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SPECIAL STUDY MODULE – PHYSICS
FOR
CLASS – XII (2015-16)

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ELECTROSTATICS (Chap. 1& 2)

VERY SHORT ANSWER TYPE QUESTIONS (1 MARK)

Q.1. Define electric flux.

**Ans.** The number of electric field lines passing through unit area normal to the given surface are known as electric flux.

Q.2. Is the electric flux scalar or vector? What is the SI unit of electric flux?

**Ans.** Scalar. SI Unit is Nm²C⁻¹

Q.3. What do you mean by quantization of electric charge?

**Ans.** The charge on a body is found in the form of integral multiple of fundamental charge e. Where e = 1.6 x 10⁻¹⁹ C.

Q.4. Why the electric field inside a dielectric slab decreases when it is placed in an external electric field?

**Ans.** Because dielectric gets polarized in opposite direction.

Q.5. Can two equi-potential surfaces intersect each other? Give reason to support your answer.

**Ans.** No, because at the point of intersection, there will be two directions of electric field which is not possible.

Q.6. The electric field is always perpendicular to equi-potential surface. Why?

**Ans.** Since work done in moving a charge between two points on equi-potential surface is zero.

Q.7: In the figure, a charge ‘q’ is kept at point ‘o’.
The work done in carrying an electron from A to B is positive. What is the nature of charge ‘q’?  
**Ans:** −ve

Q.8. A charge ‘q’ is placed at the center of a hollow metallic spherical conductor as shown in figure. What is the work done in carrying a charge of 5 µC from A to B via C.

**Ans.** zero, because the electrostatic field is conservative in nature.

Q.9. What is the angle between the direction of electric fields at axial point and equatorial point due to an electric dipole?

**Ans:** 180°

Q.10. The distance of the field point on the axis of a small dipole is doubled. By what factor, will the electric field due to dipole change?

**Ans.** 1/8 times because $E_{\text{axial}} \propto \frac{1}{r^3}$
Q.11. Why do we enclose the sensitive instruments in metal cage?

Ans. To protect them from outsider electric influence, electrostatic-shielding is needed.

Q.12. Force between two point electric charges kept at a distance d apart in air is F. if these charges are kept at same distance in water (K=80) how does the force between them change?

Ans. \( F' = F/80 \), because \( F = \frac{1}{4\pi \varepsilon_0} \frac{q_1 q_2}{r^2} \) ∴ \( F \propto \frac{1}{K} \)

Q.13. What does \( q_1 + q_2 = 0 \) signify in electrostatics?

Ans. The equation signifies that the electric charges are algebraically additive and here \( q_1 \) and \( q_2 \) are equal and opposite. Also this signifies an electric dipole.

Q.14. Electric force between two charged particles situated at a given distance is \( F \) newton. What is the force if the distance is made half?

Ans. \( F' = 4F \) because \( F = \frac{1}{4\pi \varepsilon_0} \frac{q_1 q_2}{r^2} \) or \( F \propto \frac{1}{r^2} \)

Q.15. Define dielectric constant of a medium in terms of electrostatic force?

Ans. \( K = \frac{F_d}{F_m} \). It is the ratio of force between two charges at certain distance in vacuum to force in that medium for same charges and same distance.

SHORT ANSWER TYPE QUESTIONS (2 MARKS)

Q.1. A point charge is placed at the center of spherical Gaussian surface. How will electric flux \( \phi_E \) change if:

(i) The sphere is replaced by a cube of same or different volume,
(ii) A second charge is placed near, and outside, the original sphere,
(iii) A second charge is placed inside the sphere, and
(iv) The original charge is replaced by an electric dipole?

Ans: (i) No change. \( \phi_E \) independent of shape/size.
    (ii) No change, according to Gauss’ law
    (iii) Flux will increase.
    (iv) Zero

Q.2. Is it possible to have zero flux through a surface encloses charges? Justify your answer.

Ans. Yes, the net charge will be zero. For example, electric dipole inside the Gaussian surface.

Q.3. A point charge of \(+10 \, \mu\text{C}\) is at a distance of 5 cm directly above the center of square of side 10 cm as shown. What is electric flux through the square?

Ans. \( \phi = \frac{q}{6\varepsilon_0} \)
Q.4. A uniformly charged conducting sphere of diameter 2.4 m has surface charge density 80 µC/m².

(i) Find charge on the sphere,

(ii) What is the total electric flux leaving the surface?

Ans. (i) \( q = \sigma_A = \sigma 4\pi r^2 \),

(ii) \( \Phi = \frac{q}{\varepsilon_0} \)

Q.5. An infinite line charge produces a field of \( 9 \times 10^4 \) N/C at distance of 2 cm. Calculate linear charge density.

Ans. Formula: \( E = \frac{\lambda}{2\pi \varepsilon_0 r} \), Ans: \( 1.0004 \times 10^{-8} \) C/m

Q.6. Define electric dipole moment. What is its direction?

Ans. The product of either charges of dipole and length of dipole. From positive to negative.

Q.7. For what value of angle between dipole moment and electric field the dipole remain in (i) stable equilibrium, (ii) unstable equilibrium?

Ans. (i) \( \theta = 0^0 \) (ii) \( \theta = 180^0 \)

SHORT ANSWER TYPE QUESTIONS (3 MARKS)

Q.1. Two metal plates form a parallel plate capacitor. The distance between the plates is \( d \). A metal sheet of thickness \( d/2 \) and of the same area is introduced between the plates. What is the ratio of the capacitances in the two cases?

Ans: use \( C = \frac{E_0 A}{d - t} \) and \( C = \frac{E_0 A}{d} \)

Get \( \frac{C'}{C} = 2 \)

Q.2. The graph shows the variation of voltage \( V \) across the plates of two capacitors. \( A \) and \( B \) versus increase of charge \( Q \) stored on them. Which of the capacitors has higher capacitance? Give reason for your answer.

Ans. \( C_A > C_B \), as \( C = \frac{Q}{V} \therefore C = \frac{1}{\text{slope}} \) (smaller the slope, greater the capacitance)

Q.3. The given graph shows the variation of charge \( q \) versus potential difference \( V \) for two capacitors \( C_1 \) and \( C_2 \). The two capacitors have same plate separation but the plate area of \( C_2 \) is double than that of \( C_1 \). Which of the lines in the graph correspond to \( C_1 \) and \( C_2 \) and why?
Q.4. Two point charges +3 μC and -3 μC are located at points are located at two points A and B, 20 cm apart in vacuum.

(i) Find the electric field at mid-point of the line AB joining two charges.

(ii) If a negative test charge of magnitude 1.5 x 10^{-19} C, is placed at the center, find the force experienced by the test charge.

Ans. Hint: E_1=2.7 x 10^6 NC^{-1} along AP, E_2=2.7 x 10^6 NC^{-1} along PB, E = E_1 + E_2 = 5.4 x 10^6 NC^{-1} along AB, F = q_0E = 8.1 x 10^{-3} N

Q.5. Two point charges of 5 x 10^{-19} C and +20 x 10^{-19} C are separated by a distance of 2 m. find the point on the line joining them, at which electric field intensity is zero.

Ans. E_1=E_2= \frac{q_1}{4\pi\varepsilon_0 x^2} = \frac{q_2}{4\pi\varepsilon_0 (2-x)^2} \text{ or } x = 2/3 \text{ m}

Q.6. An electric dipole consists of two opposite charges of magnitude 6x10^{-3} separated by a distance of 10 cm, placed at 30° w.r.t. uniform electric field E, experiences a torque of magnitude 6√3 Nm. Calculate (i) magnitude of electric field (ii) potential energy of electric dipole.

Ans. Hint: p = 2ql = 6x10^{-4} Cm, \tau = pESin\theta OR E = \tau / pESin\theta = 2\sqrt{3} x 10^4 N C^{-1},

POTENTIAL ENERGY (U) = -pECos\theta = - 18 J

Q.7. Sketch electric lines of force for point charges q_1 and q_2 for (i) q_1 = q_2And (ii) q_1 > q_2

Ans:

Q.8. Define electric dipole moment. Is it a scalar or vector? Give its SI unit.

Ans. Its magnitude is given by the product of magnitude of either charge and distance between them. It is represented by ‘p’.

\[ p = q (2a) \text{. It is a vector quantity and its SI unit is } \text{Cm} \]
Q.9. Draw electric lines of force due to a uniformly charged small spherical shell, charge on the shell is negative.

![Diagram of electric lines of force due to a uniformly charged small spherical shell.]

(ii)

Q.10. Find expression for force and torque on an electric dipole when kept in an uniform electric field.

**Ans.** There is a force $qE$ on charge $q$ and a force $-qE$ on charge $-q$. The net force on the dipole is zero, since $E$ is uniform.

Magnitude of torque $= qE \times 2a \sin\theta$

$= 2qaE \sin\theta = pEs\sin\theta \quad \text{-------- (1)}$

Torque $= p \times E$, Its direction is normal to the plane of the paper, coming out of it.

Q.11. The graph shows the variation of $V$ vs $q$ for two capacitors A and B. Which of the two capacitors has higher capacitance? Give reason in support of your answer.

**Ans.** Slope = $V/Q$, $1/$slope = $C$, therefore, $C_A > C_B$

Q.12. What is the nature of force between two point electric charges $q_1$ & $q_2$ kept at some distance apart in air is attractive & repulsive when (a) $q_1q_2>0$ (b) $q_1q_2<0$?

**Ans.** (a) Repulsive. As charges are of same sign (b) attractive. As charges are of opposite sign

Q.13. Define coulomb and calculate charge carried by $12.5 \times 10^{18}$ electrons.

**Ans.** Definition of 1c $n=q/e$, $q=ne=12.5 \times 10^{18}=2C$

Q.14. What do you understand by permittivity of free space? Write its numerical value in S.I. unit.

**Ans.** Definition, $\varepsilon_0=8.85 \times 10^{-12} \ C^2m^{-2}N^{-1}$

Q.15. Two fixed point charges $+4e$ and $+e$ are separated by a distance $a$, where should the third point charge be placed for it to be in equilibrium.

**Ans.** For equilibrium: $\frac{4eq}{(a-x)^2} = \frac{eq}{x^2}$ or $\frac{2}{a-x} = \frac{1}{x}$ \text{ Ans: } x = a/3
Q.16. Two identical point charges \( Q \) are separated by a distance \( 'a' \). A third point charge be placed on the line joining the above charges such that all three charges are in equilibrium. Find location and magnitude of third charge.

**Ans.** For equilibrium: 
\[
\frac{Qq}{(a+x)^2} = \frac{q}{x^2}
\]

\[
\frac{1}{a-x} = \frac{1}{x} \Rightarrow x = \frac{a}{2}
\]

and \[
\frac{Qq}{4\pi \varepsilon_0 r^2} + \frac{q}{4\pi \varepsilon_0 (r/2)^2} = 0 \quad \because q = -\frac{Q}{4} \sigma_2
\]

Q.17. Given a uniform electric field \( \vec{E} = 5 \times 10^3 \hat{i} \) N/C. find the electric flux of this field through a square of side 10 cm in y-z plane. What would be the flux through the same square if the plane makes an angle of 30° with the x-axis?

**Ans.** \( \Phi = EA \cos \theta \), 50 Nm²C⁻¹. And 25 Nm²C⁻¹

Q.18. Two infinitely long plane thin parallel sheets having surface charge densities \( \sigma_1 \) and \( \sigma_2 \) \( (\sigma_1 > \sigma_2) \) are shown in the figure. Write the magnitudes and directions of the field lines in the regions marked II and III.

**Ans.** For region II  
\( E_{II} = \frac{1}{2\varepsilon_0} (\sigma_1 - \sigma_2) \) towards right side / from sheet A to B.

For region III  
\( E_{III} = \frac{1}{2\varepsilon_0} (\sigma_1 + \sigma_2) \) towards right side / away from two sheets.

**Questions for practice:**

19. Calculate the work done in rotating an electric dipole in uniform electric field. (3 marks)

(5 MARKS)

Q.1. Derive an expression for capacitance of a parallel plate capacitor.

Q.2 A dipole is made up of two charges +q and –q separated by a distance 2a. Derive an expression for the electric field \( \vec{E} \) due to this dipole on the equatorial plane. Draw the shape of the graph between \( \vec{E} \) and \( r \) when \( r \gg a \).

If this dipole were to be put in a uniform external electric field \( \vec{E}_e \) then obtain an expression for torque acting on the dipole.

Q.1. The electric field component in figure are \( E_x = \alpha x^2 \), \( E_y = E_z = 0 \). In which \( \alpha = 800 \) N/C m¹/². Calculate (a) electric flux through cube, (b) Charge within the cube. Assume that \( a = 0.1 \) m. \( \hat{n} \)
Q.2. (i) If +5 µC charges are placed at the center of a sphere of radius 5 cm. Calculate: (a) Flux through the sphere, (b) If the radius of the sphere is doubled, finds new flux through the sphere.

(ii) Find the ratio of flux passing through sphere S₁ and S₂ in respect of given figure.

Q.3. State Gauss’ law in electrostatics. Find electric field due to infinitely charged long straight uniformly charged wire of linear charge density \( \lambda \) at a given point using Gauss’ law. Draw ‘E’ vs distance.

Q.4. Using Gauss theorem, find electric field at a point due to uniformly charged infinite plane sheet with surface charge density ‘σ’. Draw ‘E’ vs distance from sheet.

Q.5. Using Gauss theorem, find electric field at a point situated inside a uniformly charged thin spherical shell surface charge density ‘σ’.

Q.6. Derive the expression for an electric field due to an electric dipole at a point on axial line.

Q.7. Derive the expression for an electric field due to an electric dipole at a point on equatorial line.

Q.8. Show that the energy stored in a parallel plate capacitor is \( \frac{1}{2} CV^2 \). Hence derive the expression for energy density.

Q.9. Two point charges +q and -2q are placed at the vertices B and C of an equilateral triangle ABC of side ‘a’ as given in the figure. Obtain the expression for (i) the magnitude and (ii) the direction of the resultant electric field at the vertex A due to these two charges. (Use Gauss law in electrostatics)

\[
(i) E_{\text{net}} = \frac{1}{4\pi\varepsilon_0} \left( \frac{a\sqrt{3}}{a^2} \right)
\]

(ii) 30° with side AC

**CURRENT ELECTRICITY** (Chap. 3)

**V S A TYPE QUESTIONS (1 MARK)**

1. Write SI unit of resistivity. Ans: Ω m

2. V-I graph of two metallic wires of same length and cross sectional area are given below. Which of these has higher resistance?

   **Ans**: B has higher resistance.
3. Define mobility of electron and give its SI unit.

 Ans: Mobility is defined as the magnitude of drift velocity per unit electric field. 

 \( \mu = \frac{v_d}{E} \), Its SI unit is m²V⁻¹s⁻¹

4. A wire of resistivity \( \rho \) is stretched to twice its length. What will be its new resistivity?

 Ans: Resistivity will remain unchanged, because resistivity of a material is independent of its dimensions.

5. A wire of resistance 8R is bent in the form of a circle. What is the effective resistance between the ends of its diameter?

 Ans: Resistance of each half of the circle = 4R

 The effective resistance between the ends of the diameter is 

 \[ R_{\text{eff}} = \frac{4R \times 4R}{4R + 4R} = 2R \]

6. If the temperature of a conductor increases how does the resistivity of the conductor change?

 Ans: \( \rho = \frac{m}{(ne^2 \tau)} \)

 With increase in temp, \( \tau \) decreases hence, the resistivity of conductor increases.

7. Two wires of equal cross-sectional area, one of copper and the other of Manganin have the same resistance. Which one will be longer?

 Ans: The copper wire will be longer because for the same cross section area \( A \) and resistance \( R \), length of the wire \( l \) is inversely proportional to \( \rho \). \( \rho_{\text{Cu}} < \rho_{\text{Manganin}} \)

8. A toaster produces more heat than a light bulb when connected in parallel to the 220V mains. Which of the two has greater resistance?

 Ans: From the relation \( P = \frac{V^2}{R} \), it is clear that the resistance of bulb is greater as it produces less heat (i.e., its power is less) for constant potential difference.

9. What is the largest voltage you can safely put across a resistor marked 196 Ω -1W?

 Ans: \( V_{\text{max}} = \sqrt{P \cdot R} = (1 \times 196)^{1/2} = 14V. \)

10. For measuring small resistance with the help of a potentiometer, would you prefer high potential gradient or a low potential gradient?

 Ans: Low value of potential gradient is preferred.

 As sensitivity of potentiometer \( \propto \frac{1}{\text{potential gradient}} \)

**SHORT ANSWER TYPE QUESTIONS (2 MARKS)**

1. Define current density. Is it a scalar or vector? Give its SI unit.

 Ans: It is the current flowing per unit area of the cross – section of the conductor.
2. Write the principal of potentiometer and how will you increase its sensitivity?

**Ans:** When a constant current flows through a wire of uniform area of cross section then, the potential drop across any portion of the wire is directly proportional to its length.

\[ V \propto l \]

Sensitivity can be increased by (i) increasing the length of wire of potentiometer and (ii) reducing current in the circuit (iii) reducing the least count of meter scale.

3. Identify the electrical devices X and Y in the given circuit:

**Ans:** X = Ammeter and Y = resistance box.

4. In an experiment on meter bridge the balancing length on wire is 'l'. What would be its value, if the radius of the meter bridge wire is doubled? Justify your answer.

**Ans:** The balancing length remains unchanged because as per relation \( \frac{R}{x} = \frac{l}{100-l} \), the balancing length is independent of radius of bridge wire provided that it is throughout uniform.

5. Why is a potentiometer preferred over a voltmeter for measuring the emf of the combination?

**Ans:** Because potentiometer gives reading when no current is being drawn from the cell i.e., the cell is in an open circuit.

6. Under what condition can terminal potential difference of a cell be greater than its emf?

**Ans:** When current is being supplied to the cell by some external source e.g. At the time of charging a secondary cell.

7. Explain how electron mobility changes for a good conductor when (i) the temp of the conductor is decreased at constant potential difference, and (ii) applied potential difference is doubled at constant temp?

**Ans:** (i) We know that electron mobility \( \mu = \frac{v_d}{E} = \left( \frac{q}{m} \right) \cdot \tau \), where \( \tau \) is the relaxation time. If temp of the conductor is decreased, then \( \tau \) increases and hence electron mobility increases.
(ii) If at constant temp applied potential difference is doubled, it will not affect mobility of electrons.

8. Two bulbs whose resistances are in the ratio 1:2 are connected in parallel to a source of constant voltage. What will be the ratio of power dissipation in these?

Ans: Here V= constant and \( R_1/R_2=1/2 \), hence \( P_1/P_2= (V^2/R_1)/(V^2/R_2) = R_2/R_1=2/1 \).

9. A carbon resistor is marked with rings of blue, black, brown and silver colour. Write the value of resistance and tolerance. Ans: 600±10% Ω

**SHORT ANSWER TYPE QUESTIONS (3 MARKS)**

1. A potential difference V is applied across the ends of copper wire of length l and diameter D. What is the effect on drift velocity of electrons if (i) V is doubled  (ii) l is doubled  (iii) D is doubled.

Ans: Drift velocity = \( I/neA = (V/R)/neA \) or \( V_d = V/\rho \)nel

   (i) If V is doubled, drift velocity is doubled as \( v_d \propto V \)
   (ii) If l is doubled, drift velocity is halved as \( v_d \propto 1/l \)
   (iii) No change in drift velocity on changing the diameter of the wire as it is independent of diameter.

2. Define drift velocity and derive its relation with (i)electric field E and (ii) potential difference V.

Ans: (i) Drift velocity is the average constant velocity gained by free electrons under the effect of electric field. (ii) for practice

4. Draw the circuit diagram for comparing the emf's of two primary cell using potentiometer and write the formula used.

Ans: \( E_1 \propto l_1 \) and \( E_2 \propto l_2 \)

\( E_1/E_2 = l_1/l_2 \)

5. Draw the circuit diagram for determining the internal resistance of primary cell using potentiometer. Write the formula used.

Ans: diagram Ref: NCETR Text Book page no.122 figure no. 3.28(b)

\[ r = R \left( l_1 - l_2 \right) / l_2 \]

Where \( r \) is the internal resistance

\( l_1 \) = balanced length when \( k_2 \) is OFF.

\( l_2 \) = balanced when \( k_2 \) is ON.

6. Deduce the relation connecting current density(J) and the conductivity(σ) of the conductor when an electric field E is applied to it.
Ans: According to Ohm’s Law, we know that V = R.I = \( \frac{\rho l}{A} \cdot I = \frac{V}{l} = \rho \cdot \frac{l}{A} \)

But \( \frac{I}{A} = J \) and \( \frac{V}{l} = E \), hence we have

E = \( \rho J \) or \( \frac{I}{E} = \frac{1}{\rho} = \sigma \), where \( \sigma \) is the electrical conductivity of given material.

The relation \( \frac{I}{E} = \sigma \) or \( J = \sigma E \) is yet another form of Ohm’s Law.

7. A 10 m long potentiometer wire of resistance 20Ω is connected in series with 5V battery & external resistance of 480Ω. If an unknown emf \( E \) is balanced at 600cm of this wire find (a)potential gradient (b)value of unknown emf \( E \) 

Ans: \( I = \frac{E}{R + r} = \frac{5}{20 + 480} = 0.01 \) A
\( V_1 = IR = 0.01 \times 20 = 0.2 \) V

(i) \( K = \frac{V_1}{L} = \frac{0.2}{10} = 0.02 \) V/m or \( E = Kl = 0.02 \times 6 = 0.12 \) V

8. Two wires X, Y have the same resistivity, but their cross sectional areas are in the ratio 2:3 and lengths in the ratio 1:2. They are first connected in series and then in parallel to a DC source. Find out the ratio of the drift speeds of the electrons in the two wires for (i) series connection and (ii) parallel connection.

Ans: given: \( \rho_x = \rho_y \) but \( \frac{A_x}{A_y} = 2/3 \) and \( \frac{l_x}{l_y} = 1/2 \)

\( R_x/R_y = \left( \frac{\rho_x}{\rho_y} \right) \left( \frac{l_x}{l_y} \right) \left( \frac{A_y}{A_x} \right) = 1 \times \frac{1}{2} \times \frac{3}{2} = \frac{3}{4} \)

We know, \( I = neAV_d \) or, \( V_d = \frac{I}{nAE} \)

(i) X and Y in series, \( I \) is same in series combination and electron density \( n \) same.
\( (V_d)_x/(V_d)_y = (A_x/A_y) = 3/2 \)

(ii) X and Y parallel, \( V \) same. \( v_d = \frac{V}{RnAE} \)

or, \( (v_d)_x/(v_d)_y = (R_y/R_x)(A_y/A_x) = \frac{4}{3} \times \frac{3}{2} = 2/1 \)

**LONG ANSWER TYPE QUESTIONS (5 MARKS)**

Q1) In a metre bridge the null point is found at a distance of 33.7 meters from point A. If now a resistance of 12Ω is connected in parallel with S the null point occurs at 51.9cm. Determine the values of R and S.

Ans: From the first balance point,

\[ \frac{R}{S} = \frac{33.7}{66.3} \]  

----------- (1)

S is connected in parallel with a resistance of 12Ω.

\[ S_{eq} = \frac{12S}{S+12} \]

New balance condition
(51.9/48.1)=R/S_{eq}=R(S+12)/12S

Using eq (1)

51.9/48.1=([S+12]/12)\times[33.7/66.3]

Which gives S=13.5\Omega.

Using value of R/S above, we get R=6.86\Omega.

Q2) A circuit using a potentiometer and a battery of negligible internal resistance is set up as shown in figure below to develop a constant potential gradient along the wire AB. The 2 cells of emfs E_1 and E_2 are connected in series as shown in combinations (1) and (2). The balance points are obtained respectively at 400 cm and 240cm from the point A. Find (i) E_1/E_2 (iii) Balancing length for E_1 only.

Ans: (i) If ‘k’=potential gradient along potentiometer wire then,
+E_2 = k.400cm
E_2 - E_1 = k.240cm
⇒ E_1 = 80k & E_2 = 320k

E_1/E_2 = \frac{1}{4}, If balancing length for cell E_1 only be l cm, then E_1 = lk, But E_1 = 80k, Therefore, l = 80cm.

VALUE BASED QUESTIONS

1. While performing an experiment on determination of unknown resistance using meter bridge, Rahul obtained deflection in the galvanometer in the same direction even after repeated adjustments in the circuit and thus could not get any results. In order to avoid getting noticed and scolded by the teacher, he pretended having performed the experiment and copied the readings obtained by another student.

Answer the following questions based on above information:

(i) Write the possible reasons for getting in the galvanometer in the same direction.
(ii) Which two values is Rahul violating in copying the readings from another student?
(iii) What, in your opinion, should have Rahul done in the given circumstances?

Ans: (i)(a) The two resistances in the gaps (say P and Q) are not of comparable value.

(b) Current may not be flowing in both the arms due to loose connections.

(ii) Honesty, truthfulness, sincerity, desire to learn more and improve.

(iii) Rahul should have sought help from teacher to know the reasons for not able to get desired results.
2. On July, 30th 2012, North India plunged into darkness due to over-drawing of power in some states. Vijay is disturbed by this and carries out a survey to identify the causes of power loss in our country. He also educates his neighbors on using electricity devices judiciously to save power.

(i) What values are reflected in Vijay's behavior?
(ii) What measures have the Government taken to fulfill the energy demands of the people?
(iii) How can the people help the Government in their efforts?

Ans: (1) Patriotism, taking initiative, responsible behavior, social concern, leadership, teamwork/collaborative work.

(2) Initiated hydroelectricity projects, villages are supplied electricity.

(3) By saving electricity and not misusing it. Electrical appliances should be switched off when not in use or when not required.

PRACTICE QUESTIONS

1. Deduce Ohm's Law using concept of drift velocity.

2. Establish the relation between current and drift velocity.

3. Derive the condition for balanced wheat stone bridge.

Magnetic Effect of current and Magnetism (Chap. 4 & 5)

VERY SHORT ANSWER TYPE QUESTIONS (1 MARK)

1. How does the angle of dip vary from equator to poles? Ans: 0 to 90 degree

2. What is the effect on the current measuring range of a galvanometer when it is shunted? Ans: Increased

3. An electric current flows in a horizontal wire from east to west. What will be the direction of magnetic field due to current at a point: (i) North of the wire and (ii) Above the wire

Ans: i. Going into the plane of paper. ii. Towards north.

4. An electron is moving with velocity v along the axis of the long straight solenoid carrying current I. What will be the force acting on the electron due to magnetic field of solenoid? Ans: F = evBsinθ = 0

5. State two properties of material used in moving coil galvanometer?

Ans: (i) Small torsion constant makes the galvanometer highly sensitive.

(ii) High tensile strength. Thus thin wires do not break under the weight of suspension coil.

6. If a toroid uses bismuth as its core, will the field in the core be lesser or greater than when it is empty?

Ans: Bismuth is diamagnetic; hence, the overall magnetic field will be slightly less than original field.
7. Answer the following questions:
(a) The earth's magnetic field varies from point to point in space. Does it also change with time? If so, on what time scale does it change appreciably?
(b) The earth's core is known to contain iron. Yet geologists do not regard this as a source of the earth's magnetism. Why?
(c) The charged currents in the outer conducting regions of the earth's core are thought to be responsible for earth's magnetism. What might be the 'battery' (i.e., the source of energy) to sustain these currents?
(d) The earth may have even reversed the direction of its field several times during its history of 4 to 5 billion years. How can geologists know about the earth's field in such distant past?
(e) The earth's field departs from its dipole shape substantially at large distances (greater than about 30,000 km). What agencies may be responsible for this distortion?

Ans: (a) Earth's magnetic field changes with time. It takes a few hundred years to change by an appreciable amount. The variation in earth's magnetic field with the time cannot be neglected.
(b) Earth's core contains molten iron. This form of iron is not ferromagnetic. Hence, this is not considered as a source of earth's magnetism.
(c) The charged currents in the outer conducting regions of the earth's core are thought to be responsible for earth's magnetism. What might be the 'battery' (i.e., the source of energy) to sustain these currents?
(d) The radioactivity in earth's interior is the source of energy that sustains the currents in the outer conducting regions of earth's core. These charged currents are considered to be responsible for earth's magnetism.
(e) These magnetic fields got weakly recorded in rocks during their solidification. One can get clues about the geomagnetic history from the analysis of this rock magnetism. Because of the presence of the ionosphere. In this region, earth's field gets modified because of the field of single ions. While in motion, these ions produce the magnetic field associated with them.
(e) An extremely weak magnetic field can bend charged particles moving in a circle. This may not be noticeable for a large radius path. With reference to the gigantic interstellar space, the deflection can affect the passage of charged particles.
SHORT ANSWER TYPE QUESTIONS (2 MARKS)

1. **What is the main function of soft iron cylinder in the core of the coil of moving coil galvanometer?**
   
   **Ans:** due to high permeability of soft iron, the magnetic lines of force crowd through the soft iron core this increases magnetic field and sensitivity of galvanometer.

2. **What is the importance of radial magnetic field in moving coil galvanometer?**

   **Ans:** radial magnetic field makes the arm of the couple fixed and hence the torque on the coil is always same in all position of coil in magnetic field this provides linear current scale.

   Or

   It makes torque independent upon the angle between magnetic field 'B' and axis of coil and we get linear current scale.

3. **Why is ammeter connected in series in a circuit?**

   **Ans:** An ammeter is connected in series in a circuit so that whole of the current which is required to measure passes through it. Moreover, an ammeter has a low resistance so its insertion in the series circuit doesn’t change main current.

4. **Why voltmeter is always connected in parallel in the circuit?**

   **Ans:** voltmeter is highly resistive in nature, when it is connected parallel across any element of a circuit it draws small amount of current from the circuit. Hence most of the current passes through it and potential difference is measured effectively.

5. **The magnetic susceptibility of a material is -4.2 \times 10^{-6}. Identify the type of material and find its state after heating?**

   **Ans.** As the susceptibility is negative, so the material is **diamagnetic** in nature.

   ii. *There will be no change in its magnetic behavior as diamagnetism is independent of temperature.*

**Expression for the angle of dip:** In the figure, for right-angled triangle ALP,

\[
\cos \delta = \frac{AL}{AP} = \frac{B_{\|}}{B} \tag{i}
\]

\[
B_{\|} = B \cos \delta \ldots \text{(i)}
\]

\[
\sin \delta = \frac{LP}{AP} = \frac{AM}{AP} = \frac{B_{\perp}}{B} \tag{ii}
\]

Also,

\[
B_{\perp} = B \sin \delta \ldots \text{(ii)}
\]

Squaring and adding the equations (i) and (ii), we obtain
Dividing equation (ii) by (i), we obtain

\[
\frac{B_y \sin \delta}{B_y \cos \delta} = \frac{B^2_y}{B^2_H}
\]

\[
\tan \delta = \frac{B^2_y}{B^2_H}
\]

Equations (i) (ii) and (iii) are the different relations between elements of earth magnetic field. By knowing the three elements, we can determine the magnitude and direction of earth magnetic field at any place.

**LONG ANSWER TYPE QUESTIONS (5 MARKS)**

**1.** State the Biot - Savart law for the magnetic field due to a current carrying element. Use this law to obtain a formula for magnetic field at the centre of a circular loop of radius R carrying a steady current I. Sketch the magnetic field lines for a current loop clearly indicating the direction of the field. (for practice)

2. (i) Draw a schematic diagram of cyclotron and explain its underlying principle and working.  
   ii) State the function of electric and magnetic field in cyclotron.  
   iii) Deduce the expression for period of revolution and show that it does not depend on the speed of charged particle. Hence state any two limitations of cyclotron

**Ans. Schematic diagram:**

**Principle:** A charged particle can be accelerated to very high energy by making it to pass through a moderate electric field a no of times. This can be done with the help of a perpendicular mag field which throws the charged particle into a circular path, freq of which does not depend upon the speed of the particle and radius of circular path.

**Working & Theory:** As a particle q of mass m follows a circular path under the perpendicular magnetic field B, hence

\[
qvB \sin \theta = \frac{mv^2}{r} \quad \text{or} \quad r = \frac{mv}{qB}
\]

Time period of revolution is given by \( T = \frac{2\pi r}{v} \)
This frequency is called the **cyclotron frequency**. **Cyclotron frequency is independent of** ‘v’ and ‘r’.

Now as per the concept  
\[ qBv_{\text{max}} = \frac{mv_{\text{max}}^2}{r_0} \]

\[ \Rightarrow \quad v_{\text{max}} = \frac{qBr}{m} \]

**Hence, the maximum KE of the charged particle: \( K = B^2q^2r_0^2/2m \)**

**Role of Electric field:** Electric field accelerates when particle passes through the gap and imparts energy to charged particle.

**Role of Magnetic field:** Magnetic field makes the charge particle to move in circular path.

**Limitations of a Cyclotron**

- It cannot accelerate uncharged particles like neutrons.
- There is a limit of speed beyond which a charged particle cannot be accelerated by a cyclotron.
- It cannot accelerate electrons as their charge to mass ratio is very high due to which they cannot remain in phase with the field.
- It cannot produce highly energetic particles with energy of the order of 500 MeV.

**IMPORTANT NUMERICAL PROBLEMS**

1. What will be the magnetic field at point O?

   ![Diagram](image)

   **Ans- Hint:** Use formula for \( B \) due to semicircular ring/archs and Fleming’s left hand rule which is: \( B = \frac{\mu_0 |I|}{4\pi r^2} \)

   You will get \( B = \frac{\mu_0 |I|}{4\pi r^2} \) \( T \) for (ii) diagram and for (iii) diagram \( B = \frac{\mu_0}{4} \left( \frac{1}{r_1} + \frac{1}{r_2} \right) \) normally downward.
2 A short bar magnet placed with its axis at 30° with a uniform external magnetic field of 0.25 T experiences a torque of magnitude equal to $4.5 \times 10^{-2}$ J. What is the magnitude of magnetic moment of the magnet?

**Answer:**

\[
\text{Torque } \tau = 4.5 \times 10^{-2},
\]

\[
\therefore |M| = \frac{\tau}{B \sin \theta} = \frac{4.5 \times 10^{-2}}{0.25 \times \sin 30^\circ} = 0.36 \text{ J/T}
\]

3: A short bar magnet of magnetic moment $m = 0.32 \text{ J T}^{-1}$ is placed in a uniform magnetic field of 0.15 T. If the bar is free to rotate in the plane of the field, which orientation would correspond to its (a) stable, and (b) unstable equilibrium? What is the potential energy of the magnet in each case?

**Answer:**

(a) In stable equilibrium, $\theta (angle)$ is 0°.

Potential energy of the system

\[
\text{Potential energy } = -MB \cos \theta
\]

\[
=-0.32 \times 0.15 \cos 0^\circ
\]

\[
= -4.8 \times 10^{-2} \text{ J}
\]

(b) In unstable equilibrium, $\theta = 180^\circ$

Potential energy

\[
= -MB \cos \theta
\]

\[
=-0.32 \times 0.15 \cos 180^\circ
\]

\[
= 4.8 \times 10^{-2} \text{ J}
\]

4: A closely wound solenoid of 800 turns and area of cross section $2.5 \times 10^{-4} \text{ m}^2$ carries a current of 3.0 A. Explain the sense in which the solenoid acts like a bar magnet. What is its associated magnetic moment?

**Answer:**

A current-carrying solenoid behaves as a bar magnet because a magnetic field develops along its axis, i.e., along its length.

\[
|M| = nIA = 800 \times 3 \times 2.5 \times 10^{-4} = 0.6 \text{ J T}^{-1}
\]

5: A magnetic needle free to rotate in a vertical plane parallel to the magnetic meridian has its north tip pointing down at 22° with the horizontal. The horizontal component of the earth's magnetic field at the place is known to be 0.35 G. Determine the magnitude of the earth’s magnetic field at the place.

**Answer:**

\[
B_H = B \cos \theta
\]

\[
\therefore B = \frac{B_H}{\cos \delta}
\]

\[
B_H = 0.35 \text{ G}, \quad \delta = 22^\circ \Rightarrow \frac{0.35}{\cos 22^\circ} = 0.377 \text{ G}
\]

6: At a certain location in Africa, a compass points 12° west of the geographic north. The north tip of the magnetic needle of a dip circle placed in the plane of magnetic meridian points 60° above the horizontal. The horizontal component of the earth's
field is measured to be 0.16 G. Specify the direction and magnitude of the earth’s field at the location.

**Answer**: \( \theta = 12^\circ, \quad \delta = 60^\circ, \quad B_H = 0.16 \text{ G} \)

\[
B_H = B \cos \delta
\]

\[
\therefore B = \frac{B_H}{\cos \delta} = \frac{0.16}{\cos 60^\circ} = 0.32 \text{ G}
\]

Earth’s magnetic field lies in the vertical plane, 12° West of the geographic meridian, making an angle of 60° (upward) with the horizontal direction. Its magnitude is 0.32 G.

7: A Rowland ring of mean radius 15 cm has 3500 turns of wire wound on a ferromagnetic core of relative permeability 800. What is the magnetic field \( B \) in the core for a magnetising current of 1.2 A?

**Answer**: 

\[
B = \frac{\mu_r \mu_0 I N}{2 \pi r} = 4.48 \text{ T}
\]

8: A galvanometer coil has a resistance of 12 Ω and the metre shows full scale deflection for a current of 3 mA. How will you convert the metre into a voltmeter of range 0 to 18 V?

**Answer**: 

\[
R = \frac{V}{I_g} - G = 5988 \Omega
\]

Q.9: A galvanometer coil has a resistance of 15 Ω and the metre shows full scale deflection for a current of 4 mA. How will you convert the metre into an ammeter of range 0 to 6 A?

**Answer**: 

\[
S = \frac{I_g G}{I - I_g}
\]

\[
= \frac{4 \times 10^{-3} \times 15}{6 - 4 \times 10^{-3}}
\]

\[
= \frac{6 \times 10^{-2}}{6 - 0.004} \approx 0.06
\]

\[
\approx 0.01 \Omega = 10 \text{ m}\Omega
\]

10: A circular coil of wire consisting of 100 turns, each of radius 8.0 cm carries a current of 0.40 A. What is the magnitude of the magnetic field \( B \) at the center of the coil?

**Answer**: 

\[
|B| = \frac{\mu_0 2\pi nI}{4\pi} \quad \Rightarrow \quad |B| = \frac{4\pi \times 10^{-7} \times 2\pi \times 100 \times 0.4}{0.08}
\]

\[
= 3.14 \times 10^{-4} \text{ T}
\]
11: A horizontal overhead power line carries a current of 90 A in east to west direction. What is the magnitude and direction of the magnetic field due to the current 1.5 m below the line?

Answer:

\[ B = \frac{\mu_0 I}{4\pi r} \]

\[ B = \frac{4\pi \times 10^{-7} \times 2 \times 90}{4\pi \times 1.5} = 1.2 \times 10^{-5} \text{ T} \]

Towards south

PRACTICE QUESTIONS

1. State Biot-Savart law. Using it derive an expression for the magnetic field due to a current carrying circular loop of N turns and radius R, at a point distance x from its centre on the axis of the loop.

2. Derive an expression for the force experienced by a current carrying conductor placed in uniform Magnetic Field.

3. (i) Derive an expression for the force experienced by any one of the two parallel wires carrying current I₁ and I₂ separated by distance r.
   (ii) Also mention the direction of force in each case.

4. Draw the hysteresis curve and mark the point of retentively and coercivity on it.

5. Using Ampere's circuital law, derive an expression for the magnetic field along the axis of a current carrying toroidal solenoid of N number of turn having radius r.

6. Using Ampere's circuital law, calculate the magnetic field due to an infinitely long wire carrying current I.

7. A long solenoid with closely wound turns has n turns, per unit of its length. A steady current 'I' flows through this solenoid. Use Ampere's circular to obtain an expression for the magnetic field at a point on its axis and closed to its mid-point.

8. Name and define the magnetic elements of earth's magnetic field at a place. Derive an expression for the angle of dip in terms of the horizontal component and the resultant magnetic field of the earth at a given place.

9. Distinguish amongst Dia, Para and ferromagnetic substances.

EMI AND AC (Chap. 6 & 7)

VERY SHORT ANSWER TYPE QUESTIONS (1 MARK)

1. What is the unit and dimensional formula of magnetic flux?
   Ans. Weber \([ML^2T^{-2}A^{-1}]\)

2. What is the direction of induced current in loop (1) and loop (2), if current increases from A to B?
Ans- In loop (1), it will be clockwise and in loop (2) it will be anticlockwise.

3. A closed loop of wire is being moved with constant velocity without changing its orientation inside a uniform magnetic field. Will this induce a current in the loop?
   Ans- No, there is no change in the magnetic flux.

4. A plot of magnetic flux (\( \Phi \)) versus current (I) is shown in the figure for two inductors A and B. Which of two has larger value of self inductance?

Ans- [A]

5. The instantaneous value of e.m.f. is given by \( E = 300 \sin 314t \) volt. What is the peak and rms value of e.m.f.?
   Ans- \( E_0 = 300 \text{ volt, } E_{rms} = \frac{E_0}{\sqrt{2}} = 212.1 \text{ volt} \)

6. Why a 220V AC is considered to be more dangerous than 220V DC?
   Ans- Peak value & AC (311 volt) is more than 220V DC which is constant.

7. A capacitor blocks D.C. Why?
   Ans- \( X_C = \frac{1}{2\pi fC} \), for DC: \( f = 0 \). Therefore \( X_C = \infty \).

8. The instantaneous current and voltage of an AC circuit are given by \( I = 10 \sin 314t A \) and \( V = 50 \sin(314t + \frac{\pi}{2}) \) volt. What is power dissipation in the circuit?
   Ans- Zero.

9. In a series LCR circuit, the voltage across an inductor, a capacitor and a resistor are 30 V, 30 V and 60 V respectively. What is the phase difference between the applied voltage and the current in the circuit?
   Ans- Zero.

10. What is meant by ‘Wattless current’?
    Ans- the current in the circuit when average power is zero is called wattless current.

11. Why is the core of a transformer laminated?
    Ans- To minimize the energy loss due to ‘Eddy current’.

12. Why can’t a transformer be used to step up D.C. voltage?
    Ans- No change of magnetic flux, no mutual induction.
13. The power factor of an AC circuit is 0.5. What will be the phase difference between voltage and current in this circuit?

\[ \cos \Phi = \frac{1}{2}, \ \Phi = \frac{\pi}{3} \text{ radian} \]

14. Why is choke coil needed in the use of fluorescent tubes with ac mains?

Ans. Choke coil reduces the voltage across the fluorescent tube without wastage of power.

**SHORT ANSWER TYPE QUESTIONS (2 MARKS)**

1. Explain any two applications of eddy current.

Ans- 1. Speedometer, 2. Induction motor

2. Two coils P & S are arranged as shown in the figure
   (a) What will be the direction of induced current in loop S when the switch is closed?
   (b) What will be the direction of induced current in loop S when the switch is opened?

Ans- (a) anticlockwise (b) clockwise

3. A 12V battery is connected to a circuit of 6Ω resistance; 10H coil through a switch drives a constant current in the circuit. The switch is suddenly opened. Assuming that it takes 1ms to open the switch. Calculate the average e.m.f. induced across the coil.

\[ l_{\text{initial}} = 2A, l_{\text{final}} = 0A, E = -l \frac{dl}{dt} = 20,000 \text{V} \]

4. A coil of mean area 500 cm² having 1000 turns is held perpendicular to a uniform magnetic field of 0.4 Gauss. The coil is turned through 180° in \( \frac{1}{10} \) seconds. Calculate the average induced e.m.f.

Ans- 0.004 Volt.

5. Two identical co-axial coil carry equal currents. What will happen to the current in each loop if the loops approach each other?

Ans- According to Lenz's Law current in each coil will decrease.

6. (a) The graphs (i) and (ii) represent the variation of the opposition offered by the circuit element to the flow of alternating current with the frequency of the applied e.m.f. Identify the current element corresponding to each graph

(i)

(ii)

(ii) Write the expression of the impedance offered by the series combination of the above two elements connected across the AC which will be ahead in phase in this circuit, voltage or current?

Ans- \( R, L \ ; Z = \sqrt{R^2 + X_L^2} \)

7. An alternating current is given by \( I = I_1 \cos \omega t + I_2 \sin \omega t \). Find the rms current in the circuit.

Ans- \( \sqrt{\frac{I_1^2 + I_2^2}{2}} \)
8. An alternating current having a peak value of 14 A is used to heat a metal wire. What is the value of steady current, which can produce the same heating as produced by AC? Why?

Ans - $I_{rms} = 10 A$

9. An LCR series circuit is connected to an AC source. Which of its components dissipates power L, C or R? Justify your answer.

Ans - Resistance, Power in L and C is zero

10. The peak value if an AC is 5A and its frequency is 60 Hz. Find its rms value. How long will the current take to reach the peak value starting from zero?

Ans - $I_{rms} = 3.5 A, t = \frac{1}{240} \text{ seconds}$

11. An inductor of inductance 100 mH is connected in series with a resistance, a variable capacitor and an AC source of frequency 2kHz. What should be the value of capacitance of a capacitor so that maximum current may be drawn in the circuit?

Ans: $X_C = X_L C = \frac{1}{\omega^2 L} C = \frac{1}{4\pi^2 f^2 l} = 63nF$

12. 11kW of electric power can be transmitted to a distant station at (i) 220 kV and (ii) 22KV. Which of the two modes of transmission should be preferred and why?

Ans - 22 kV, Heating loss is minimum.

13. In an AC circuit V and I are given by $V = 100 \sin 100t$ volts and $I = 100 \sin(100t + \frac{\pi}{3})$ mA respectively. What is the power dissipated in the circuit?

Ans - $V_0 = 100 V, I_0 = 100 mA, \phi = \frac{\pi}{3}, P = I_{rms}V_{rms}\cos\phi = 2.5 \text{ watt}$

SHORT ANSWER TYPE QUESTIONS(3 MARKS)

1. The magnetic flux linked with a coil passing perpendicular to the plane of the coil changes with time and given as: $\phi = 4t^2 + 2t + 3 \text{ weber}$, where t is in seconds. What is the magnitude of e.m.f. induced at t=1s.

Ans-Formula: $E = \frac{d\phi}{dt}, E = (8t+2) \text{ V}$, Now when t = 1 s then E = 10 volts.

2. Two coils have mutual inductance of 0.005H. The current changes in the first coil according to the equation $I = 10 \sin 100\pi tA$. Calculate the maximum value of e.m.f. in the second coil. Ans- 5$\pi$ volts.

3. How do R, $X_C$ and $X_L$ get affected when the frequency of applied AC is doubled?

Ans- (i) R remains unaffected. (ii) $X_S$ becomes doubled (iii) $X_C$ becomes halved.

4. A 44mH inductor is connected to 220 V, 50 Hz AC supply. Determine the rms value of current in the circuit.

Ans- $I_{rms} = \frac{V_{rms}}{X_L} = 15.9 \text{ A}$

5. In an LCR series circuit is connected to an AC source having voltage $V = V_0 \sin wt$. Derive expression for the impedance, instantaneous current and its phase relationship to the applied voltage.

Ans: $Z = \sqrt{R^2 + (X_L - X_C)^2}$, if $V_L > V_C, l = V_0 \sin(\omega t - \Phi)/Z, \tan\Phi = \frac{X_L - X_C}{R}$

6. An AC source of voltage $E = E_0 \sin \omega t$ is connected one by one to 3 circuit elements X, Y and Z. It is observed that the current flowing in them.
(a) Is in phase with applied voltage for element X.
(b) Lags applied voltage in phase by $\frac{\pi}{2}$ for element Y.
(c) Leads applied voltage in phase by $\frac{\pi}{2}$ for element Z.

Identify the three circuit elements. Ans: R, L, C.

7. Given below are two electric circuits A and B.

Calculate the ratio of power factor of the circuit B to the power factor of the circuit A. Ans: $\cos \varphi = \frac{R}{Z}$

8. An AC generator consists of a coil of 100 turns and cross sectional area 3 m², rotating at an angular frequency of 60 rad/s in a uniform magnetic field of 0.04 T, the resistance of the coil is 500 ohm.

(a) The maximum current drawn from the generator and
(b) The maximum power dissipated in the coil.

Ans: (a) 1.44, (b) 518.4

9. An AC voltage of 100 V, 50 Hz is connected across a 20 ohm resistor and 2 mH inductor in series. Calculate (a) Impedance of the circuit. (b) rms current in the circuit. Ans: (a) $Z = \sqrt{R^2 + X_L^2} = 20$ ohm (approx.), (b) rms current = $\frac{V}{Z} = 5$ A

11. (a) A series LCR circuit is connected to an a.c. source of variable frequency. Draw a suitable phasor diagram to deduce the expressions for the amplitude of the current and phase angle.

(b) Obtain the condition at resonance. Draw a plot showing the variation of current with the frequency of a.c. source for two resistances $R_1$ and $R_2$ ($R_1 > R_2$). Hence define the quality factor, Q and write its role in the tuning of the circuit.

Ans. (a) $I_m = \frac{V_m}{\sqrt{R^2 + (X_C - X_L)^2}}$

And

$\phi = tan^{-1} \left( \frac{X_C - X_L}{R} \right)$

(b)

Quality factor of LCR circuit is defined as $\frac{\omega_0}{2\Delta \omega}$.

A larger value of quality factor corresponds to a sharper resonance.

**PRACTICE QUESTIONS**
LONG ANSWER TYPE QUESTIONS (5 MARKS)

(1) State the working of AC generator with the help of a labeled diagram.

The coil of an AC generator having N turns each of area A is rotated with a constant angular velocity ω. Deduce the expression for alternating e.m.f. generated in the coil. What is the source of energy generation in this device?

(2) Explain the term inductive reactance. Show graphically the variation of inductive reactance with frequency of the applied alternating voltage.

An AC voltage \( E = E_0 \sin \omega t \) is applied across a pure inductor of inductance L. Show mathematically that the current flowing through it lags behind the applied voltage by a phase angle of \( \frac{\pi}{2} \).

(3) The figure shows a series LCR circuit with \( L = 5 \text{H} \), \( C = 80 \mu \text{F} \), and \( R = 40 \text{ohm} \) connected to a variable frequency 240 V source.

Calculate
(a) The angular frequency of the source which drives the circuit at resonance.
(b) The current at resonating frequency.
(c) The rms potential drop across the capacitor at resonance.

Ans:
(a) \( \omega = \frac{1}{\sqrt{LC}} = 15 \text{ rad/s} \)
(b) \( I_{\text{rms}} = \frac{V_{\text{rms}}}{R} = 6 \text{ A} \)
(c) \( V_{\text{rms}} = I_{\text{rms}} \times X_C = 1500 \text{ V} \)

(4) The primary coil of an ideal step-up transformer has 100 turns and transformation ratio is also 100. The input voltage and power are 220 V and 1100 W respectively.

Calculate
(a) Number of turns in the secondary. The current in the primary.
(b) Voltage across the secondary. The current in the secondary.
(c) Power in secondary

Ans: 
(a) 10,000 ( \( N_2/N_1 = 100 \) )
(b) \( P_1 = V_1 \times I_1, I_1 = 5 \text{ A} \)
(c) \( V_2/V_1 = N_2/N_1, V_2 = 22000 \text{ V} \)
(d) 0.05 A
(e) \( P_2 = P_1 = 1100 \text{ W} \)

EM Waves (Chap. 8)

VERY SHORT ANSWER TYPE QUESTIONS (1 MARK)

1. Why only microwaves are used in ovens?
Ans: The frequency of microwaves matches with the frequency of water molecules. So water can absorb energy from microwaves by resonance.

2. Name the waves used in radar. Write the order of their wavelengths.
Ans: Microwaves, order of wavelength (\( \lambda \)) = 10^{-2} \text{ m}.

3. What is the ratio of velocities of light rays of wavelength 4000 A\(^0\) and 8000 A\(^0\) in vacuum?
Ans: 1 since speed of all the EM waves in vacuum are same.

4. What is displacement current? Give its SI units.
Ans: Displacement current arises due to change in electric flux changing with time.
5. Name the electromagnetic radiations used for viewing the objects through haze and fog? Ans: IR

6. What did Maxwell prove about magnetic field?
   Ans. Magnetic field is produced not only by a current, but also by a time varying electric field.

7. What is the basic source of EM waves?
   Ans: An accelerating charge is a basic source of electromagnetic waves.

8. How are electric and magnetic fields related to each other?
   Ans: \( c = \frac{E}{B} \) where \( c \) is speed of light, \( E \) is electric field and \( B \) is magnetic field.

9. What is the basic difference between various types of EM waves?
   Ans. The basic difference between various types of EM waves lies in their wavelengths and frequencies.

10. In a plane e. m. wave, the electric field oscillates sinusoidal at a frequency of \( 2 \times 10^2 \) Hz and amplitude \( 48 \) V/m. What will be the amplitude of the magnetic field?
    Ans. \( (1.6 \times 10^{-7} \)T\) (Hint: \( B = E/c \))

11. Why are microwaves used in RADAR?
    Ans: because they have directional property

12. Radio waves and gamma rays both are transverse in nature and electromagnetic in character and have the same speed in vacuum. In what respects are they different?
    Ans. Radio waves have atomic origin, while the gamma rays are nuclear origin. Further owing to their very small wavelength, the gamma rays are highly penetrating in comparison to radio waves.

13. What is the main difference between characteristic X-ray and \( \alpha \)-rays?
    Ans. X-rays are emitted when orbital electron jumps from some outer shell to the inner shell in case of an atom of a heavy element. While \( \alpha \) are emitted by radio-active nuclei.

14. The wavelength of electromagnetic radiation is doubled? What will happen to the energy of the photon?
    Ans. The frequency and hence energy will become half.

15. Write the frequency limit of visible range of electromagnetic spectrum in kHz.
    Ans. \( 4 \times 10^{11} \) kHz– \( 8 \times 10^{11} \) kHz.

16. Name the part of the electromagnetic spectrum that is used to keep plants warm in green houses. Ans: IR

17. Optical and radio telescopes are built on the ground but X-ray astronomy is possible only from satellite of the earth why?
    Ans. X-rays are absorbed by the atmosphere. Also they are harmful for human beings, but visible and radio waves can penetrate through it.

18. Out of microwaves, ultraviolet rays and infrared rays, which radiation will be most effective for emission of electrons from a metallic surface?
    Ans. Ultraviolet rays are most effective for photoelectric emission because they have highest frequency and hence most energetic.

19. Give difference between the displacement current and conduction current?
Ans: Conduction current arises due to flow of electrons in the conductor whereas displacement current arises due to time varying electric field/flux.

20. The charging current for a capacitor is 0.25 A. What is the displacement current across its plates? Ans: 0.25 A

SHORT ANSWER TYPE QUESTIONS (2 MARKS)

Q.1 Give one use of each of the following--:
(i) Microwave, (ii) Infrared waves, (iii) UV radiations (iv) Gamma Radiations
Ans. (i) Long distance or Satellite communication. (ii) To treat muscular strains. (iii) Sterilizing surgical instruments, (iv) Radio Therapy

Q.2 Electromagnetic waves with wavelength
(i) \(\lambda_1\), are used to treat muscular strain.
(ii) \(\lambda_2\), are used by a FM radio station for broadcasting.
(iii) \(\lambda_3\), are produced by bombarding metal target by high speed electrons.
(iv) \(\lambda_4\), are absorbed by the ozone layer of the atmosphere.
Identify and name the part of electromagnetic spectrum to which these radiation belong. Arrange these wave lengths, in decreasing order of magnitude.
Ans: \(\lambda_1\) \(\rightarrow\) Infrared radiation. \(\lambda_2\) \(\rightarrow\) VHF/Radio waves.
\(\lambda_3\) \(\rightarrow\) X-rays, \(\lambda_4\) \(\rightarrow\) UV, \(\lambda_2 > \lambda_1 > \lambda_4 > \lambda_3\)

Q3: (a) Which of the following, if any, can act as a source of electromagnetic waves:
(i) A charge moving with constant velocity.
(ii) A charge moving in circular orbit. (iii) A charge at rest. Give reason
(b) Identify the part of electromagnetic spectrum to which the waves of frequency
(i) \(10^{20}\) Hz and (ii) \(10^9\) Hz belong.
Ans: (a) (i) Can’t produce em waves because no acceleration.
(ii) It is accelerated motion - can produce em waves.
(iii) Can’t produce em waves because no acceleration.
(b) (i) gamma rays (ii) Micro waves

SHORT ANSWER TYPE QUESTIONS (3 MARKS)

1. What do electromagnetic waves consists of? Explain as what factors does its velocity in vacuum depend?
Suppose that the electric field part of an electromagnetic wave in vacuum is
\[E = [(3.1 \times 10^4 \text{ N/C}) \cos \{(1.8 \text{ rad/m}) y + (5.4 \times 10^6 \text{ rad/s}) t\}] \hat{i}.\]
(i) What is the frequency? (ii) What is the wavelength?
(iii) Write an expression for the magnetic field part of the wave.
(iv) In which direction is the wave travelling?
Ans: Comparing given equation with \(E = E_0 \cos \{(ky + \omega t)\}\), we get, \(E_0 = (3.1 \times 10^4) \text{ NC}^{-1}\)
\(k = 1.8 \text{ radm}^{-1}\) And \(\omega = 5.4 \times 10^6 \text{ rad s}^{-1}\)
(i) \(\theta = \frac{\omega}{2\pi} = 8.6 \times 10^5 \text{ Hz}\), (ii) \(\lambda = \frac{2\pi}{k} = 3.5m\), (iii) \(B_0 = \frac{E_0}{c} = 1.03 \times 10^{-4} \text{T}\)
\(\therefore \vec{B} = [(1.03 \times 10^{-4}T) \cos \{(1.8 \text{ rad/m}) y + (5.4 \times 10^6 \text{ rad/s}) t\}] \hat{k}\)
(ii) \(y\)-axis
2. Find the wavelength of em wave of frequency $5 \times 10^{19}$ Hz in free space. Give its two applications. Ans. $\lambda = \frac{c}{v} = 0.06 \, \text{Å}$, This wavelength corresponds to x-rays. Uses: (i) medical diagnosis, in astronomy.

**PRACTICE QUESTIONS**

1. An electromagnetic wave exerts pressure on the surface on which it is incident. Justify.

2. Identify the part of the part of em spectrum:

   (i) Used in air craft navigation, (ii) Adjacent to low frequency em spectrum, (iii) Produced by bombarding a metal target by high speed electrons. (iv) For taking photograph of the sky during night and foggy days. Arrange them in increasing order of their wavelengths.

3. Give one use of each of the following: (i) Microwaves (ii) infrared waves (iii) ultraviolet radiation, (iv) Gamma rays (v) X-rays (vi) radio waves.

4. Show by going by simple example how electromagnetic waves carry energy and momentum.

   **Ans.** Consider a plane perpendicular to the direction of propagation of the wave. An electric charge, on the plane, will be set in motion by electric and magnetic fields of em wave, incident on this plane. This illustrates that em waves carry energy and momentum.

5. If the earth did not have atmosphere, would its average surface temperature be higher or lower than what it is now. Explain.

   **Ans.** (a). Average surface temperature will be lower because there will no green-house effect in absence of atmosphere.

   (b). Since electromagnetic waves carry both energy and momentum, therefore they exert pressure on the surface on which they are incident.

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**Ray Optics (Chap.9)**

**VERY SHORT ANSWER TYPE QUESTIONS (1 MARK)**

Q1 A glass lens of refractive index 1.5 is placed in a thorough of liquid. What must be the refractive index of the liquid in order to make the lens disappear?

   **Ans.** The glass lens will disappear in the liquid if the refractive index of liquid is equal to that of glass i.e., refractive index of liquid = 1.5.

Q2. How does the power of a convex lens vary, if the incident red light is replaced by violet light?

   **Ans** Power of a lens increases if red light is replaced by violet light.

Q.3 An object is held at the principal focus of a concave lens of focal length $f$. Where is the image formed?

   **Ans** Image will be formed between optical centre and focus of lens; towards the side of the object.

   \[
   \frac{1}{v} = \frac{1}{u} - \frac{1}{f}, \text{ u} = -f \text{ and } f = -f, \text{ we get } v = -\frac{f}{2}.
   \]

Q.4 At what angle of incidence should a light beam strike a glass slab of refractive index 3, such that the reflected and the refracted rays are perpendicular to each other?
The reflected and refracted rays are mutually perpendicular at polarizing angle; so from Brewster’s law $i_p = \tan^{-1}(n) = \tan^{-1}\sqrt{3} = 60^\circ$.

Q.5 Two thin lenses of power +6 D and −2 D are in contact. What is the focal length of the combination?

Ans Net power of lens combination $P = +6D - 2D = +4D$

$$P = \frac{1}{f} \Rightarrow f = \frac{1}{P} = \frac{1}{4} \text{ m} = 25 \text{ cm}$$

Q6 A converging lens is kept co-axially in contact with a diverging lens. Both the lenses are being of equal focal lengths. What is the focal length of the combination?

Ans Let focal length of converging and diverging lenses be $+f$ and $-f$ respectively.

Power of combination $P = P_1 + P_2 = \frac{1}{f} - \frac{1}{f} = 0$,

Now, focal length of the combination is: $f = 1/P$ or $P = 1/0 = \infty$.

Q7. Why does the sky appear blue?

Ans The light is scattered by air molecules. According to Lord Rayleigh the intensity of scattered light $\propto \frac{1}{\lambda^4}$

As $\lambda_{blue} < \lambda_{red}$ accordingly blue colour is scattered the most and red the least, so sky appears blue.

Q8 I. What is the relation between critical angle and refractive index of a material?

II. Does critical angle is depend on the colour of colour of right? Explain.

Ans. I. Reactive index $(\mu) = \frac{1}{\sin C}$, Where $C$ is the critical angle

II. Since, refractive index on the depends upon the wavelength of the light, the critical angle for a given pair of media for a different for a different wavelength (colors) of light.

SHORT ANSWER TYPE QUESTIONS (2 MARKS)

Q.1. (a) A mobile phone lines along the principal axis a concave mirror show, with the help of a suitable diagram, the formation of its image. Explain why magnification is not uniform.

(b) Suppose the lower half of the concave mirror’s reflecting surface is covered with an opaque material. What effect this will have on the image of the object?

Ans. (a)

(b) Only intensity will reduce.

Q1. A ray of light incident on an equilateral glass prism $(\mu = \sqrt{3})$ moves parallel to the base line of the prism inside it. Find the angle of incidence for this ray.
Ans. Angle of refraction = $30^\circ$

Refractive index $\mu = \sqrt{3}$

By Snell’s law $\mu = \frac{\sin I}{\sin i}$

$$\sin I = \sqrt{3} \sin 30 = \frac{\sqrt{3}}{2}, \quad \text{So} \quad i = 60^\circ$$

Q2 Two convex lenses of same focal length but of aperture $A_1$ and $A_2$ ($A_1 < A_2$) are used as the objective lenses in two astronomical telescopes having identical eyepieces. What is the ratio of their resolving power? Which telescope will you prefer and why?

Ans. We know that large the aperture of objective larger the resolving power.

Ratio of their resolving power = $A_1/A_2$

We will prefer telescope $A_2$ as having large resolving power.

Q3. A convex lens made up of glass of refractive index 1.5 is dipped in turn in (i) a medium of refractive index 1.65 (ii) a medium of refractive index 1.33.

a) Will it behave as a converging lens or a diverging lens in two cases?

b) How will its focal length change in two media?

Ans. As per lens maker’s formula

$$\frac{1}{f} = \left(\frac{n_2 - n_1}{n_1}\right) \left(\frac{1}{r} - \frac{1}{r'}\right)$$

Where $n_2$ is the refractive index of lens and $n_1$ is the refractive index of medium

(a) When lens is immersed in the medium of refractive index greater than that of lens then converging lens behave as diverging.

(b) When it is immersed in the medium of refractive index 1.00 then its nature remains same while focal length increases.

Q4 (a) The bluish color predominates in the clear sky.

(b) Violet colour is seen at the bottom of the spectrum when white light is dispersed by a prism. State reasons to explain these observations.

Ans. (A) According to Rayleigh scattering, scattering of light is inversely proportional to the fourth power of wave length, wave length of blue color is least so scatter in large amount.

(b) As per Cauchy relation the deviation or bending of light is inversely proportional to the wavelength and wavelength of violet is small so bending will be large.

Q5. An illuminated object and a screen are placed 90 cm apart. Determine the focal length and nature of the lens required to produce a clear image on the screen, twice the size of the object.

Ans. Magnification $m = -2 = \frac{v}{u}$ \implies \( v = -2u \)

Given that $v + u = 9$

So: $2u + u = 90 \implies 3u = 90 \implies u = 30$

Then $v = 60$

Use Lens formula: $f = 20$ cm,
Nature of lens: Convex (Converging) lens.

Q6 How is the resolving power of a microscope affected when,

(i) The wavelength of illuminating radiations is decreased?

(ii) The diameter of the objective lens is decreased? Justify your answer.

Ans Resolving power of microscope is $2\mu \sin \beta / 1.22\lambda$

i) As wavelength decreases resolving power increases.

ii) Resolving power is decreases as diameter of objective decreases.

Q7 A ray of light passing through a triangular glass prism from air undergoes minimum deviation when angle of incidence is $\frac{3}{4}$ of the angle of prism. Calculate the speed of light in the prism.

Ans We know that

$r_1 + r_2 = \lambda = 60^\circ$

When light undergoes minimum deviation then $r_1 = r_2$ therefore $r = 30^\circ$
Given that \( i = 34^\circ (60) = 45^\circ \)

Now \( \mu = \frac{c_1}{c_2} = \frac{\sin i}{\sin r} \Rightarrow \frac{c_1}{c_2} = \frac{1}{\sqrt{2}}/\frac{1}{2} = \sqrt{2} = 1.414 \)

So \( c_2 = 2.12 \times 10^8 \text{ m/s} \).

**Q8**  
Draw a labeled ray diagram of compound microscope in near point position. 
Write the expression for its magnifying power.

\[
m = \frac{L}{f_0} (1 + \frac{d}{f_e})
\]

**Q9**  
A convex lens and a concave mirror of same focal length in air are immersed in water of refractive index 4/3. What will be the effect on their focal lengths. Justify your answer.

Ans:  
In lens refraction takes place so focal length of convex lens increases as relative refractive index decreases while in mirror reflection takes place so there will be no change in the focal length.

**Q10:**  
A beam of light converges to a point P. A lens is placed in the path of the convergent beam 12 cm from P. At what point does the beam converges, if the lens is a convex lens of focal length 20 cm.

Ans:  
\[ u = 12 \text{ cm, } f = 20 \text{ cm} \]

Formula: 
\[
\frac{1}{f} = \frac{1}{v} - \frac{1}{u}
\]

\[
\frac{1}{20} = \frac{1}{v} - \frac{1}{12}
\]

After simplifying \( v = +7.5 \text{ cm} \) from the lens. As \( v \) comes out to be positive so image will be real.

**Q11:**  
What do you understand by the phenomena of total internal reflection. Give two conditions for it to take place.

Ans:  
When a ray of light is allowed to incident on an interface from denser medium side at an angle greater than critical angle then light suffer total internal reflection.  
Two conditions:  
  i) Ray should go from denser medium to rarer medium.  
  ii) The angle of incidence should be greater than critical angle.

**Q12:**  
On what factors the critical angle for given media depends.

Ans:  
Nature of medium in contacts and wavelength of light used.

**SHORT ANSWER TYPE QUESTIONS (3 MARKS)**

**Q2**  
i) Draw a neat labeled ray diagram of an astronomical telescope in normal adjustment.

Explain its working briefly.
(ii) An astronomical telescope uses two lenses of powers 10D and 1D. What is its magnifying power in normal adjustment?

**Ans.**

Light from a distant object enters the objective and a real image is formed in the tube at its second focal point. The eye piece magnifies this image producing a final inverted image at infinity.

**Calculation of magnifying power:**

Given: Power of eyepiece = 10D
Power of objective = 1D
Magnifying power in normal adjustment: \( m = \frac{f_0}{f_e} = \frac{P_e}{P_o} = \frac{10}{1} = 10 \)

Q3 The radii of curvature of the faces of a double convex lens are 10 cm and 15 cm. If the focal length if the lens is 12 cm find the refractive index of the material of lens.

**Ans.** By lens maker’s formula

\[ \frac{1}{f} = (n_2 - n_1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right) \]

\[ \frac{1}{12} = (n - 1) \left( \frac{1}{10} - \frac{1}{15} \right) \text{ or } \frac{1}{12} = (n - 1) \left( \frac{1}{15} \right) \]

After simplification: \( n = 1.5 \)

Q5 A compound microscope uses an objective lens of focal length 4 cm and eye piece lens of focal length 10 cm. An object is placed at 6 cm from the objective lens. Calculate the magnifying power of the compound microscope. Also calculate the length of microscope.

**Ans:**

Formula used

\[ \frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0} \]

\( v_0 = 12 \text{ cm} \)

Magnification by eyepiece \( m_e = 1 + \frac{f_e}{D} = 3.5 \) or 2.5

\( m = m_e \cdot m_o = 7 \) or 5

Length of microscope \( L = v_0 + u_0 = 19.1 \text{ cm} \)

Q7: A convex lens made up of glass of refractive index 1.5 is dipped in turn in (i) a medium of refractive index 1.65 (ii) a medium of refractive index 1.33.

a) Will it behave as a converging lens or a diverging lens in two cases?

b) How will its focal length change in two media?

**Ans.**

As per lens maker's formula \( \frac{1}{f} = \frac{(n_2 - n_1)}{n_1} (1/R-1/r) \)

Where \( n_2 \) is the refractive index of lens and \( n_1 \) is the refractive index of medium

a) When lens is immersed in the medium of refractive index greater then that of lens then converging lens behave as diverging. And and when it is immersed in the medium of refractive index 1.00 then its nature remains same while focal length increases.

Q11: The following data was recorded for the values of the object distance and the corresponding values of image distance in the experiment on study of real image formation by a convex lens of power 5D. One of these observations is incorrect. Identify that observation and give the reason for your choice

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<th>3</th>
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<td>61</td>
<td>37</td>
<td>35</td>
<td>32</td>
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</tbody>
</table>
**Ans:** The power of lens is = 5 D, Focal length = 20 cm

Observation-3 is incorrect because if object is between f and 2f then image will be formed beyond 2f.

**LONG ANSWER TYPE QUESTIONS (5 MARKS)**

**Q1**  
(a) A convex lens of focal length $f_1$ is kept in contact with a concave lens of focal length $f_2$. Find the focal length of the combination. When will it be converging and diverging.

(b) A parallel beam of light of 500nm falls on a narrow slit and the resulting diffraction pattern is observed on a screen 1 m away. It is observed that the first minimum is at a distance of 2.5 mm from the centre of the screen Calculate the width of the slit.

**Ans**(a) We know that when lenses are put in combination then their focal length comes out to be

\[ \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} \]

As focal length of concave lens is negative so

\[ \frac{1}{f} = \frac{1}{f_1} - \frac{1}{f_2} \]

If $f_1$ is greater than $f_2$ then combination will be converging and if $f_1$ is less than $f_2$ it will be diverging. If $f_1$ and $f_2$ are equal then combination behave as a plane glass.

(b) wave length $\lambda = 500 \times 10^{-9}$ m

Separation between slit and screen $D= 1$ m

Distance of first min. $x = 2.5 \times 10^{-3}$ m

By using formula:

\[ X = \lambda \frac{D}{d}, \quad d = \lambda \frac{D}{x} = 500 \times 10^{-9} \times 1 / 2.5 \times 10^{-3} = 2 \times 10^{-4}$ m

**Q4**  
Draw a ray diagram to show the image formation by a concave mirror when the object is kept between its focus and pole. Using this diagram, derive the magnification formula.

**Ans.**

\[ \Delta ABP \text{ is similar to } \Delta A'B'P \]

\[ \frac{A'B'}{AB} = \frac{B'P}{BP} \]

Now $A'B' = 1$, $AB = 0$, $B'P = +ve$ and $BP = -u$

\[ \text{So magnification } m = \frac{1}{0} = -\frac{v}{u} \]

**IMPORTANT NUMERICALS**

1. A converging lens has a focal length of 20 cm in air. It is made of material of refractive index 1.5. If it is immersed in water of refractive index 4/3. What will be the new focal length?
Ans: Given $f_a = 20 \text{ cm}, n_\alpha = 1.5, n_t = 4/3$

$$f_i = \frac{n_\alpha - 1}{n_t - 1} \times f_a = \frac{1.5 - 1}{\left(\frac{4}{3} - 1\right)} \times 20 \text{ cm} = 80 \text{ cm}$$

2. An illuminated object and a screen are placed 90 cm apart. Determine the focal length and nature of the lens required to produce a clear image on the screen twice the size of the object.

Ans: Given $u+v = 90 \text{ cm}$ ..........(1)

$$\frac{v}{u} \text{ gives} \quad \frac{|v|}{|u|} = 2 \quad \text{or} \quad v = 2u \quad .......(2)$$

from eq 1 & 2 we get $|u| = 30 \text{ cm}$ and $|v| = 60 \text{ cm}$

from sign convention, $u = -30 \text{ cm}$ and $v = 60 \text{ cm}$

using lens formula we get $f = 20 \text{ cm}$ (convex lens)

3. Two lenses of power 10D and -5D are placed in contact.
   a. Calculate the power of lens combination.
   b. Where should an object be placed from the lens so as to obtain a virtual image of magnification 2?

Ans :
   a. Given $P_1 = 10 \text{ D}, P_2 = -5 \text{ D}$

$$P = P_1 + P_2 = 10D + (-5D) = 5D$$
   b. Focal Length $F = \frac{1}{P} = \frac{1}{5} = 20\text{cm} \text{ (convergent lens)}$

Magnification $m = \frac{v}{u} = +2 => v = 2u$

From lens formula $u = -10 \text{ cm}$.

VALUE BASED QUESTION

Q1 One day Chetan’s mother developed a severe stomach ache all of a sudden. She was rushed to the doctor who suggested for an immediate endoscopy test and gave an estimate of expenditure for the same. Chetan immediately contacted his class teacher and shared the information with her. The class teacher arranged for the money and rushed to the hospital. On realising that Chetan belonged to a below average income group family, even the doctor offered concession for the test fee. The test was conducted successfully. Answer the following questions based on the above information:

(a) Which principle in optics is made use of in endoscopy?
(b) Briefly explain the values reflected in the action taken by the teacher.
(c) In what way do you appreciate the response of the doctor on the given situation?

Ans. (a) Total internal reflection: If a light ray enters at one end of an optic fibre coated with a material of low refractive index, it refracted and strikes the walls at angle greater than critical angle. Thus light rays shows multiple reflections, without being absorbed at the side walls.

(b) The teacher knows that Chetan belongs to a below average income group family, so he/she immediately arranged the money required to be paid as test fee. His/her caring and helping attitude towards the others resulted in timely help to Chetan’s mother. Such helping attitude on the part of the person living in the society makes it a better society to live in.

(c) Seeing the situation of Chetan’s family and helping attitude of class teacher, doctor took the sympathetic view of the situation, and give the reduction in fee, which is highly appreciable. Such professional ethics of doctor in the society would be an immense help to the person’s belonging to below average income groups.
QUESTIONS FOR PRACTICE

Q1: Obtain lens maker’s formula using the expression:
\[ \frac{n_2}{v'} - \frac{n_1}{u} = \frac{n_2 - n_1}{R_1} \]

Here the ray of light propagating from a rarer medium of refractive index \(n_1\) to a denser medium of refractive index \(n_2\) is incident on the convex side of spherical refracting surface of radius of curvature \(R\).

Q2: Draw a ray diagram to show refraction of ray of monochromatic light passing through a glass prism. Deduce the expression for the refractive index of glass prism in terms of the angle of prism and angle of minimum deviation.

Q3: You are given three lenses \(L_1, L_2,\) and \(L_3\), each of focal length 20 cm. An object is kept at 40 cm in front of \(L_1\) as shown. The final real image is formed at the focus ‘I’ of \(L_3\). Find the separation between \(L_1, L_2,\) and \(L_3\).

Q5: (a) A point object is placed in front of a double concave lens (of refractive index \(n = n_2/n_1\) with respect to air) with the special face of radii of curvature \(R_1\) and \(R_2\). Show the path of rays due to refraction at first and subsequently at the second surface to obtain the formation of the real image of the object.

Hence obtain the lens marker’s formula for a thin lens

(b) A double convex lens having both faces of the same radius of curvature of the lens required to get the focal length of 20 cm. (Ans. \(R = 22\) cm)

WAVE OPTICS (Chap. 10)

Very Short Answer Type Questions (1 Mark)

Q1. An object is seen first in red light & then in violet light through a simple microscope. In which case is magnifying power large?

**Ans:** It is larger when seen in violet light.

Q2. Name the wave phenomenon which is exhibited by light waves but not by sound waves.

**Ans:** Polarization

Q3. Define elliptically polarized light.

**Ans:** - Suppose we have plane polarized light with \(E\) inclined at an angle \(45^\circ\) with the direction of propagation. Pass this light through the quarter wave plate. The resultant light obtained is called elliptically polarized light.

Q4. How is a wavefront to the direction of corresponding rays?

**Ans:** The wavefront is always perpendicular to the direction of rays.

Q5. What is the phase difference between any two points on a wavefront?

**Ans:** Zero.

Q6. If a wavefront undergoes refraction, what happens to its phase?

**Ans:** There is no change in its phase.

Q7. What is the geometrical shape of the wave front in each of the following cases?
(a) Light diverging from a point source.
(b) Light emerging out of a convex lens, when a point source is placed at its focus.
(c) The portion of the wave front of light from a distant star intercepted by the earth.

Ans. (a) Spherical in shape, (b) Plane wave front, (c) Plane wave front.

Q8. State two conditions, which must be satisfied for two light sources to be coherent.

Ans. (i) The two light waves should be of same wavelength.
(ii) The two light waves should either be in phase or should have a constant phase difference.

Q9. What happens to the interference pattern, if the phase difference between the two sources continuously varies?

Ans. The position of minima and maxima will also vary. Such an interference pattern will not be a sustained one and it will not be observed.

Q10. The phase difference between two light waves from two slits of Young’s experiment is ‘3π’ radian. What will be the nature of the central fringe in the fringe pattern?

Ans. It will be dark.

Q11. State the condition for diffraction of light to occur.

Ans. The size of the obstacle should be of the order of the wavelength of light used.

Q12. How does resolving power of a telescope change on decreasing the aperture of its object lens? Justify your answer.

Ans. Resolving power of a telescope = D/1.22l. Therefore, on decreasing aperture (D) of the objective lens, the resolving power of the telescope decreases.

Q13. Which phenomenon establishes that light waves are transverse in nature?

Ans. Only transverse waves can be polarized. Since light waves can be polarized, they must be transverse in nature.

Q14. Can you detect by the naked eye, whether given light is polarized or not? Why?

Ans. No. because human eye is a lens and the slit or rectangular aperture.

Q15. A ray of light is incident on a medium at polarizing angle. What is the angle between the reflected and refracted rays?

Ans. It is 90°.

Q16. What are the uses of Polaroid?

Ans. Polaroids are used in sunglasses, in wind shields of automobiles, in window panes, in making three dimensional motion pictures.

Q17. Draw intensity distribution curve for diffraction.

Ans:
Short Answer Type Questions (2 MARKS)

Q1. Why no interference is observed, when two coherent sources are (i) infinitely close to each other (ii) far apart from each other?

**Ans.** We know that the fringe width is given by $\beta = \frac{\lambda D}{d}$.

(i) In case the two sources are infinitely close to each other means $d$ is about to zero and $\beta$ will be very large so general illumination will take place.

(ii) When the two sources are moved far apart ($d$ very large), the fringe width will be very small and they will not be separately visible.

Q2. What is the effect on the interference fringes in a Young's double slit experiment due to each of the following operations?

(a) The screen is moved away from the plane of the slits.
(b) The source is replaced by another source of shorter wavelength.

**Ans.** We know that the fringe width is given by $\beta = \frac{\lambda D}{d}$.

(a) Fringe width increases, since $D$ increases.

(b) Fringe width decrease in $\lambda$ decrease fringe.

Q3. What will be the effect on the interference fringes in a Young's double slit if: (a) the apparatus is immersed in water, (b) white light is used instead of monochromatic light.

**Ans.** (a) for a medium of refractive index $\mu$, the fringe width is given by: $\beta = \frac{\beta_o}{\mu}$.

Where $\beta_o$ is the fringe width in air. Hence, the fringe width decreases to $1/\mu$ times.

(b) The different colors of white light will produce different interference patterns but the central bright fringes due to all colors are at the same position. Therefore, the central bright fringe is white in color. Since the wavelength of the blue light is smallest, the fringe closest on the either side of the central white fringe is blue and the farthest is red. Beyond a few fringes, no clear fringe pattern is visible.

Q4. Draw the intensity pattern obtained in Young's double slit experiment.

**Ans:** intensity distribution curve for interference.

Q5. How does the resolving power of a compound microscope change on

(i) Decreasing the wavelength of light used, and
(ii) Decreasing the diameter of its object lens?

Ans. Resolving Power of a microscope = \(2\mu \sin \theta / \lambda\)

(i) On decreasing the wavelength of light, resolving power will increase.

(ii) On decreasing diameter of objective lens, semi vertical angle \(\theta\) will decrease and hence resolving power will decrease.

Q6. Define critical angle and polarizing angle. What is the relation between the two?

Ans. Critical Angle (C): It is the angle of incidence in denser medium, at which the ray of light after undergoing refraction at the surface of separation of the two media, becomes parallel to the surface of separation. Polarizing angle (p): The angle of incidence, at which when ordinary light is incident on transparent refracting medium, the reflected light becomes maximum rich in plane polarized light is called polarizing.

Q7. Write two points of difference between interference and diffraction on the basis of (a) change in intensity of bright fringe (b) fringe width

Ans: -

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Interference</th>
<th>Diffraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All the bright fringes are of same intensity.</td>
<td>The intensity of bright fringes decreases with increasing distance from the central bright fringe.</td>
</tr>
<tr>
<td>2</td>
<td>For monochromatic light the fringe width is same</td>
<td>The width of diffraction fringe is never same.</td>
</tr>
</tbody>
</table>

Q8. Light of wavelength 600 nm is incident on an aperture of size 2 mm. Calculate the distance up to which the ray of light can travel such that its spread is less than the size of aperture.

Ans: -

Given: \(d = 2 \times 10^{-3} m\), \(\lambda = 6 \times 10^{-7} m\)

\[s = \frac{A^2}{\lambda} = \frac{(2 \times 10^{-3} m)^2}{6 \times 10^{-7} m} = 6.6 m\]

Q9. Consider interference between waves from two sources of intensities \(I\) and \(4I\). Find the intensities at points where the phase difference is (a) 0 (b) \(\pi /2\) and (c) \(\pi\).

Solution: - The resultant intensity at a point where two waves of amplitude \(a_1^2\) and \(a_2^2\) meet with a phase difference of \(\Phi\) is given by:

\[I_R = a_1^2 + a_2^2 + 2a_1a_2\cos \Phi\]

Here - \(a_1^2 = I\), SO \(I_R = I + 4I + 2\sqrt{I}\sqrt{4I}\cos \Phi\). Now: (a) for \(\Phi = 0\), \(I_R = 9I\)

(b) for \(\Phi = \pi /2\), \(I_R = 5I\)

(c) for \(\Phi = \pi\), \(I_R = I\)
Q.10 (a) State and explain Huygen's principle.

(b) Draw the wave front that corresponds to a beam of light; (i) coming from a very far off source (ii) diverging radically from a point.

Ans:-(a) (i) Every point on primary wave front acts as a source of secondary wavelets. These wavelets travel in the medium with same velocity of the primary waves in all the possible directions.

(ii) The forward envelope on the secondary wavelets gives new wave front.

(b) Wave fronts:

Short Answer Type Questions(3 Marks)

Q1. (a) Why are the coherent sources necessary to produce a sustained interference pattern?

(b) In Young's double slit experiment using monochromatic light of wavelength $\lambda$, the intensity of light at a point on the screen where the path difference is $\lambda$, is K units. Find out the intensity of light at a point where path difference is $2\lambda/3$.

Ans: Coherent sources mean the sources that produce light of constant phase difference which is the essential condition for the sustained interference.

$I=4I_0 \cos^2 \frac{\theta}{2}$ where $\theta$ is phase difference

If path diff. is $\lambda$ then phase diff. will be $2\pi$

If path diff. is $\frac{3}{2}\lambda$ then phase diff. will be $4\pi/3$

So $I = 4 I_0 \cos^2 \frac{\theta}{2} = 4 I_0 \times 1/4 = I_0$

$I_0 = K/4$

Q2. (a) Why is diffraction of sound waves easier to observe than diffraction of light waves? (b) What two main changes in diffraction pattern of single slit will you observe when the monochromatic source of light is replaced by a source of white light?

Ans:-(a) for diffraction to occur, the size of the obstacle should be comparable to the wavelength. Wavelength of sound waves is comparable to the daily life objects while wavelength of light is much smaller. Hence it is easier to observe than diffraction of light waves.

(b) With white light diffraction pattern shows following changes:-

(i) the diffraction band is colored although the central maximum is white.

(ii) As bandwidth is proportional to the wavelength, so red band with higher wavelength is wider than blue band with smaller wavelength.

Q3. Deduce the law of refraction on the basis of Huygen’s principle.

(Refer NCERT Text book topic number 10.3.1)
Q4.  (a) Sketch the graph showing the variation of intensity of transmitted light on the angle of rotation between a polarizer and analyzer.

(b) A ray of light is incident at an angle of incidence $I_P$ on the surface of separation between air and a medium of refractive index $\mu$, such that the angle between the reflected and refracted ray is $90^\circ$. Obtain the relation between $I_P$ and $\mu$. (CBSE-1998, 2001, 2002.)

**Ans :**
(a) From Malus law: $I = I_0 \cos^2 \theta$

(b) According to the question - $I_P + r = 90^\circ$

Or $r = 90^\circ - I_P$

From Snell’s law, $\mu = \frac{\sin I_P}{\sin r} = \frac{\sin I_P}{\sin(90^\circ - I_P)}$

$= \frac{\sin I_P}{\cos I_P}$

Or $\mu = \tan I_P$

This is the required relation & known as **Brewster’s Law**.

Q5. In Young’s double slit experiment, while using a source of light of wave length 5000 Å, the fringe width obtained is 0.6 cm. If the distance between the slits and the screen is reduced to half, calculate the new fringe width.

**Sol.** $\beta = 0.6 \text{ cm}$ Since: $\beta = \lambda \frac{D}{d}$

Therefore, $\frac{\beta_2}{\beta_1} = \frac{D_2}{D_1} \frac{\beta_2}{\beta_1}$

but $D_2 = D_1/2$

Therefore, $\beta_2 = (D_1/2D_1) \beta_1$

$= \frac{1}{2} \beta_1 = \frac{1}{2} 0.6$

$= 0.3 \text{ cm}$

Q6. Red light of wave length 6500 Å from a distant source falls on a slit 0.50 mm wide. What is the distance between the two dark bands on each side of the central brightband of diffraction pattern observed on a screen placed 1.8 m from the slit?

**Sol.** Distance between the two dark bands on each side of the central maximum of diffraction pattern = width of the central maximum, Therefore $x = \frac{(2 \lambda D)}{d}$

$\lambda = 6500 \text{ Å} = 6.5 \times 10^{-7} \text{ m}$, $D = 1.8 \text{ m}$, $d = 0.5 \text{ mm} = 0.5 \times 10^{-3} \text{ m}$

$x = \frac{2 \times 6.5 \times 10^{-7} \times 1.8}{0.5 \times 10^{-3}}$

$= 4.68 \times 10^{-3} \text{ m}$

$= 4.68 \text{ mm}$

Q7. A slit of width ‘a’ is illuminated by light of wavelength 6000 Å. For what value of ‘a’ will the first maximum fall at an angle of diffraction of 30º? (ii) First minimum fall at an angle of diffraction 30º?
Sol. \( \lambda = 6000 \, \text{Å} = 6 \times 10^{-7} \, \text{m}, \, \theta = 30^\circ, \, n = 1 \)

For the first maximum of diffraction pattern

\[
\sin \theta_n = (2n+1) \frac{\lambda}{2d}, \quad \sin \theta_1 = \frac{3 \lambda}{2d}
\]

or \( a = \frac{3 \lambda}{2 \sin \theta} = \frac{3 \times 6 \times 10^{-7}}{2 \sin 30^\circ} = 1.8 \times 10^{-6} \, \text{m} \)

For first minimum of diffraction pattern.

\[
\sin \theta_n = n \frac{\lambda}{d} \quad \text{or} \quad \sin \theta_1 = \frac{\lambda}{d}
\]

\( a = \frac{\lambda}{\sin \theta_1} = \frac{6 \times 10^{-7}}{0.5} = 1.2 \times 10^{-6} \, \text{m} \)

QUESTIONS FOR PRACTICE

Q.1. (a) Derive the expression for fringe width in Young’s double slit experiment.

(b) Explain the effect on fringe width when:

(i) The separation between the slits is increased

(ii) The screen is moved away from the slits

(ii) The monochromatic source is replaced by the monochromatic source of smaller wavelength

(iv) The monochromatic source is replaced by white light.

Q.2. (i) Distinguish between un-polarized and linearly polarized light.

(ii) What does a Polaroid consist of? How does it produce linearly polarized light?

(iii) Explain briefly how sunlight is polarized by scattering through atmospheric particles.

Q.3. Two polaroids 'A' and 'B' are kept in crossed position. How should a third polaroid 'C' be placed between them so that the intensity of polarized light transmitted by polaroid B reduces to \(1/8\)th of the intensity of unpolarised light incident on A?

Q.4 In young’s double slit experiment, derive the condition for

i. Constructive interference and

ii. Destructive interference at a point on the screen.

iii. Draw the graph showing the variation of intensity with distance from the centre.
Dual Nature of Matter (Chap. 11)

VERY SHORT ANSWER TYPE QUESTIONS (1 MARK)

Q1. Express de Broglie wavelength associated with electron in terms of accelerated voltage.
Ans. \( \lambda = \frac{h}{\sqrt{2meV}} = \frac{12.27}{\sqrt{V}} \text{Å} \)

Q2. An electron and a proton have the same kinetic energy. Which one of the two has the larger wavelength and why?
Ans. According to de Broglie equation in terms of kinetic energy as electron has smaller mass than a proton hence an electron has the larger wavelength because

\[ \lambda = \frac{h}{\sqrt{2mE}} \alpha \frac{1}{\sqrt{m}} \]

Q3. Show graphically the variation of the de Broglie wavelength with the potential difference the electron is accelerated?
Ans.: As de Broglie wavelength \( \lambda \propto \frac{1}{\sqrt{V}} \)

So

\[ \text{Fig. 5} \]

Q4. The maximum kinetic energy of a photoelectron is 3 eV. What is its stopping potential?
Ans.: Stopping potential, \( V_o = \frac{\text{Kinetic energy}}{e} = 3 \text{ eV} / e = 3V \)

Q5. What is threshold frequency? Does it depend on the nature of emitter?
Ans.: The minimum value of the frequency of incident radiation below which the photoelectric emission stops altogether is called threshold frequency. Yes, threshold frequency depends on the nature of photoelectric emitter.

Q6. Calculate the frequency associated with photon of energy 3.3x10^{-10} J?
Ans.: \( E = h \nu \Rightarrow \nu = \frac{E}{h} = 5 \times 10^{23} \text{ Hz} \)

Q7. If the intensity of the incident radiation in a photo cell is increased, how does the stopping potential varies?
Ans.: Stopping potential remains unaffected.

Q8. Do non-metals show photoelectric effect?
Ans.: Yes for higher value of frequency of em waves.

Q9. What determine the velocity of the photoelectrons?
Ans.: It depends on the frequency of incident radiation and work function of metal surface.

Q10. Can we use any substance as photoelectric emitter?
Ans.: Yes by exposing the surface by suitable electromagnetic radiations.

SHORT ANSWER TYPE QUESTIONS (2 MARKS)

Q1. An electron and a proton have the same de Broglie wavelength associated with them. How is their K. E. related with each other?
Ans.: de Broglie wavelength, \( \lambda = \frac{h}{\sqrt{2mE}} \)

Given \( \lambda_e = \lambda_p \Rightarrow \left[ \frac{h}{\sqrt{2mE}} \right]_e = \left[ \frac{h}{\sqrt{2mE}} \right]_p \)

\[ \Rightarrow \frac{E_e}{E_p} = \frac{m_p}{m_e} \approx 1840, \text{ Hence K.E. of electron} = 1840 \times \text{(K.E. of proton)} \]
Q2. What is the effect on the velocity of the photoelectrons if the wavelength of incident light is decreased?
Ans. 

Kinetic energy of photoelectrons is given by Einstein's photoelectric equation,

\[ K_{\text{max}} = \frac{1}{2}mv^2_{\text{max}} = h\nu - W_0 = \frac{hc}{\lambda} - W_0 \]

So \[ v^2_{\text{max}} \propto \frac{1}{\lambda} \] or \[ v_{\text{max}} \propto \frac{1}{\sqrt{\lambda}} \]

As the wavelength of incident light decreases, the velocity of photoelectrons increases.

Q3. Which parameters are kept as constant in the fig. 4 above? Give the relation between frequencies of incident radiations.
Ans. Intensity of incident radiation is kept as a constant.
\[ \nu_1 < \nu_2 < \nu_3 \]

Q4. The two lines A and B shown in the graph is the plot of de Broglie wavelength as a function of \[ \frac{1}{\sqrt{\nu}} \] for two particles having the same charge. Which of the two represent the particle of heavier mass?
Ans. 

A7) de Broglie wavelength, \[ \lambda = \frac{h}{\sqrt{2mq\nu}} = \frac{h}{\sqrt{2mq}} \cdot \frac{1}{\sqrt{\nu}} \]

So slope of \( \lambda \) versus \( \frac{1}{\sqrt{\nu}} \) graph = \[ \frac{h}{\sqrt{2mq}} \]

For the particles of same charge \( q \), slope \( \propto \frac{1}{\sqrt{m}} \)

As the slope of line A is smaller than that of line B, so the line A represents the heavier particle.

Q5. A radio transmitter at a frequency of 880 kHz and a power of 10 kW. Find the no. of photons emitted per second.
Ans. As \[ n = \frac{\text{energy emitted per second}}{\text{energy of one photon}} = 1.716 \times 10^{31} \]

Q6. Two beams, one of red light and the other of blue light of the same intensity are incident on a metallic surface to emit electrons. Which one of the two beams emits electrons of greater kinetic energy?
Ans: Blue light emits electron of greater kinetic energy.

Q7. Light from bulb falls on a wooden table but no electrons are emitted Why?
Ans: The work function of wooden table is very high than the energy of light available from bulb. Hence no photoelectric emission takes place.

Q8. Light of frequency 1.5 times the threshold frequency is incident on a photosensitive material. If the frequency is halved and intensity is doubled then what happens to photoelectric current.

Ans: Photoelectric current becomes zero as no photoelectrons emitted because frequency of incident radiation decreases below the threshold.

Q9. A particle of mass M at rest decays into two particles of masses m₁ and m₂ having non zero velocities. What is the ratio of the de Broglie wavelength of the two particles?

Ans: By conservation of linear momentum,

\[ m_1 v_1 + m_2 v_2 = M \times 0 \quad \text{or} \quad m_1 v_1 = -m_2 v_2 \]

so \[ \frac{m_1}{m_2} = \frac{|v_2|}{|v_1|} = 1 \]

Q10. The plot between the maximum kinetic energy of photoelectrons versus frequency of incident radiations is shown below for two surfaces A and B. Answer the followings:

a. Which of the metal has greater work function?

b. For which of the metals will stopping potential be more for the same frequency of incident radiations?

Ans. a. Metal B has greater work function.
b. Metal A has more stopping potential.

Q11. The frequency of incident light on a metal surface is doubled. How will this affect the value of kinetic energy emitted photoelectrons?

Ans.

\[ h\nu = \phi + \text{K.E.} \quad \text{so} \quad h\nu_1 = \phi + k_1 \quad \text{and} \quad h\nu_2 = \phi + k_2 \]

Dividing \[ \frac{v_1}{v_2} = \frac{\phi + k_2}{\phi + k_1} \quad \text{or} \quad 2 = \frac{\phi + k_2}{\phi + k_1} \quad \text{as} \quad v_2 = 2 v_1 \]

So \[ k_2 = \phi + 2k_1 \]

Kinetic energy will become slightly more than double.

Q13. An electron and a proton are accelerated through the same potential. Which one of these two has

(i) Greater value of de Broglie wavelength associated with it and (ii) less momentum justify your answer.
Q14. What is the significance or objective of Davisson and Germer experiment?
Ans.: To prove wave nature of particles experimentally.

Value Based Questions
Q1. In a multistoried building, once a fire broke out at midnight due to electrical short circuit. Ravi along with others rushed to the spot, informed the fire service and put off the fire. But by that time a huge amount of damage had already been done. Ravi being Secretary of the building decided to fix fire alarms (using photo cell) in all the floors: (a) What values were shown by Ravi in this situation?
(b) On what principal fire alarm work?
Ans.: Ravi is sincere, responsible, cooperative and social. He is having scientific temperament also. Fire alarm works on the principle of photoelectric effect.

Numerical Problems
Q1. What is the energy in joules associated with a photon of wavelength 4000 Å?
Ans. Here \( \lambda = 4000 \text{ Å} = 4 \times 10^{-7} \text{m} \), \( h = 6.6 \times 10^{-34} \text{Js} \), \( c = 3 \times 10^8 \text{ms}^{-1} \)

\[
\therefore \text{Energy of a photon } E = h \nu = \frac{hc}{\lambda} = \frac{(6.6 \times 10^{-34} \times 3 \times 10^8)}{4 \times 10^{-7}} = 4.95 \times 10^{-19} \text{J}
\]

Q2. Calculate the longest wavelength of radiation that will be ejected by an electron from the surface having work function 1.9 eV, Given that \( h = 6.625 \times 10^{-34} \text{Js} \).
Ans. We know, work function \( \phi = \frac{hc}{\lambda_0} \) or \( \lambda_0 = \frac{hc}{\phi} \)

Here \( h = 6.625 \times 10^{-34} \text{Js} \), \( c = 3 \times 10^8 \text{ms}^{-1} \), \( \phi = 1.9 \text{eV} = 1.9 \times 1.6 \times 10^{-19} \text{J} \)

Then \( \lambda_0 = \frac{(6.625 \times 10^{-34} \times 3 \times 10^8)}{(1.9 \times 1.6 \times 10^{-19})} \)

\[= 6.538 \times 10^{-7} \text{m} \text{ or } 6538 \text{ Å} \]

Q3. Calculate de-Broglie wavelength of an electron beam accelerated through a potential difference of 60 V.
Ans. Here \( V = 60 \text{volt} \).

For electron, \( \lambda = \frac{12.27}{\sqrt{V}} \text{Å} = \frac{12.27}{\sqrt{60}} = 1.58 \text{Å} \)
Q4. de-Broglie wavelength of a proton is 2Å. What is its (i) velocity and (ii) kinetic energy? Given mass of proton = 1.67 x 10^{-27} kg.

Ans. Here \( \lambda = 2 \text{Å} = 2 \times 10^{-10} \text{ m} \), \( m = 1.67 \times 10^{-27} \text{ kg} \)

(i) we know \( \lambda = \frac{\hbar}{m v} \Rightarrow v = \frac{\hbar}{m \lambda} = \frac{(6.625 \times 10^{-34})}{1.67 \times 10^{-27} \times 2 \times 10^{-10}} \)

= 1.98 \times 10^3 \text{ ms}^{-1}

(ii) K.E. = \( \frac{1}{2} mv^2 = \frac{1}{2} \times 1.67 \times 10^{-27} \times (1.98 \times 10^3) = 3.27 \times 10^{-21} \text{ J} \)

Q5 Calculate the energy of an electron which has de-Broglie wavelength 1 A. Given \( h = 6.6 \times 10^{-34} \text{ Js} \).

Ans. Here \( \lambda = 1 \text{ Å} = 10^{-10} \text{ m} \), \( h = 6.6 \times 10^{-34} \text{ Js} \), \( m = 9.1 \times 10^{-31} \text{ kg} \)

Using \( \lambda = \frac{h}{\sqrt{2mE}} \), we have

\[ E = \frac{h^2}{2m\lambda^2} = \frac{(6.6x10^{-34})^2}{2x9.1x10^{-31} x (10^{-10})^2} = 2.39 \times 10^{-17} \text{ J} \]

\[ = \frac{(2.39 \times 10^{-17})}{1.6 \times 10^{-19}} \text{ eV} = 149 \text{ eV} \]

Q6. A source of light (1000 W) is emitting light of wavelength 6000 Å. Calculate the number of photons emitted per second.

Ans. \( n = \frac{E}{\lambda} = \frac{1000 \times 6 \times 10^{-7}}{6.62 \times 10^{-34} \times 3 \times 10^8} = 3 \times 10^{20} \text{ photons per second} \)

Q7. The work function of a photosensitive material is 2eV. Calculate the wavelength of the incident light that will just cause photoemission.

Ans. \( \phi = \frac{h \nu_0}{\lambda_0} \Rightarrow \lambda_0 = \frac{hc}{\phi} = \frac{(6.62 \times 10^{-34} \times 3 \times 10^8)}{2 \times 1.6 \times 10^{-19}} = 6206 \text{ Å} \)

Q8. Light of wavelength 3500 Å is incident on two metals A & B. Which metal will yield photo electrons if their work functions are 4.2 eV & 1.9 eV respectively?

Sol. Wave length of radiation is given as \( \lambda = 3500 \text{ Å} = 3500 \times 10^{-10} \text{ m} \)

The energy of incident light \( E = \frac{hc}{\lambda} = \frac{(6.62 \times 10^{-34} \times 3 \times 10^8)}{3500 \times 10^{-10}} = 3.546 \text{ eV} \)

The incident light will eject electrons from a metal surface if its energy is greater than the work function of that metal, accordingly metal B will yield photo electrons as the value of work function (1.9 V) of this metal is less than the energy of incident light (3.546 eV).

**QUESTIONS FOR PRACTICE**

Q1. The two lines A and B shown in the graph is the plot of de Broglie wavelength as a function of \( \frac{1}{\sqrt{V}} \) for two particles having the same charge. Which of the two represent the particle of heavier mass?
2. The graph shows the variation of stopping potential with frequency of incident radiation for two photosensitive metals A and B. Which one of the two has higher value of work function? Justify your answer.

Atoms and Nuclei (Chap. 12&13)

VERY SHORT ANSWER TYPE QUESTIONS (1 MARK)

Q1. Plot a graph showing the variation in scattered alpha particles with scattering angle.
   Ans: given

Q2. Four nuclei of an element fuse together to form a heavy nucleus. If the process is accompanied by the release of energy, which of the two, the parent or the daughter nucleus would have higher B. E./nucleon?
   Ans: Daughter nucleus

Q3. Draw a graph showing the variation of decay rate with no. of active nuclei.
   Ans:
Q4. Name the absorbing material used to control the reaction rate in a nuclear reactor.
Ans: Cadmium rod.

Q5. Name the phenomena by which energy is produced in stars.
Ans: Uncontrolled nuclear fusion reaction.

Q6. What is the ratio of nuclear densities of two nuclei having mass numbers in the ratio 1:4?
Ans: 1:1

Q7. Why do alpha particles have high ionizing power?
Ans: Because of their large mass and large nuclear cross section.

Q8. Compare the radii of two nuclei with mass no. 1 and 27 respectively.
Ans: \( \frac{R_1}{R_2} = \left( \frac{A_1}{A_2} \right)^{1/3} = \left( \frac{1}{27} \right)^{1/3} = \frac{1}{3} \)

Q9. If the total energy of an electron in an orbit is ‘-E’ then what will be the KE and Potential energy of the electron in the same orbit?
Ans: P.E. = -2E and K.E. = E

Q10. How the radius(r) of an orbit varies with n?
Ans: \( r \propto n^2 \)

Q11. What is Bohr’s quantization condition?
Ans: Angular momentum = nh/2\( \pi \)

Q12. Define disintegration constant.
Ans: It is the reciprocal of that time in which 1/e times original concentration left undecayed.

Q13. Write down two characteristic features of nuclear force which distinguish it from Coulomb force.
Ans: 1. Nuclear forces are saturated force. 2. Nuclear force are charge independent.

Q14. Define ionization energy and give its value for Hydrogen atom.
Ans: It is the minimum amount of energy required to remove an electron from an atom in its gaseous state. Ionization energy for H atom is 13.6eV.

Q15. Why energy levels are not equispaced in atoms.
Ans: According to Bohr’s theory only those energy levels are allowed in which angular momentum of electrons is quantized.

Q16. Calculate the energy equivalent of 1g of substance.
Ans: \( E = mc^2 = 10^{-3} \times (3 \times 10^8)^2 = 9 \times 10^{13} \) J

Q17. Out of \( _3^7 \)B\(_4\) and \( _3^7 \)B\(_7\) which one is more stable?
Ans: For \( _3^7 \)B\(_7\) neutron to proton ratio is more than the \( _3^7 \)B\(_4\).

SHORT ANSWER TYPE QUESTIONS (2 MARKS)

Q1. Why energy spectrum of \( \beta \)- particle is continuous?
Ans: Because emission of beta particle takes place along with antiparticles (neutrino). The two share the energy with each other so the spectrum is continuous.

Q2. A radioactive nucleus ‘A’ undergoes a series of decays according to the following scheme:

\[
A \xrightarrow{\alpha} A_1 \xrightarrow{\beta} A_2 \xrightarrow{\alpha} A_3 \xrightarrow{\gamma} A_4
\]
The mass no. and atomic no. of A are 180 and 72 respectively. What are these numbers for A_4?
Ans:

\[
\begin{align*}
180 & \rightarrow A & \rightarrow 176 & \rightarrow A_1 & \rightarrow 176 & \rightarrow A_2 & \rightarrow 172 & \rightarrow A_3 & \rightarrow 172 & \rightarrow A_4 \\
72 & \rightarrow A & \rightarrow 70 & \rightarrow A_1 & \rightarrow 71 & \rightarrow A_2 & \rightarrow 69 & \rightarrow A_3 & \rightarrow 69 & \rightarrow A_4 \\
\end{align*}
\]

Thus, mass number of A_4 is 172 and atomic number is 69.

Q3. a) The mass of a nucleus in its ground state is always less than the total mass of its constituents- neutrons and protons. Explain
b) Plot a graph showing the variation of potential energy of a pair of nucleons as a function of their separation.
Ans: a) Because this mass appears in terms of its binding energy. (b) given graph

Q5. The energy of the electron in the ground state of hydrogen atom is -13.6 eV.
   i) What do the negative sign signify?
   ii) How much energy is required to take an electron in this atom from the ground state to the first excited state?
Ans: Negative sign signify that electron is bound to nucleus by attractive forces.
   Energy of ground state of H atom May be given as  \( E_n = -\frac{13.6}{n^2} \)
   Energy of first excited state = \( -\frac{13.6}{2^2} = -\frac{13.6}{4} = -3.4 \) eV
   Energy required  \( -3.4 - (-13.6) = 10.2 \) eV

Q4. a) What is meant by half-life of a radioactive element?
   b) The half-life of a radioactive substance is 30 s. Calculate the decay constant and time taken for the sample to decay by \( \frac{3}{4} \)th of the initial value.
Ans: The time taken by the sample to reduce to half its original concentration.

\[
\frac{N}{N_0} = \left(\frac{1}{2}\right)^n \\
1 - \frac{3}{4} = \left(\frac{1}{2}\right)^n \quad \text{or} \quad \left(\frac{1}{2}\right)^2 = \left(\frac{1}{2}\right)^n
\]

This gives
\[
n = \frac{t}{T} = 2 \quad \text{or} \quad t = 2T = 2 \times 30 = 60 \text{ s}
\]

Q5. The half-life of \( ^{38}\text{Sr}^{90} \) is 28 years. What is the disintegration rate of 15 mg of this isotope?
Ans: Given that  \( T_{1/2} = 28 \) years  mass of radioactive sample = 15 mg
   Rate of disintegration of radioactive sample = \( \frac{dN}{dt} = \lambda N \)
   Where \( N \) = no. of atoms left undecayed.
   No. of atoms can be calculated by mole concept.  \( \text{(Ans: } 7.877 \times 10^{10} \text{Bq}) \)

Q6. Select the pairs of isotopes & isotones from the followings:

\[ _6^7C, _11^7N, _{14}^{15}P, _{15}^{30}P, _{31}^{6}C \]
Ans: $^6\text{C}_{13}$ and $^6\text{C}_{12}$, $^{15}\text{P}_{30}$ and $^{15}\text{P}_{31}$ the two pairs are having the same number of protons so these are isotopes while $^6\text{C}_{13}$ and $^7\text{N}_{14}$ are isotones as these are having same no. of neutrons.

Q7. 9. Tritium has a half-life of 12.5 years against beta decay. What fraction of a sample of pure tritium will remain un-decayed after 25 years?

Ans: Half-life of Tritium = 12.5 years
If $N_0$ is the initial concentration of Tritium
$N$ no. of concentration left un-decayed then
$N = N_0 \left(\frac{1}{2}\right)^n$ where $n = t/T$, $t =$ total time taken, $T =$ Half life
After substitution we get $N = N_0/4$

SHORT ANSWER TYPE QUESTIONS (3 MARKS)

Q1. Plot binding energy per nucleon with mass no. and conclusion can be drawn?
Ans: Plot the graph as shown in text book.
Conclusions:
  a. B E per nucleon is almost constant between mass no. 30-170
  b. This conclude that force is attractive and produce energy of MeV.
  c. In the region of 30-170 nuclear force is constant as force becomes saturated.
  d. Nucleus above 170 and below 30 are unstable so to gain stability they tends to acquire stable energy range that is 30-170.

Q2. The energy level diagram of an element is given below. Identify, by doing necessary calculations, which transition corresponds to the emission of a spectral line of wavelength 102.7 nm.
Ans.

\[
\Delta E = \frac{h c}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{102.7 \times 10^{-9}} J
\]
\[
= \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{1027 \times 10^{-9}} \times 1.6 \times 10^{-19} eV = \frac{66 \times 3000}{1027 \times 16} = 12.04 eV
\]
Now, $\Delta E = |13.6 - (-1.50)| = 12.1 eV$
Hence, transition shown by arrow D corresponds to emission of $\lambda = 102.7 \text{ nm}$.

Q3. State the law of radioactive decay. Plot a graph showing the number (N) of un-decayed nuclei as a function of time (t) for a given radioactive sample having half-life $T_{1/2}$. Depict in the plot the number of un-decayed nuclei at (i) $t = 3T_{1/2}$ and (ii) $t = 5T_{1/2}$.
Ans: Graph shown in figure.
Q4. Study the gamma beta decay of $^{27}\text{Co}^{60}$ with the help of energy level diagram and also give the energy of emitted gamma radiations.

\[ \begin{align*}
^{27}\text{Co}^{60} & \xrightarrow{\beta} \quad \text{E}_\gamma = 1.17 \text{ MeV} \\
& \quad \text{E}_\gamma = 1.33 \text{ MeV} \\
^{23}\text{N}^{60} & 
\end{align*} \]

Ans:

Q5. Explain how Rutherford’s experiment on scattering of alpha particles led to the estimation of the size of nucleus. What are its drawbacks?

Ans. As most of the a-particle passed straight through gold foil and a very few scattered back, it indicated that the central part of the atom must be positive and it should be a very small part of the atom. As only 1 in about 8000 alpha particles retraced its path, the size of nucleus was estimated to be about 1/10,000 th of the size of an atom.

Drawbacks :

(i) Rutherford’s atom model cannot explain the stability of the atom.
(ii) If Rutherford atom model is true, the electron can remove in orbits of all possible radii and hence it should emit continuous energy spectrum. The atoms like hydrogen possess line Spectrum.

NUMERICAL PROBLEMS

Q1. The Isotope uranium $^{92}\text{U}^{238}$ decays successively to form $^{90}\text{Th}^{234}$, $^{91}\text{Pa}^{234}$, $^{92}\text{U}^{234}$, $^{90}\text{Th}^{230}$and $^{88}\text{Ra}^{226}$. What are the radiations emitted in these five steps?

Ans. In the 1st step ($^{92}\text{U}^{238}$ to $^{90}\text{Th}^{234}$) : when $^{92}\text{U}^{238}$ decays to $^{90}\text{Th}^{234}$, mass number decreases by 4 and atomic number decreases by 2. Therefore alpha-particle (2He4) is emitted. The decay takes place as below:

\[ ^{92}\text{U}^{238} \rightarrow ^{90}\text{Th}^{234} + 2\text{He}^4 \]

In the 2nd step ($^{90}\text{Th}^{234}$ to $^{91}\text{Pa}^{234}$) :- When $^{90}\text{Th}^{234}$ decays to $^{91}\text{Pa}^{234}$, mass number remain unchanged and the atomic number increase by 1. Therefore, β-particle is emitted. The decay takes place as represented below:

\[ ^{90}\text{Th}^{234} \rightarrow ^{91}\text{Pa}^{234} + -1\text{e}^0 \]

In 3rd step $^{91}\text{Pa}^{234}$ to $^{92}\text{U}^{234}$ :- Here also the mass number remains same & the atomic number increase by 1. Therefore in 3rd step, β- decay takes place which is represented as below:

\[ ^{91}\text{Pa}^{234} \rightarrow ^{92}\text{U}^{234} + -1\text{e}^0 \]

In 4th step ($^{92}\text{U}^{234}$ to $^{90}\text{Th}^{230}$) and in 5th step ($^{90}\text{Th}^{230}$to $^{88}\text{Ra}^{226}$) :- In each of these two steps alpha decay takes place.

Q2. A neutron is absorbed by a $^{3}\text{Li}^{6}$ nucleus with subsequent emission of an alpha particle, write the corresponding nuclear reaction. Calculate the energy released in this reaction.
Given that $m(\text{Li}^6) = 6.015126 \text{ a.m.u.} ; m(\text{He}^4)=4.002604 \text{ a.m.u.}; m(\text{n}) = 1.008665 \text{ a.m.u.} , m(\text{H}^3) = 3.016049 \text{ a.m.u.}$

Ans. The nuclear reaction may be expressed as

$$\text{o}_1\text{n} + \text{Li}^6 \rightarrow \text{H}^3 + \text{He}^4 + Q$$

where $Q$ is energy released.

$$Q = [m(\text{o}_1\text{n})+ m(\text{Li}^6) – m(\text{H}^3) – m(\text{He}^4)] \times 931.5 \text{ MeV}$$

$$= [1.008665 + 6.015126 – 3.16049 – 4.002604] \times 931.5 \text{ MeV}$$

$$= 4.786 \text{ MeV}$$

Q.3 The short wavelength limit for the Lyman series of hydrogen is $913.4 \text{ Å}$. Calculate the short wavelength limit for the Balmer series of hydrogen spectrum.

Ans. $\lambda = \frac{\lambda \text{Ly}}{n_f^2 - n_i^2}$

$\therefore \lambda_B = \frac{4 R}{R_0} = 3653.6 \text{ Å}$

Q7. Define the activity of a radio nucleus. Write its S.I. unit. Give a plot of the activity of a radioactive substance versus time. How long will a radioactive isotope, whose half-life is $T$ years for its activity to reduce to $1/8$th of its initial value?

Ans. The activity of a radioactive element at any instant is equal to its decay at that instant.

S.I unit of activity is Becquerel ($=1$ disintegration /second). The plot is shown in figure.

Numerical: $R = \left(\frac{1}{n_f^2 - n_i^2}\right)^n$ or ‘$t$’ = 3T years

**QUESTIONS FOR PRACTICE**

Q1. Explain Bohr’s Second postulate of quantization of angular momentum by de Broglie theory.

Q2. Draw the schematic arrangement of the Geiger Marsden experiment. How did the scattering of alpha particles of a thin foil of gold provide an important way to determine an upper limit on the size of the nucleus? Explain briefly.

Q3. State the law of radioactive decay. If $N_0$ is the number of radioactive nuclei in the sample at some initial time $t_0$, find the relation to determine the number of $N$ present at a subsequent time. Draw a plot of $N$ as a function of time.

Q4. Using Rutherford model of the atom, derive the expression for the total energy of the electron in hydrogen atom. What is the significance of total negative energy possessed by the electron.

Q5. Using Bohr's postulate of the atomic model, derive the expression for radius of $n$th electron orbit. Hence obtain the expression for Bohr's radius.

Q6. Define the terms (i) half-life, (ii) average life. Find out their relationship with the decay constant.
Electronic Devices (Chap. 14)

VERY SHORT ANSWER TYPE QUESTIONS (1MARK)
1. What is the order of energy gap in an intrinsic semiconductor?
   Ans: 0.2ev to 3ev.

2. How does the energy gap vary in a semiconductor when doped with pentavalent element?
   Ans: It decreases.

3. How does the conductivity of a semiconductor change with the rise in its temperature?
   Ans: It increases with the rise in its temperature.

4. Doping silicon with indium leads to which type of semiconductor?
   Ans: p-type semiconductor.

5. Why is the conductivity of n-type semiconductor greater than that of the p-type semiconductor even when both of them have same level of doping?
   Ans: This is because under a given electric field, free electrons have higher mobility than holes.

SHORT ANSWER TYPE QUESTIONS (2 MARKS)
1. The ratio of number of free electrons to holes ne/nh for two different materials A and B are 1 and respectively. Name the type of semiconductor to which A and B belongs.
   Ans: A is an intrinsic semiconductor as ne = nh.
       B is a p-type semiconductor as ne < nh.

2. Differentiate the electrical conductivity of both types of extrinsic semiconductors in terms of the energy band diagram.
   Ans.
   ![Energy bands of (a) n-type semiconductor at T > 0K, (b) p-type semiconductor at T > 0K.]

3. Why photodiode usually operated in reverse biased mode?
   Ans: In reverse biased mode, the reverse saturation current is directly proportional to the intensity of incident light. Therefore it is usually operated in reversed biased mode.

4. State the factors which control wavelength and intensity of light emitted by LED.
   Ans: (i) Nature of semiconductor & (ii) Forward current
6. Pure silicon at 300K has equal electron and holes concentration $1.5 \times 10^{16}$ per m$^3$. Doping by indium increases hole concentration to $4.5 \times 10^{22}$ per m$^3$. Calculate new electron concentration.

**Ans:** $n_e n_h = n_i^2 \Rightarrow n_e = \frac{n_i^2}{n_h} = \frac{(1.5 \times 10^{16})^2}{4.5 \times 10^{22}} = 5 \times 10^9$ m$^{-3}$

7. Explain how the width of depletion layer in a p-n junction diode changes when the junction is: (i) Forward biased (ii) reverse biased.

**Ans:** (i) The width of depletion layer in a p-n junction diode decreases when it is forward biased. (ii) The width of depletion layer in a p-n junction diode increases when it is reverse biased.

9. The output of an unregulated d.c. power supply is to be regulated. Name the device that can be used for this purpose and draw the relevant circuit diagram.

**Ans:** The device is zener diode.

For relevant circuit diagram Refer NCERT Textbook Page No. 486 Fig. 14.22

10. Give the logical symbol for an AND gate. Draw the output wave form for input wave forms A and B.

**Ans:**

![Input & Output pulse waveforms of AND gate](image)

11. Name the 2-input logic gate, whose truth table is given below:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

If this logic gate is connected to a NOT gate, what will be the output when

(i) A = 1, B = 1 and (ii) A = 0, B = 1?

**Ans:** The given logic gate is a NOR gate.

(i) When NOR is connected to a NOT gate, the gate becomes OR gate.
For $A = 1$, $B = 1$, $Y = 1$, (ii) For $A = 0$, $B = 1$, $Y = 1$

12. In the following diagrams, write which of the diodes are forward biased and which are reverse biased.
13. The output of a 2-input NAND gate is fed to a NOT gate. Write down the truth table for the output of the combination for all inputs.

\[
\begin{array}{|c|c|c|}
\hline
A & B & Y \\
\hline
0 & 0 & 1 \\
0 & 1 & 0 \\
1 & 0 & 0 \\
1 & 1 & 1 \\
\hline
\end{array}
\]

Ans: The resultant gate is AND gate. The truth table is:

14. If the emitter and base regions of a transistor have same doping concentration, state how (i) collector current and (ii) dc current gain of the transistor will change.

\[\text{Ans :} (i) \text{ Here } I_E = I_B. \text{ In a transistor, } I_E + I_B = I_C \]
\[\text{So, } I_C = 0, \beta = I_C / I_E = 0.\]

16. Identify the logic gates marked X, Y in the following figure.

Write down the output at Z, when A = 1, B = 1 and A = 0, B = 1.

Ans: X is NAND gate and Y is OR gate.

\[\text{Output } Z = \overline{A} \cdot \overline{B} + A, \text{ For } A = 1, B = 1, Z = 1,\]
\[\text{For } A = 0, B = 1, Z = 1\]

19. Draw the output waveform at X, using the given inputs A and B for the logic circuit shown below. Also, identify the logic operation performed by this circuit.

Ans: The equivalent gate is OR gate. The output waveform is as follows:

20. Explain briefly why the output and input signals of a common-emitter amplifier differ in phase by 180°.

\[\text{Ans: The output of a CE amplifier is given by}\]
\[V_O = V_{CC} - I_C R_C\]
\[V_O = -C_{RC}\]

Therefore, as the input voltage of the CE amplifier increases its output voltage decreases and vice-versa.
**SHORT ANSWER TYPE QUESTIONS (3 MARKS)**

1. A semiconductor has equal electron and hole concentration of $2 \times 10^8/m^3$. On doping with a certain impurity, the hole concentration increases to $4 \times 10^{10}/m^3$.
   (i) What type of semiconductor is obtained on doping?
   (ii) Calculate the new electron hole concentration of the semiconductor.
   (iii) How does the energy gap vary with doping?

   **Ans:**
   
   (i) $n_h = 4 \times 10^{10}/m^3$
   
   (ii) $n_e = n_i^2 / n_h = (2 \times 10^8)^2 / 4 \times 10^{10} = 10^6/m^3$
   
   Since $n_e < n_h$, so the semiconductor is p-type semiconductor.

   (iii) The energy gap decreases with doping.

2. Explain (i) forward biasing, (ii) reverse biasing of a p-n junction diode. With the help of a circuit diagram, explain the use of this device as a half wave rectifier.

   **Ans:**
   
   (i) When p-type of the p-n junction is more positive w.r.t n-type, then the diode is forward biased.

   (ii) When p-type of the p-n junction is more negative w.r.t n-type, then the diode is reverse biased.

   **Half wave rectifier:** for diagram Refer NCERT Textbook page No. 483 fig. 14.18 (a)(b)

   **Explanation:** During the positive cycle of the input signal the diode is reverse biased and so it does not conduct the current & hence no output voltage across R. During the negative cycle of the input signal the diode is forward biased and so it conducts the current & hence an output voltage across R.

3. Explain the formation (i) ‘potential barrier’ and (ii) ‘depletion region’ in a p-n junction diode. How does the width of the depletion region vary with increase in forward bias?

   **Ans.** Electron and hole recombines in the depletion region to form the double layer of charge and electric field called junction field. This junction field acting over the junction width develops potential barrier.

   The region at the junction is free from charge carrier called depletion region.

   On increasing the forward biased voltage the width of depletion layer decreases.

   ![Diode Circuit Diagram]

   **Expression for voltage gain:**

   \[
   V_{cc} = V_{ce} + I_R R_L
   \]

   \[
   V_{bb} = V_{be} + I_b R_b
   \]
5. For a common emitter amplifier, the audio signal voltage across the collector resistance of 2kΩ is 2V. If the current amplification factor of the transistor is 100, calculate (i) input signal voltage, (ii) base current, and (iii) power gain. Given that the value of the base resistance is 1kΩ.

Ans:
\[ V_C = I_C R_C = 2V \]
\[ I_C = \frac{2}{2 \times 10^3} = 10^{-3}A = 1mA \]
\[ \beta = \frac{I_C}{I_B} \]
\[ I_B = 10^{-3}/100 = 10^{-5}A \]
\[ V_i = I_B R_B = 10^{-5} \times 10^3 = 0.01V \]
\[ P_v = \beta x R_C / R_B = 100 \times 2kΩ/1kΩ = 200 \]

6. Give reasons for the following:

(i) The zener diode is fabricated by heavily doping both the p and n sides of the junction.

(ii) A photodiode, when used as a detector of optical signals is operated under reverse bias.

(iii) The band gap of the semiconductor used for fabrication of visible LED’s must at least be 1.8eV.

Ans. (i) Heavily doping makes the depletion layer very thin. This makes the electric field of the junction very high, even for a small reverse bias voltage. This in turn helps the zener diode to act as a ‘voltage regulator’.

(ii) When operated under reverse bias, the photodiode can detect changes in current with changes in light intensity more easily.

(iii) The photon energy of visible light photons varies from about 1.8 eV to 3 eV. Hence for visible LED’s, the semiconductor must have a band gap of 1.8 eV

VALUE BASED QUESTION (4 MARKS)

1. Prakash finds his friend Rakesh connecting his new television set directly to switch board. Prakash advises Rakesh not to do so and to connect the television through a voltage stabilizer.

a) Identify the diode used in voltage regulator and give its symbol.

b) What values did Prakash exhibit in the situation described?
   • Helpful and concerned
   • Practical application of theoretical knowledge.
2. Pradyumna connected a series of solar cells to light up his house which he heated the water.

Briefly describe the typical p-n junction solar cell. What are the values exhibited by Pradyumna?

- Eco – friendly.
- Less consumption of electricity / saving of electrical energy.

3. Sekhar visited his grandparents who lived in a small village. He found the people of the village uninformed about the internet. So he conducted awareness classes about the advantages and applications of the internet. Mention the applications of internet.

State the values shown by Shekhar.

- Concern for the villages.
- Helping tendency.
- Contributing to the development of the country.

4. What types of circuits are used to get steady DC output from a pulsating voltage? How does the working principle of the circuit allow you to overcome hurdles in your life?

- Unwanted habits / thoughts to be eliminated.
- To be steady in life.

5. Ashwin was given 3 semiconductors A, B and C with respective bandgaps of 3eV, 2eV and 1eV for use in a photodetector to detect $\lambda = 1400$nm. He found that the photodetector was not working with these semiconductors and did not know why. His friend Akash found out the reason for it and explained it to him. Why did the photodetector not work? What according to you are the values shown by Akash?

- Helping tendency.
- Presence of mind.
- High degree of awareness.
- Concern for his friend.

6. A student of class 12 was trying to understand the concepts of semiconductors and insulators in terms of energy gaps. How would you explain these concepts to that student? What values should we imbibe from this in our daily life?

- Ready to change with a little push.
- Ready / Eager to learn and move to a higher level.

7. Extrinsic semiconductors are preferred over intrinsic semiconductors in most of the important electronic devices. Give reason. Name the 2 types of extrinsic semiconductors. Mention some values that can be imbibed into our lives from the properties of extrinsic semiconductor.

- Team work
- Accepting diversity.

**QUESTIONS FOR PRACTICE**

1. With the help of a diagram show the energy band diagram for conductor, semiconductor and Insulator.
   Ans: Refer NCERT Textbook Page No. 471 Fig. 14.2 (a),(b),(c)

2. Draw the circuit diagrams to show forward biasing and reverse biasing of a p-n junction diode. Draw the corresponding characteristic curve.
   Ans: Refer NCERT Textbook Page No. 481 Fig. 14.16 (a),(b),(c)
3. Show the biasing of a photodiode with the help of a circuit diagram. Draw graphs to show variations in reverse bias currents for different illumination intensities.  
Ans: Refer NCERT Textbook Page No. 487 Fig. 14.23 (a),(b)

4. Draw a circuit diagram to study the input and output characteristics of a n-p-n transistor in its CE configuration. Draw the typical input and output characteristics and explain how these graphs are used to calculate (i) input resistance, (ii) output resistance and (iii) current amplification factor of the transistor.  
Ans: Refer NCERT Textbook page No. 493 & 494 & fig. 14.29 & 14.30 (a)(b)

5. (a) Describe briefly, with the help of a diagram, the role of the two important processes involved in the formation of a p-n junction.  
(b) Name the device which is used as a voltage regulator. Draw the necessary circuit diagram and explain its working.  
Ans: Refer NCERT Textbook the relevant section.

6. Draw the circuit arrangement for studying the I-V characteristics of a p-n junction diode in (i) forward and (ii) reverse bias. Briefly explain how the typical I-V characteristics of a diode are obtained and draw these characteristics.

7. How photo diodes are used for detecting optical signals.

8. Draw a circuit diagram of an n-p-n transistor with proper basing. describe briefly its working. Write the relation between currents in different branches of transistor circuit. Why base is lightly doped and has smallest width.

9. Which device is used as a voltage regulator and why? With a neat circuit diagram explain how it works.

COMMUNICATION SYSTEM (Chap. 15)

VERY SHORT ANSWER TYPE QUESTIONS (1 MARK)

1. What frequency band is used for mobile phone?  
Ans U.H.F. range of frequency about 800-950 MHz

2. What frequency bands are used for up linking and downlinking in satellite communication?  
Ans. For up-linking 5.925 to 6.425 GHz  
For down-linking 3.7 to 4.2 GHz

3. Identify the parts X and Y in the following block diagram of a generalized communication system.

X  Transmitter  Y  Receiver

Ans. Part X is message signal or information source.  
Part Y is a transmission channel.

4. Give two example of communication system which use space wave mode.
5. Why is the amplitude of modulating signal kept less than the amplitude of carrier wave?

**Ans.** To avoid the distortion.

6. Why are the broadcast frequencies (carrier waves) sufficiently spaced in amplitude modulated wave?

**Ans.** To avoid the mixing up of signals.

7. What type of modulation is required for radio broadcast?

**Ans.** Amplitude modulation.

8. What type of modulation is required for television broadcast?

**Ans.** Frequency modulation.

9. Why is short wave band used for long distance radio broadcast?

**Ans.** Short waves are not absorbed by the earth’s atmosphere.

10. Name the type of radio wave propagation which involves TV signals, broadcast by a tall antenna are intercepted directly by the receiver antenna?

**Ans.** Space wave propagation.

**SHORT ANSWER TYPE QUESTIONS (2 MARKS)**

1. Which of the following would produce analog signals and which would produce digital signals?

   i) A vibrating tuning fork.
   
   ii) A musical sound due to a vibrating sitar string.
   
   iii) A light pulse.
   
   iv) Output of NAND gate.

   **Ans.** i) analog ii) Analog iii) Digital iv) Digital

2. Two waves A and B of frequencies 2 MHz and 3 MHz are beamed in the same direction for communication via sky wave. Which one of these is likely to travel longer distance in ionosphere before suffering total internal reflection?

   **Ans.** The refractive index increases with increase in frequency which implies that for higher frequency waves, angle of refraction is less, i.e., bending is less. Hence, the condition of total internal reflection is attained after travelling larger distance (by 3 MHz wave).

**SHORT ANSWER TYPE QUESTIONS (3 MARKS)**

Q1. What is the range of frequencies used for TV transmission? What is common between this waves and light waves?

**Ans.** 76 MHz-88 MHz and 420 MHz - 890 MHz, Speed of waves
Q2. State two factors, by which the range of TV signal can be increased.

**Ans** i) By using repeaters
ii) By increasing height of transmitting or receiving antenna
iii) Using satellites

Q3. Which mode of propagation is used by short wave broadcast services having frequencies range from a few MHz up to 30 MHz? Explain diagrammatically how long distance communication can be achieved by this mode. Why is there an upper limit to frequency of waves used in this mode?

**Ans:** Sky wave mode.

Q4. Why is communication using line of sight mode limited to frequencies above 40 MHz?

**Ans** 1) For these frequencies size of antenna is small and can be installed at large heights
2) These waves has directional property

Q5. What would be the modulation index for amplitude modulated wave for which the maximum amplitude is ‘a’ while the minimum amplitude is ‘b’?

**Ans:** \( M_a = \frac{(a-b)}{(a+b)} \)

Q6. Calculate the length of a half wave dipole antenna at (a) 1MHz (b) 100MHz (c) 1000MHz. What conclusion can you draw from the results?

**Ans:**
- a) \( L = \frac{3 \times 10^8}{2 \times 10^6} = 150 \) Similarly (b) = 1.5m (d) = 0.15m

Q7. A tower is 80m tall. Calculate the maximum distance up to which the signal transmitted from the tower by this mode by this mode can be received. (Radius of the earth is 6400km).

**Ans.** Maximum coverage distance: \( d = \sqrt{2R_e h} = 32 \text{ km} \).

Q8. Which method is used to locate position of any person or earth by using electromagnetic waves and a satellite system? Brief explain it.

**Ans.** GPS device is fitted in the system to locate its exact position on the Earth. It transmits and receives the electromagnetic waves and gets link up with the satellite. The longitudes of the GPS device is determined by measuring its distance from three satellites. This information is used to identify the location of the GPS device.

**QUESTIONS FOR PRACTICE**

Q1. We do not choose audio signal to transmit just by directly converting it to an e.m. wave of the same frequency. Give two reasons for the same.

Q2. For an amplitude modulated wave, the maximum amplitude is found to be 10V, while the minimum amplitude is found to be 2V. Determine the modulation index. What will be the value of modulation index (\( \mu \)) if the minimum amplitude is zero volt?
Q3. A carrier wave of peak voltage 12V is used to transmit a message signal. What should be the peak voltage of the modulating signal, in order to have a modulation index of 75%?

Q4. Draw a plot of variation of amplitude versus $\omega$ for an amplitude modulated wave. Define modulation index. State its importance for effective amplitude modulation.

Q5. What does the term LOS communication mean? Name the types of waves that are used for this communication. What is the range of their frequencies? Give typical example, with help of suitable figure of communication system that use space wave mode propagation.

Q6. Draw a block diagram of a simple amplitude modulation; explain briefly how amplitude modulation is achieved.

Q7. Draw the block diagram of a communication system. What is the function of a transducer?

Q9. Which method is used to locate position of any person or earth by using electromagnetic waves and a satellite system? Briefly explain it.