snell's law of refraction.

(ii) $d = 0.3$ mm, $D = 1.5$ m, $\lambda = 600$ nm

For destructive interference

$$x_n = \left(n - \frac{1}{2}\right)\frac{\lambda D}{d}; (n = 1, 2, 3, 4)$$

for 4[th] dark fringe

$$x_4 = \left(4 - \frac{1}{2}\right)\frac{600 \times 10^{-9} \times 1.5}{0.3 \times 10^{-3}}$$

$x_4 = 4.5$ nm **[2 Marks]**

53. (i) A wavefront is defined as a surface of constant phase.

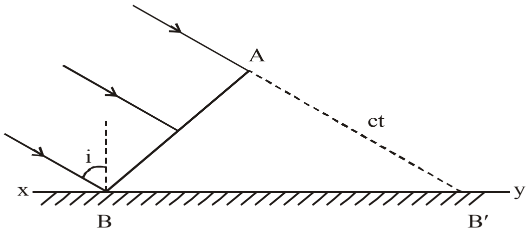
(a) The ray indicates the direction of propagation of wave while the wavefront is the surface of constant phase.

(b) The ray at each point of a wavefront is normal to the wavefront at that point. **[1 Mark]**

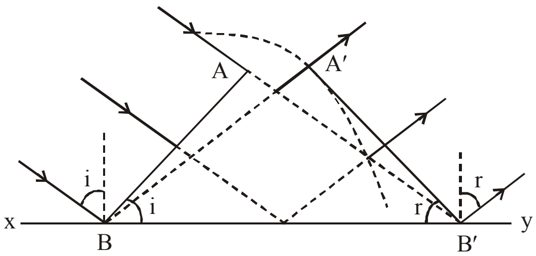
(ii) Huygen's principle states that every point on a given wavefront act as a source of secondary wavelets which travel in all direction with the velocity of light in the medium. The position of the new wavefront at any instant is a surface touching these secondary wavelets tangentially in the forward direction at that instant. **[1½ Marks]**

Laws of reflection by Huygens' principle

Let us consider a plane wavefront *AB* incident on the plane reflection surface *xy*. Incident rays are normal to the wavefront *AB*.



Let in time '*t*' the secondary wavelets reaches *B′* covering a distance *ct*. Similarly from each point on primary wavefront *AB*. Secondary wavelets start growing with the speed '*c*'. To find reflected wavefront after time '*t*', let us draw a sphere of radius '*ct*' taking '*B*' as center and now a tangent is drawn from *B′* on the sphere the tangent *B′A′* represents reflected wavefront after time t.



For every point on wavefront *AB* a corresponding point lie on the reflected wavefront *A′B′*.

So, comparing two triangle $\Delta BAB'$ and $\Delta B'A'B$ We get

$AB' = A'B = ct$

BB' = common

$\angle A = \angle A' = 90°$

Hence, two triangles are congruent, hence $\angle i = \angle r$. This proves law of reflection. Also incident ray, normal to point of incidence and reflected ray lie in same plane. This prove second law of reflection. **[2 Marks]**

(iii) In YDSE, d = 3mm, D = 1m

$x_{4,bright} = x_{2,dark} + 5 \times 10^{-3}$

$$\Rightarrow \frac{4\lambda D}{d} = \frac{3\lambda D}{2d} + 5\times10^{-3}$$

$$\Rightarrow \frac{5}{2}\cdot\frac{\lambda D}{d} = 5\times10^{-3}$$

$$\Rightarrow \frac{5\times\lambda\times1}{2\times3\times10^{-3}} = 5\times10^{-3}$$

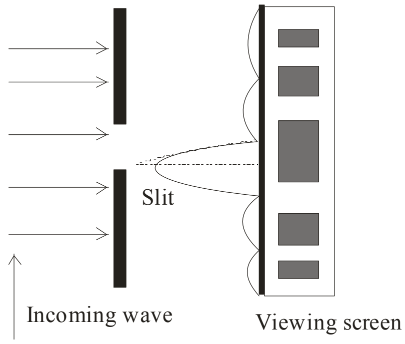
$\therefore$ $\lambda = 6000$ nm **[2 Marks]**

Topic-3: Diffraction

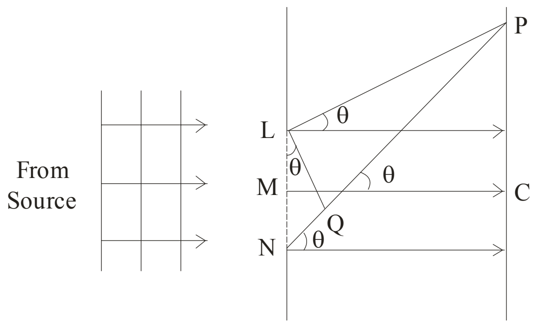
54. **(c)** In the phenomenon of interference and diffraction, the energy is conserved, but at some points bright fringes are produced, whereas at other points dark fringes are produced.

55. (i) A single narrow slit is illuminated by a monochromatic source of light. The diffraction pattern is obtained on the screen placed infront of the slits.

There is a central bright region called as central maximum. All the waves reaching this region are in phase hence the intensity is maximum. On both side of central maximum, there are alternate dark and bright regions, the intensity becoming weaker away from the centre. **[1 Mark]**



The intensity at any point P on the screen depends on the path difference between the waves arising from different parts of the wavefront at the slit.



According to the figure, the path difference (NP – LP) between the two edges of the slit can be calculated.

Path difference, NP – LP = NQ = a sin θ ≈ aθ

At the central point C on the screen, the angle θ is zero, therefore all path diffrence ar zero and hence all the parts of slit contribute in phase. Due to this, the intensity at C is maximum. The positions of other secondary maxima are obtained at, $\theta = \left(n + \frac{1}{2}\right)\frac{\lambda}{a}$, and the positions of secondary minima are obtained at $\theta = \frac{n\lambda}{a}$, where n = ± 1, ± 2, ±3, ...

The variation of intensity with angle in single slit diffraction

Central maxima: The central maxima lies between the first minima on both sides.

(ii) using mirror formula

$$\frac{1}{f}=\frac{1}{u}+\frac{1}{v}, \text{ or } \frac{1}{v}=\frac{1}{f}-\frac{1}{u}, \text{ or } v=\frac{uf}{u-f}$$ **[1 Mark]**

if object distance is 'x' and focal length is f_o, then, $u = -x$, and $f = -f_o$ (concave mirror)

$$\therefore c=\frac{xf_o}{f_o-x}$$

for an object placed between pole and focus, $x < f_o$, hence $f_o - x$ = positive.

So, v will be positive i.e., image will be formed behind the mirror (virtual).

Magnification of image is given by;

$$m=-\frac{v}{u}=\frac{-xf_o}{(f_o-x)(-x)}=\frac{f_o}{f_o-x}=\frac{f_o-x+x}{f_o-x}$$

$$m=1+\frac{x}{f_o-x}$$

Clearly, $m > 1$, hence image will be enlarged. **[1 Mark]**

Chapter 11 : Dual Nature of Radiation and Matter

Topic-1: ***Electron Emission, Photoelectric Effect, Experimental Study of Photoelectric Effect, Photoelectric Effect and Wave Theory of Light, Einstein's Photoelectric Equation: Energy Quantum of Radiation, Particle Nature of Light: The Photon***

56. (a) From Einstein photoelectric equation,

K. E = hν - ϕ

$$\Rightarrow \text{K.E} \propto \frac{1}{\text{Intercept on } V_o \text{ axis}}$$

∴ Kinetic energy of metal A is maximum. **[1 Mark]**

57. (a) There is a minimum frequency of incident radiation below which no electrons are emitted. This observation on photoelectric effect is explained by quantum nature of light. **[1 Mark]**

58. (d) As, energy of yellow light is less than work function of zinc. So, electrons are not ejected when yellow light falls on it. **[1 Mark]**

59. (a) Einstein photoelectric equation is. **[1 Mark]**

$$E=\phi_o+KE \text{ or } h\nu=h\nu_o+\frac{1}{2}mV^2$$

Millikan Constructed cascade of experiments and obtained slope of the V_o vs ν graph. Using the slope of graph and charge of electron, he calculated a value which exactly matches with Plack's constant. Millikan repeated this experiment on number of alkali metals over a large range of incident radiation and found the same result and hence verified photoelectric equation with great precision.

(b) At the thresold frequency (ν_o), electrons are just ejected and do not have any kinetic energy. Below this frequency there is no electron emission. Thus energy of the photon with this frequency must be work function of metal. **[1 Mark]**

Topic-2: ***Wave Nature of Matter***

60. The de-Broglie wavelength is

$$\lambda=\frac{h}{\sqrt{2mqV}} \Rightarrow \lambda \propto \frac{1}{\sqrt{mqV}}$$ **[1 Mark]**

∴ For proton and deuteron,

$$\frac{\lambda_p}{\lambda_d}=\sqrt{\frac{m_d q_d V_d}{m_p q_p V_p}}=\sqrt{\frac{2m_p.q_p.V_d}{m_p.q_p.V_p}}=\frac{1}{2}$$

$$\therefore \frac{V_p}{V_d}=8$$ **[1 Mark]**

Chapter 12 : Atoms

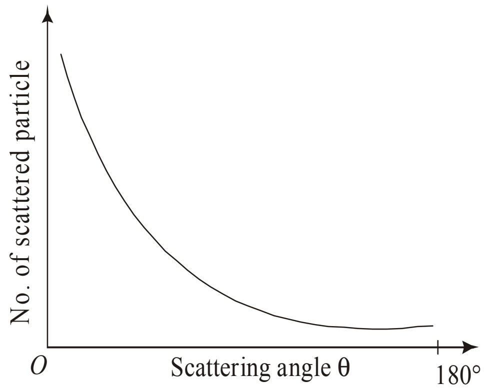
Topic-1: ***Alpha-particle Scattering & Rutherford's Nuclear Model of Atom and Atomic Spectra***

61. (d) The impact parameter is

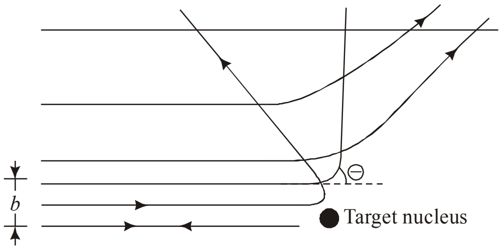
$$b=\frac{Ze^2\cot\left(\frac{\theta}{2}\right)}{4\pi\varepsilon_0 E} \Rightarrow b \propto Z$$

Also, at $\theta = 180° \Rightarrow b = 0$ **[1 Mark]**

62.



From the graph, it is conclude that only a small fraction of incident particles undergo head on collision having large scattering angle. This implies that the mass of the atom is concentrated in a small volume. Since α-particle rebound back, massive positively charged nucleus reside inside the atom occupying small region. **[1½ Marks]**



From above diagram, we can conclude that small impact parameter '*b*' suffers large scattering angle that it show the upper limit to the size of nucleus.

Note

Another way to ask this question:-
Q. In study of Geiger - Mardon experiment on scattering of α-particles by a thin foil of gold, draw the trajectory of α-particle in coulomb field of target nucleus. Explain briefly how one gets the information on the size of nucleus from this study.

Also, Loss in kinetic energy = gain in potential energy

$\Rightarrow$ $K.E. = \frac{K(Ze)(2e)}{r_0}$

$\Rightarrow$ $r_0 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2Ze^2}{K.E}$ which is distance of closest approach. **[1½ Marks]**

Topic-2: *Bohr Model of the Hydrogen Atom, The Line Spectra of the Hydrogen Atom and De Broglie's Explanation of Bohr's Second Postulate of Quantisation*

63. (c) $E_1 = -13.6 eV$

$\therefore \quad E_n = \frac{E_1}{n^2}$

In first excited state, n = 2

$\therefore \quad E_2 = \frac{E_1}{4} = \frac{-13.6}{4} = -3.4 eV$

$\therefore \quad (K.E)_2 = -E_2 = 3.4 eV$

$(P.E)_2 = 2E = -2 \times 3.4 = -6.8 eV$ **[1 Mark]**

64. (d) For Balmer series of hydrogen atom

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$$

where, n = 3, 4, 5, ...

As, wavelength (λ) decreases ⇒ n increases

∴ The spectral lines appears closeds together and becomes weaker in intensity **[1 Mark]**

65. (c) The radius of nth orbit in Bohr's model of hydrogen atom is

$r_n = 0.53 \times n^2 A° \Rightarrow r_n \propto n^2$ **[1 Mark]**

66. (a) $\Delta E = 2.55 eV = 2.55 \times 1.6 \times 10^{-19} J$ **[1 Mark]**

wavelength of the radiation

$$\lambda = \frac{hc}{\Delta E} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{2.55 \times 1.6 \times 10^{-19}}$$

$\Rightarrow \lambda = 487.5 nm$

(b) This wavelength will fall in Balmer series of Hydrogen spectrum **[1 Mark]**

67. $r = 1.5 \times 10^{11} cm, V_o = 30 km/sec, m_e = 6 \times 10^{24} kg.$

using Bohr's postulate

i.e., angular momentum is quantized **[1 Mark]**

$mvr = n\hbar$, or $n = \frac{mvr}{\hbar}$,

$$\Rightarrow n = \frac{6 \times 10^{24} \times 30 \times 1.5 \times 10^9}{1.055 \times 10^{-34}}$$

$n = 255.92 \times 10^{67}$ **[1 Mark]**

Chapter 13 : Nuclei

Topic-2: *Mass-Energy and Nuclear Binding Energy, Nuclear Force, Nuclear Energy*

68. (a) **[1 Mark]**

69. (a)

Nuclear fission	Nuclear fusion
1. When the nucleus of an atom split into lighter nuclei through a nuclear reaction, the process is termed nuclear fission.	1. Nuclear fusion is a reaction through which two or more lighter nuclei collide with each other to form a heavier nucleus.
2. ${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{144}_{56}Ba + {}^{89}_{36}Kr + 3{}^{1}_{0}n + 210 MeV$	2. ${}^{1}_{1}H + {}^{1}_{1}H \rightarrow {}^{2}_{1}H + e^+ + \nu + 0.42 MeV$

[1½ Marks]

(b) A = 239, m = 1g

Energy per fission = 180 MeV

∴ Number of ${}^{293}_{94}Pu$ atoms in 1g is

$$N = \left(\frac{m}{A}\right) N_o = \frac{1}{239} \times 6.023 \times 10^{23}$$

∴ Total energy released is

$$E = \frac{6.023 \times 10^{23} \times 180}{239} = 4.54 \times 10^{23} MeV$$ **[1½ Marks]**

Chapter 14 : Semiconductor Electronics: Material Devices and Simple Ciruits

Topic-2: *Intrinsic Semiconductor, Extrinsic Semiconductor*

70. **(b)** $n_e = \frac{5\times10^{28}}{10^6} = 5 \times 10^{22}\ m^{-3}$

$n_h = 4.5 \times 10^9\ m^{-3}$

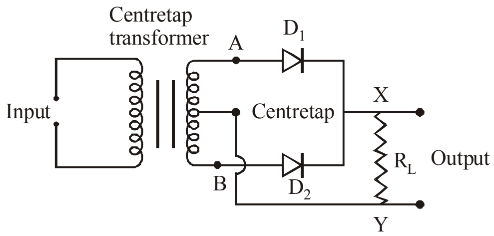
$\therefore\ n_i^2 = n_e \times n_h = 5 \times 10^{22} \times 4.5 \times 10^9$

$\therefore\ n_i = 1.5 \times 10^{16}\ m^{-3}$ **[1 Mark]**

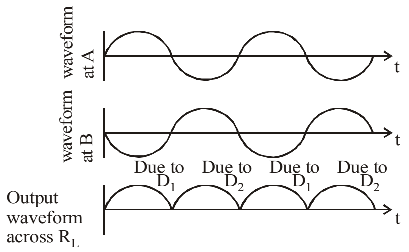
71. **(b)** For metals, α = +ve and for semiconductors, α = –ve. The current flows in metal due to free electrons, whereas in P-type semiconductors due to holes or positive charged. **[1 Mark]**

72. **(a)** In p-n junction diode an appreciable amount of current (in the range of mA) passes through it during forward baised arrangement while in reverse baised configuration a very negligible current passes through it (in micrometer range). Hence it can be used in the rectification of alternating current. **[1 Mark]**

(b) **P-N junction diode as a full wave rectifier :** The circuit uses two diodes connected to the ends of a centre tapped transformer. The voltage rectified by the two diodes is half of the secondary voltage i.e., each diode conducts for half cycle of input but alternately so that net output across load comes as half sinusoids with positive values only.



For positive cycle diode D_1 conducts (FB) but D_2 is being out of phase is reverse biased and does not conduct. Thus output across R_L is due to D_1 only. In negative cycle of input D_1 is R.B. but D_2 is F.B. and conducts as with respect to centretap point A is negative but B is positive. Hence output across R_L is due to D_2.



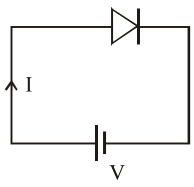
[2 Marks]

73. **(a)** A doped semiconductor is electrically neutral because it has equal number of electrons as there are protons. By doping, only the conductivity of semiconductor increases. **[1 Mark]**

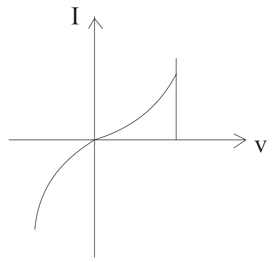
(b) In a p-n junction under equilibrium, there is not net current because diffusion current is exactly equal and opposite to the drift current for both carriers. **[1 Mark]**

(c) In a diode, the reverse current is practically not dependent on the applied voltage because the reverse current is due to the drifting of the minority charge carriers from one region to another through the junction. Hence a small amount of voltage is enough to carry on the sweeping of the minority charge carriers. **[1 Mark]**

74.



p-n junction in forward bias **[½ Mark]**



[2 Marks]

Topic-3: *p-n Junction, Semiconductor Diode, Application of Junction Diode as a Rectifier*

75. (i) (c)

(ii) (d) $n_i = 2 \times 10^{10}\ cm^{-3}$, $n_n = 8 \times 10^3\ cm^{-3}$

$\therefore\ n_i^2 = n_h \cdot n_e$

$$\Rightarrow\ n_e = \frac{\left(2\times10^{10}\right)^2}{8\times10^3} = 5\times10^{22}\,m^{-3}$$

(iii) (A) (c) (OR) (iii) (B). (a)

(iv) (d) $\omega = 100\pi$ rad/s $\therefore\ T = \frac{2\pi}{\omega} = \frac{2\pi}{100\pi} = \frac{1}{50}$ s

For half wave rectifier, $T_{output} = T = \frac{1}{50}$ s

$\therefore$ Frequency, $f_{output} = \frac{1}{T_{output}} = 50$Hz

For full wave rectifier,

$T_{output} = \frac{T}{2} = \frac{1}{100}$ s

$\therefore$ Frequency, $f_{output} = \frac{1}{T_{output}} = 100$Hz **[4 Marks]**