ಜಿಲ್ಲಾಡಳಿತ

ಮತ್ತು

ಪದವಿಪೂರ್ವ ಶಿಕ್ಷಣ ಇಲಾಖೆ

ಚಿಕ್ಕಬಳ್ಳಾಪುರ ಜಿಲ್ಲೆ

ಸುಲಲಿತ

ದ್ವಿತೀಯ ಪಿಯುಸಿ ವಾರ್ಷಿಕ ಪರೀಕ್ಷೆಗೆ
ಸರಳ ಅಭ್ಯಾಸ ಕೈಪಿಡಿ

PHYSICS

ಸಹಕಾರ:

ಚಿಕ್ಕಬಳ್ಳಾಪುರ ಜಿಲ್ಲಾ ಪದವಿಪೂರ್ವ ಕಾಲೇಜು
ಪ್ರಾಂಶುಪಾಲರ ಮತ್ತು ಉಪನ್ಯಾಸಕರ ಸಂಘ.

Chapter-1

Electric Charges and Fields

ONE MARK QUESTIONS

1. How many electrons are present in –1C of charge.

Ans: 6.25×10^{18} electrons

2. Name the S.I. Unit of charge?

Ans: Coulomb or C.

3. Define the electric field at a point ?

Ans: It is the electric force experienced per unit positive charge at a point in an electric field.

4. Name the S.I. unit of electric field?

Ans: NC^{-1} or Vm^{-1}

5. Is electric field a scalar or a vector?

Ans: Vector.

6. What is electric dipole?

Ans: It is a system of two equal and opposite charges seperated by a small distance.

7. Define electric dipole moment?

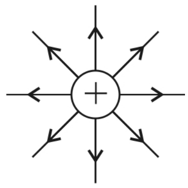
Ans: It is defined as the product of magnetude of one of the charge and seperation of dipole.

8. State the principle of super position of electric fields?

Ans: Total electric field at a point due to number of charges is equal to the vector sum of electric fields due to individual charges at that point.

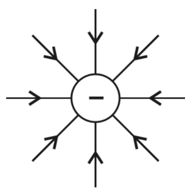
9. Draw the pattern of electric field lines due to an isolated positive point charge.

Ans:



10. Draw the pattern of electric field lines due to an isolated negative point charge.

Ans:



11. State Gauss law in electrostatics ?

Ans: The total electric flux through any closed surface in free space is equal to $\frac{1}{\varepsilon^0}$ times the total electric charge enclosed by the surface.

12. What is electric field inside a charged spherical shell?

Ans: Zero.

TWO MARKS QUESTIONS

13. State and explain columns law in electrostatics ?

Ans: The electrostatic force of attraction or repulsion between any two stationary point charges is directly proportional to the product of the magnitude of the charges and inversly proportional to the square of the distance between them and it acts the line joining the two points charges.

$$F \ \alpha \ \frac{q_1 \, q_2}{d^2} \Rightarrow F \ \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{d^2}$$

14. Write any two differences between polar and non-polar molecules?

Ans:

Polar molecules	Non-polar molecules
■ Centre of positive charge and negative charge do not coinside.	Centre of positive charge and negative charges coinside.
■ They posses permanent dipole moment.	They do not posses permanent dipole moment.

15. Define linear density of charge and mention its S.I. unit?

Ans: It is defined as amount of charge per unit length.

S.I. unit is C/m.

16. Define surface density of charge and mention its SI unit.

Ans: It is defined as amount of charge per unit area. SI unit is C/m^2.

17. Define volume density of charge and mention its SI unit.

Ans: It is defined as amount of charge per unit volume. SI unit is C/m^3.

18. When is the torque on an electric dipole (i) maximum and (ii) minimum?

Ans: i) Torque $\tau = PE \sin\theta$ is maximum when dipole axis is perpendicular to electric field.

i.e., $\tau_{max} = P.E.$ when $\theta = 90°$.

ii) Torque is minimum when dipole axis is parallel to electric field.

$\tau_{min} = 0$ when, $\theta = 0°$ or $\theta = 180°$.

19. Give the physical significance of electric dipole?

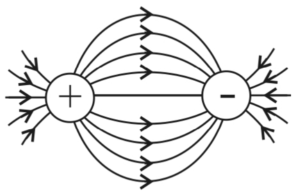
Ans: i) In the study of the effect of electric field on an insulator and

ii) In the study of radiation of energy from an antenna.

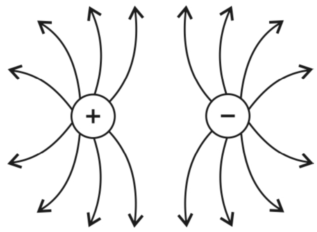
20. Sketch the electric field lines of

Ans: i) Two equal and opposite charges.

ii) Two equal positive charges.



(i)



(ii)

THEREE MARK QUESTIONS

21. Mention three basic properties of electric charge.

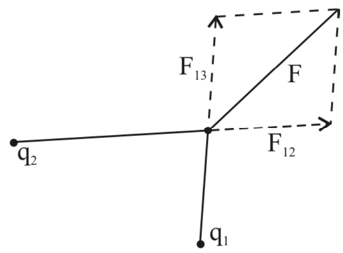
Ans:
- Additive property of charge
- Conservation property of charge
- Quantization property of charge.

22. Write Coulombs law in vector form.

Ans: $\vec{F} = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1 q_2}{r^2}\right)\hat{r}$ where, $\hat{r}$ is a unit vector.

23. Derive the expression for force on a point charge due to multiple point charges.

Ans: Let there be a system of three charges q_1, q_2 and q_3.



The force on q_1 and q_2 is,

$$\vec{F}_{12} = K.\frac{q_1 q_2}{r_2}\hat{r}_{12} \quad \ldots (1)$$

The force on q_1 due to q_3 is, $\vec{F}_{13} = K.\frac{q_1 q_2}{r^2_{13}}.\hat{r}_{13} \ldots (2)$

Let $\vec{F}$ be the total force on q_1 due to q_2 and q_3 individually, then

$$\vec{F} = \vec{F}_{12} + \vec{F}_{13}$$

$$\vec{F} = K.\frac{q_1 q_2}{r_{12}^2}\hat{r}_{12} + K.\frac{q_1 q_3}{r_{13}^2}\hat{r}_{13}$$

24. Write the three properties of electric field lines?

Ans: a) Electric field lines start from positive charge and terminate on negative charge.

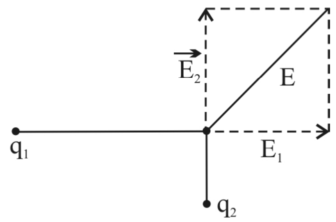
b) Electric field leave or enter the charged conductor normally.

c) Electric field lines never intersect each other.

25. Obtain the expression for electric field at a point due to multiple point charges.

Ans: The electric field at a point P due to q_1 and q_2 are given by,

$$\vec{E_1} = \frac{1}{4\pi\varepsilon_0} \times \frac{q_1}{r_1^2} . \hat{r}_1 \qquad \ldots (1)$$



$$\vec{E}_2 = \frac{1}{4\pi\varepsilon_0} \times \frac{q_2^2}{r_2^2} . \hat{r}_2 \qquad \ldots (2)$$

By the superposition principle field of p, due to two charges is,

$$\vec{E} = \vec{E}_1 + \vec{E}_2$$

$$\vec{F} = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{r_1^2}\right)\hat{r}_1 + \frac{1}{4\pi\varepsilon_0}\left(\frac{q_2}{r_2^2}\right)\hat{r}_2$$

26. Write the physical significance of electric field?

Ans: a) The field explains the mechanism by which two charges exert colombian force on each other.

b) The force acting any charge in a field can be easily calculated.

c) Electric field is a property of source charge and independent of magnitude of test charge.

27. State and explain the Gauss law in electrostatics.

Ans: Total electric flux through a closed surface in vaccum is equal to $\frac{1}{\varepsilon_0}$ times, the net charge enclosed by the surface.

Consider a charge 'q' which is placed in a closed surface S which is in vaccume. Then the total electric flux through the closed surface is given by,

$$\phi = \left(\frac{1}{\varepsilon_0}\right) q$$

28. Derive expression for the torque on a dipole placed in a uniform electric field?

Ans: The force experienced by the charge is given by, $F = \pm q\vec{F}$.

There force constitute a torque on a dipole is given by,

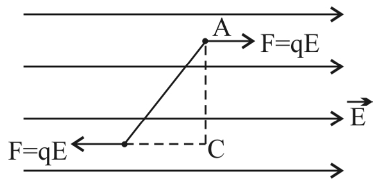
Torque T = Force $\times$ Perpendicular distance between the two forces

$= (qE) \times AC$

$= E \times AB \sin\theta$

$= E . \; q\,2a \sin\theta$

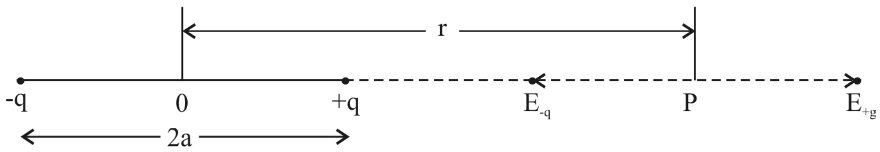
$T = P.E \; \sin\theta$



FIVE MARK QUESTIONS

29. Derive the expression for electric field at a point on the axis of an electric dipole?

Ans:



The electric fields E_{+q} and E_{-q} at a point p, due to charge +q and –q are given by,

$$E_{+q} = \frac{1}{4\pi\,\varepsilon_0} \times \frac{q}{(r-a)^2} \quad \ldots (1)$$

$$E_{-q} = \frac{1}{4\pi\varepsilon_0} \times \frac{q}{(r+a)^2} \quad \ldots (2)$$

The resultant electric field is given by superposition principle.

$$\vec{E} = E_{+q} - E_{-q}$$

$$= \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{(r-a)^2} - \frac{q}{(r+a)^2}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{(r+a)^2-(r-a)^2}{(r-a)^2\,(r+a)^2}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{r^2+2ar+a^2-[r^2-2ar+a^2]}{(r^2-a^2)^2}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{r^2+2ar+a^2-r^2+2ar-a^2}{(r^2-a^2)^2}\right]$$

$$E = \frac{1}{4\pi\varepsilon_0}\left[\frac{q\times 2a\,.\,2r}{(r^2-a^2)^2}\right] \quad [\therefore (q\times 2a) = p]$$

$$E = \frac{1}{4\pi\varepsilon_0} \times \frac{2pr}{(r^2-a^2)^2}$$

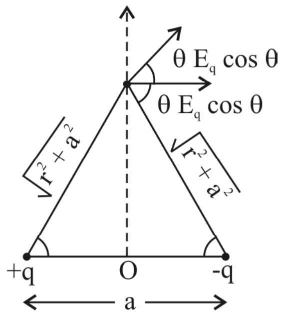
when $x >> a,\ a^2$ is neglected.

$$E = \frac{1}{4\pi\varepsilon_0} \times \frac{2pr}{r^4}$$

$$E = \frac{1}{4\pi\varepsilon_0} \times \frac{2p}{r^3}$$

30. Derive the expression for electric field at a point on the equatorial line of an electric dipole?

Ans: Let p be a point at a distance 'r' from the center of the dipole on the equitorial line the magnitude of electric field at p due to +q is,



$$E_{+q} = \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{(r^2+a^2)}\right) \text{ away from the charge } +q.$$

Similarly, $$E_{-q} = \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{(r^2+a^2)}\right) \text{ towards from the charge } -q.$$

The two vectors can be resolved into two components.

i) Parallel to dipole axis $E_{+q}\cos\theta$ and $E_{-q}\cos\theta$.

ii) Perpendicular to dipole axis $E_{+q}\sin\theta$ and $E_{-q}\sin\theta$. The perpendicular components are equal magnitude and opposite in direction. So they get cancelled.

Resultant electric field is, $\vec{E} = E_{+q}\cos\theta + E_{-q}\cos\theta$

$$\vec{E} = 2\,E_{+q}\cos\theta$$

$$\vec{E} = 2 \times \left[\frac{1}{4\pi\varepsilon_0}\frac{q}{(r^2+a^2)}\right]\cos\theta$$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \times \frac{2q}{(r^2+a^2)} \cdot \frac{a}{(r^2+a^2)^{\frac{1}{2}}} \quad \Big| \cos\theta = \frac{a^8}{(r^2+a^2)^{\frac{1}{2}}}$$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \times \frac{q \times 2a}{(r^2+a^2)^{\frac{3}{2}}}$$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \times \frac{p}{(r^2+a^2)^{\frac{3}{2}}}$$

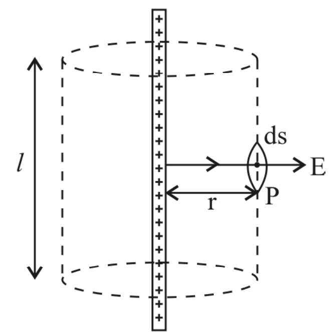
when r >> a, then a^2 is neglected.

$$E = \frac{1}{4\pi\varepsilon_0} \times \frac{p}{\left(r^2\right)^{\frac{3}{2}}}$$

$$E = \frac{1}{4\pi\varepsilon_0} \times \frac{2p}{r^3}$$

31. Derive the expression for electric field at a point due to infinitely long uniformly charged straight wire using gauss law.

Ans: Consider an infinitely long thin straight wire with uniform linear charge density λ. Let P be the point at which electric field is calculated. Construct an imaginary cylinder around the wire such that p lies on its surface.



Electric flux through the surface ds is

$$d\phi = E\cos\theta \, . \, ds \qquad \theta = 0,\ \cos\theta = 1$$

$$\therefore\ d\phi = E \, . \, ds$$

Flux through Gaussian surface, $\phi = E\int ds$.

$$\phi = E\,S$$

where 'S' is the surface area = $2\pi rl$ . . . (1)

$$\therefore \ \phi = E \times 2\pi rl \quad ...(2)$$

but $\phi = \frac{1}{\varepsilon_0} q$

From (1) and (2)

$$\phi = E \,.\, 2\pi rl$$

$$\frac{q}{\varepsilon_0} = E \,.\, 2\pi rl$$

$$E = \frac{1}{\varepsilon_0} \times \frac{q}{2\pi rl} \quad ...(3)$$

According to linear charge density,

$$\lambda = \frac{q}{l} \quad ...(4)$$

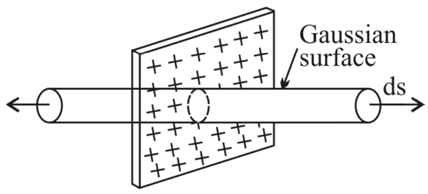
$$q = \lambda l$$

Substitute equation (4) in (3)

$$E = \frac{1}{\varepsilon_0} \times \frac{\lambda l}{2\pi rl} \quad \Rightarrow \quad E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

32. Derive an expression for electric field due to uniformly charged infinite plane sheet.

Ans: Consider infinite thin plane sheet having positive charges uniformly distributed electric field is perpendicular to the plane sheet of charge and is directed in outward direction.



The electric flux crossing the Gaussian surface is $\phi = E \times$ Area of the end faces (circular caps) of the cylinder.

$$\phi = E \,.\, 2ds \quad ...(1)$$

According to Gauss theorem, we have, $\phi = \frac{q}{\varepsilon_0}$

Here, the charge enclosed by the Gaussian surface, $q = \sigma\, ds$.

$$\phi = \frac{\sigma A}{\varepsilon_0} \quad ...(2)$$

From (1) and (2) we have, $E \times 2\,ds = \frac{\sigma\, ds}{\varepsilon_0}$

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

* * *

Chapter-2

Electric Potential and Capacitance

ONE MARK QUESTIONS

1. What is capacitor?

Ans: A device used to store electric charge is called a capacitor.

2. What is an equipotential surface?

Ans: A surface on which every point has same potential is called equipotential surface.

TWO MARK QUESTIONS

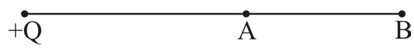
3. What is electrostatic shielding? Mention one application of it.

Ans: A method to protect certain region from the effect of electric field is called electrostatic shielding.

This method is used to protect sensitive instruments.

4. Write the relation between electric field and potential. A point charge +Q is placed at a point O as shown in the figure is the potential difference positive, negative or zero?

Ans:
- Relation between electric field and potential,
  $E = -\frac{dv}{dx}$.



- Potential difference, $V_A - V_B$ is positive.

5. Mention any two factors on which the capacitance of a parallel plate capacitor depends.

Ans: i) Area of plates

ii) Distance between the plates

iii) Delectric constant of the medium between plates.

6. A parallel plate capacitor with air between plates has a capacitance C. What will be the capacitance if

i) Distance between plates is doubled.

ii) Space between plates is filled with dielectric constant 5.

Ans: i) Capacitance becomes half $\left[C' = \frac{1}{2}C\right]$.

ii) Capacitance increases by 5 times $[C' = 5C]$.

7. Distinguish between polar and non-polar molecules.

Ans:

Polar Molecules	Non-polar Molecules
■ Molecules have permanent dipole moment.	Molecules to not have permanent dipole moment.
■ *Example:* HCl, H_2O	*Example:* H_2, N_2

THREE MARK QUESTIONS

8. Write any three properties of equipotential surface.

Ans: i) Two equipotential surfaces never interesect.

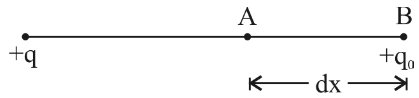
ii) Work done in moving a charge between two points on equipotential surface is zero.

iii) Electric field is always normal to equipotential surface.

9. Derive the relation connecting electric field and electric potential.

Ans: Let q $\rightarrow$ source charge

$q_o \rightarrow$ test charge



Work done $dw = F\,dx$ . . . (1)

$= -q_0 E\,dx$

[$\because F = q_0 E$. –ve sign shows that F is ooposite to work.]

By definition of potential difference,

$$dV = \frac{dw}{q_0} = \frac{-q_0 E}{q_0} dx \quad \text{[by Eqn. (1)]}$$

$$dV = -E\,dx$$

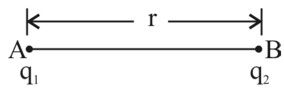
$$E = \frac{-dV}{dx}$$

10. Derive the expression for potential energy of a system of two charges in the absence of external electric field.

Ans: We shall consider a region where there is no field.

Let us bring q_1 from ∞ to point A.

Work done $W_1 = 0$ [$\because$ no field.]



Potential at point B. $V = \frac{1}{4\pi\varepsilon_0} \frac{q_1}{4}$ . . . (1)

Now, bring q_2 from ∞ to point B.

Work done, $W_2 = Vq_2 = \frac{1}{4\pi\varepsilon_0} \frac{q_1 . q_2}{r}$ [*From Equation (1)*]

Total work done, $W = W_1 + W_2$

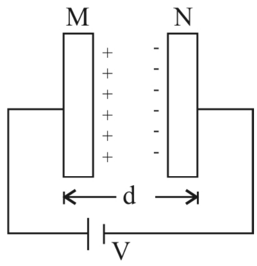
$$= 0 + \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r}$$

$\therefore$ potential energy = total workdone.

$$\boxed{U = \frac{1}{4\pi \epsilon_0} \frac{q_1 q_2}{r}}$$

11. Derive the expression for capacitance of a parallel plate capacitor.

Ans: We shall consider parallel plate capacitors M and N,



A $\rightarrow$ area of each plates

d $\rightarrow$ distance between plates

V $\rightarrow$ p.d. across plates

+q and –q $\rightarrow$ charges on M and N.

Let $\sigma = \frac{q}{A}$ . . . (1) be surface charge density.

Electric field between plates, $E = \frac{\sigma}{\varepsilon_0} = \frac{q}{A\varepsilon_0}$ . . . (2) [*By equation (1)*]

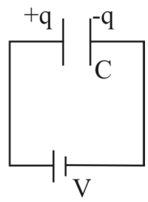
Potential difference, $V = ED = \frac{q}{A\,\varepsilon_0} . d$ . . . (3) [*By equation (2)*]

W.K.T. capacitance, $C = \frac{q}{V} = \frac{q}{\frac{q}{A\,\varepsilon_0} \times d}$ [*By equation (3)*]

$$\boxed{C = \frac{A\varepsilon_0}{d}}$$

12. Derive the expression for energy stored in a charged capacitor.

Ans: C $\rightarrow$ Capacitance of capacitor



V $\rightarrow$ p.d. across capacitor

W.K.T. $V = \frac{q}{C}$ . . . (1)

If dw is small work done to store dq, then

$dw = V\,dq$

$= \frac{q}{C} dq$ . . . (2) From (1)]

Total work done in storing charge from 0 to Q.

$$W = \int_0^Q dw$$

$$= \int_0^Q \frac{q}{C} dq \qquad \text{[From (2)]}$$

$$= \frac{1}{C}\int_0^Q q\,dq$$

$$= \frac{1}{C}\left[\frac{q^2}{2}\right]_0^Q$$

$$= \frac{1}{C}\left[\frac{Q^2}{2} - 0\right]$$

$$= \frac{Q^2}{2C}$$

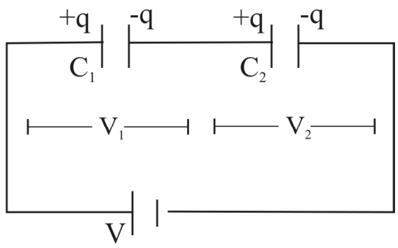
$$\boxed{\therefore \quad W = \frac{Q^2}{2C} = U}$$ [Energy stored in capacitor.]

13. Obtain the expression for effective capacitance of two capacitors connected in series.

Ans: Lets consider 2 capacitors C_1 and C_2 connected in series.

$V \rightarrow$ p.d. across combination

$V_1, V_2 \rightarrow$ p.d. across C_1 and C_2 respectively.



Here, $V = V_1 + V_2$ . . . (1)

But, $V_1 = \frac{q}{C_1}$, $V_2 = \frac{q}{C_2}$ Substitute in (1).

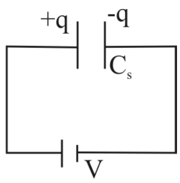
$$V = \frac{q}{C_1} + \frac{q}{C_2}$$

$$V = q\left[\frac{1}{C_1} + \frac{1}{C_2}\right] \quad \ldots(2)$$

We shall replace the combination by an equivalent capacitance C_s.

Here, $V = \frac{q}{C_s}$ . . . (3)

Equate (2) and (3):



$$\frac{q}{C_s} = q\left[\frac{1}{C_1} + \frac{1}{C_2}\right]$$

$$\boxed{\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2}}$$

14. Derive an expression for potential energy of electric dipole placed in a uniform electric field.

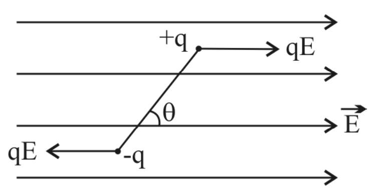
Ans: A dipole is placed in a uniform electric field 'E' making an angle θ.

Small work done in rotating the dipole, $dw = \tau\, d\theta$ . . . (1)

Potential energy, U = Total work done in rotating dipole from 90° to θ.

$$U = \int_{90}^{\theta} dw = \int_{90}^{\theta} \tau\, d\theta \quad \textit{[From Equation (1)]}$$

$$= \int_{90}^{\theta} PE \sin\theta \; d\theta \qquad [\because \tau = PE\sin\theta]$$



$$= PE\int_{90}^{\theta} \sin\theta \; d\theta$$

$$= PE\left[-\cos\theta\right]_{90}^{\theta}$$

$$= -PE\,[\cos\theta - \cos 90]$$

$$\boxed{U = -PE\cos\theta}$$

* * *

Chapter-3

Current Electricity

ONE MARK QUESTIONS

1. **Define current density.**

Ans: The current per unit area of cross section of the conductor is called current density.

(OR)

$$\text{Current density (j)} = \frac{\text{Current}}{\text{Area of cross section of the conductor}}$$

2. **What is drift velocity?**

Ans: The average velocity with which free electrons are drifted in a conductor under the influence of electric field is called drift velocity.

3. **Define mobiliy of free electrons.**

Ans: The magnitude of drift velocity per unit electric field is called mobility of free electron.

4. **Define relaxation time?**

Ans: The average time interval between two successive collisions of free electrons is called relaxation time.

5. **Write the SI unit of mobility of charges.**

Ans: **m^2/VS.**

6. **Write the SI unit of resistivity.**

Ans: Ωm.

7. **Name the SI unit of current density?**

Ans: Am^{-2}.

8. **Define internal resistance of cell?**

Ans: The resistance offered by electrodes and electrolyte of the cell to the flow of current is called internal resistance of a cell.

9. **Define emf of a cell.**

Ans: The potential difference across the ends of a cell when it is open circuit is called emf of a cell.

10. **What is the significance of Kirchhoff's first law ? [Current rule (OR) Junction rule.]**

Ans: Law of conservation of charge.

11. What is the significance of Kirchhoff's second law? (Voltage rule (OR) Loop rule.]

Ans: Law of conservation of energy.

12. Write the balancing condition for Wheatstone's network.

Ans: $I_g = 0$.

13. What is the principle of metre-bridge.

Ans: Balanced Wheatstone network.

TWO MARK QUESTIONS

14. Write the expression for drift velocity interms of current. Explain the terms used.

Ans: $Vd = \frac{I}{nAe}$

where, Vd $\rightarrow$ drift velocity

I $\rightarrow$ current

n $\rightarrow$ number of electrons per unit volume

A $\rightarrow$ area of crosssection

e $\rightarrow$ charge of electron

15. State and explain Ohm's law.

Ans: ***Statement:*** The current (I) through a metallic conductor is directly proportional to the potential difference between its ends, provided temperature and other physical conditions kept constant.

$$V \alpha I$$

$$V = IR$$

where, V = Potential different; I = current; R = Resistance

16. Mention the limitations of Ohm's law.

Ans: i) It is not applicable for semiconductors (Diodes, Transistors).

ii) It is not applicable to super conductors.

iii) It is not applicable to vacuum tubes.

17. What is Ohmic device? Give example.

Ans: The devices which obey Ohm's law are called ohmic devices.

Example: Metallic conductors at normal temperature volt meter, ammeter.

18. What are non-ohmic devices? Give example.

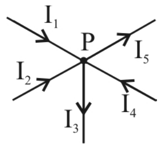
Ans: The devices which do not obey Ohm's law are called non-ohmic devices.

Example: Diode, Transistors, Vaccum tubes.

19. State and explain Kirchhoff's junction rule. (Current rule)

Ans: "In an electrical network, algebraic sum of currents at a node is zero."

At the node, 'p'.



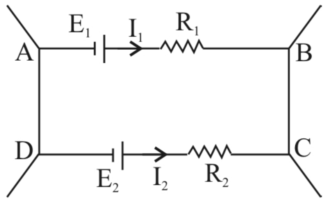
$$I_1 + I_2 - I_3 + I_4 - I_5 = 0$$

OR $$I_1 + I_2 + I_4 = I_3 + I_5$$

20. State and explain Kirchhoff's loop rule. (Voltage rule).

Ans: "In an electrical loop, the algebraic sum of IR (current and resistance) products is equal to the algebraic sum of the emfs.

Explanation:



Applying Loop rule to ABCDA,

$$-E_1 + I_1 R_1 - I_2 R_2 + E_2 = 0$$

$$I_1 R_1 - I_2 R_2 = E_1 - E_2$$

21. What are the uses of potentiometer?

Ans: i) Used to find internal resistance of the cell.

ii) Used to compare the emf of two cells.

THREE MARK QUESTIONS

22. Mention the factors on which the resistance of a conductor depends.

Ans: i) The length of the conductor $(R \alpha\, l)$

ii) Area of cross-section of the conductor $\left(R \alpha \frac{1}{A}\right)$

iii) Temperature of the conductor. $(R \alpha\, T)$

iv) Material of the conductor.

23. Derive an expression for drift velocity in terms of relaxation time.

Ans: The acceleration of a free electron due to electric field E is,

$a = \frac{F}{m}$, but F = –eE [where, 'e' is charge of electron and 'm' is mass of electron.]

$$\therefore a = \frac{-eE}{m} \quad \ldots (1)$$

We have, $v = u + at \quad \ldots (2)$

For drift velocity, v = vd, t = τ (average relaxation time) and average initial velocity, u = 0.

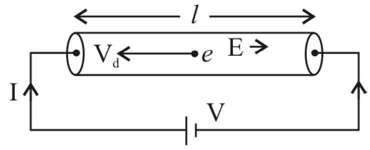
Equation (2) becomes $V_d = a\tau \quad \ldots (3)$

Substitute (1) in (3),

$$V_d = \frac{-eE\tau}{m} \quad \text{OR} \quad |V_d| = \frac{eE\tau}{m}$$

24. Obtain an expression for current in terms of drift velocity (OR) show that $I = nAeV_d$, where the symbols have their usual meanings.

Ans: Consider, a conductor of length 'l' and uniform area of cross section 'A'.



When potential difference 'v' is applied across the ends of the conductor, electric field 'E' is set up. The electrons are drifted with drift velocity V_d.

We have, $I = \frac{q}{t}$ . . . (1)

But, $Q = Ne$ . . . (2)

Number of electrons per unit volume is given by,

$$n = \frac{\text{Number of free electrons}}{\text{volume of the conductor}}$$

$$n = \frac{N}{V}$$

$$N = nV \quad [\because V = A \times l]$$

$$N = nAl \qquad \text{. . . (3)}$$

Equation (2) $\Rightarrow q = nAle$

Equation (1) $\Rightarrow I = \frac{nAle}{t}$

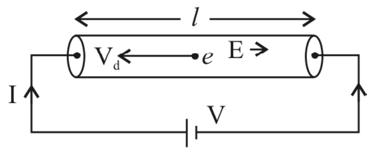
$$I = nAV_de \quad \left(\because \frac{l}{t} = V_d\right)$$

25. Derive the relation between current density and conductivity of a conductor (OR) show that $\vec{j} = \sigma\vec{E}$.

Ans: Consider a conductor of length 'l' and uniform area of cross section 'A'.

V is the p.d. applied, I is the current, E is the electric field,

We have, $I = \frac{V}{R}$ . . . (1)



But, $R = \frac{\rho l}{A}$ . . . (1) $\Rightarrow I = \frac{V}{\left(\frac{\rho l}{A}\right)} = \frac{VA}{\rho l}$

$\frac{I}{A} = \frac{V}{\rho l}$ . . . (2)

But, $\frac{I}{A} = j$ (Current density)

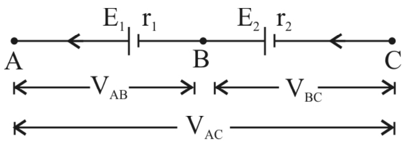
$\frac{V}{l} = E$ and $\frac{1}{\rho} = \sigma$ (conductivity)

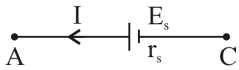
Substitute in (2) $j = \sigma E$ $\qquad \vec{j} = \sigma\vec{E}$

FIVE MARK QUESTIONS

26. Derive an expression for equivalent emf and equivalent internal resistance when two cells connected in series.

Ans: Consider two cells P and Q of E_1, r_1 and E_2, r_2 are connected in series. I is the current through the combination.





Let $V_{AB} \rightarrow$ p.d. across A and B

$V_{BC} \rightarrow$ p.d. across B and C

$V_{AC} \rightarrow$ p.d. across A and C

We have, $E = V + IR$

$V = E - IR$ . . . (1)

For cell 'P' $V_{AB} = E_1 - Ir_1$ . . . (2)

For cell 'Q' $V_{BC} = E_2 - Ir_2$ . . . (3)

But , $V_{AC} = V_{AB} + V_{BC}$

$= E_1 - Ir_1 + E_2 - Ir_2$

$V_{AC} = E_1 + E_2 - I(r_1 + r_2)$ . . . (4)

when this combination is replaced by an equivalent cell of emf Es and intrenal resistance r_s.

$V_{AC} = E_s - Ir_s$ . . . (5)

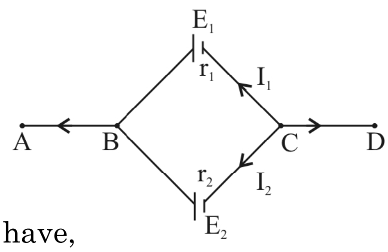
On comparing (4) and (5)

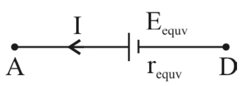
$E_s = E_1 + E_2$ and $r_s = r_1 + r_2$

27. Derive an expression for equivalent emf and equivalent internal resistance of two cells, when connected is parallel.

Ans: Consider two cells P and Q of emf and internal resistance E1, r1 and E2, r2 are connected in parallel.

Let I be the main current, I_1 and I_2 be the currents through the cells P and Q. E_{eqv} , r_{eqv} be the equivalent cell.





By definition we have,

$E = V + Ir$

$I = \frac{E - V}{r}$ . . . (1)

The current through 'P' is, $I_1 = \dfrac{E_1 - V}{r_1}$ . . . (2)

The current through 'Q' is, $I_2 = \dfrac{E_2 - V}{r_2}$ . . . (3)

The total current, $I = I_1 + I_2$

$$= \frac{E_1 - V}{r_1} + \frac{E_2 - V}{r_2}$$

$$= \frac{E_1 r_2 - V r_2 + E_2 r_1 - V r_1}{r_1 \, r_2}$$

$$= \frac{E_1 r_2 + E_2 r_1 - V(r_1 + r_2)}{r_1 \, r_2}$$

$$I = \frac{E_1 r_2 + E_2 r_1}{r_1 \, r_2} - \frac{V(r_1 + r_2)}{r_1 \, r_2} \quad \ldots (4)$$

When the combination is replaced by equivalent cell of emf Ep and internal resistance r_p.

$$I = \frac{E_p - V}{r_p} = \frac{E_p}{r_p} - \frac{V}{r_p} \quad \ldots (5)$$

Comparing (4) and (5)

$$\frac{1}{r_p} = \frac{r_1 + r_2}{r_1 \, r_2} \qquad \therefore \; r_p = \frac{r_1 r_2}{r_1 + r_2}$$

$$\frac{E_p}{r_p} = \frac{E_1 \, r_2 + E_2 \, r_1}{r_1 \, r_2} \Rightarrow E_p = r_p \left(\frac{E_1 r_2 + E_2 r_1}{r_1 \, r_2} \right) = \frac{r_1 \, r_2}{(r_1 + r_2)} \left(\frac{E_1 \, r_2 + E_2 \, r_1}{r_1 \, r_2} \right)$$

$$\therefore \; E_p = \frac{E_1 \, r_2 + E_2 \, r_1}{r_1 + r_2}$$

28. Obtain the expression for balanced condition for the Wheatstone's network.

Ans: Consider P, Q, R and S are 4 resistances connected in the form of a bridge.

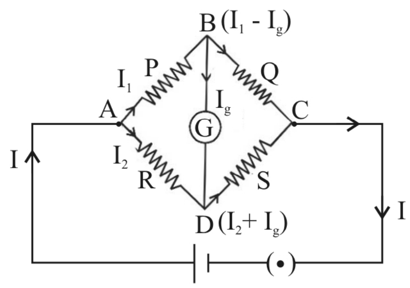
When the wheatstone bridge is balanced, Ig = 0.

i) Applying loop rule to mesh ABDA,

$I_1 P + I_g . G - I_2 R = 0$

$I_1 P - I_2 R = 0 \quad (\because \; Ig = 0)$

$\therefore \; I_1 P = I_2 R$ . . . (1)



ii) Applying loop rule to mesh BCDB.

$(I_1 - I_g) \, Q - (I_2 + I_g) \, S - I_g . G = 0$

$I_1 Q - I_2 S = 0 \quad (\because \; Ig = 0)$

$\therefore \; I_1 Q = I_2 S$ . . . (2)

Consider, $\dfrac{(1)}{(2)} \Rightarrow \dfrac{I_1 P}{I_1 Q} = \dfrac{I_2 R}{I_2 S}$; $\quad \therefore \; \dfrac{P}{Q} = \dfrac{R}{S}$

SOLUTIONS TO PROBLEMS

1. A battery of internal resistance 3Ω is connected to 20Ω resistor and potential difference across the resistor is 10V. If another resistor of $30\ \Omega$ is connected in series with the first resistor and battery is again connected to the combination. Calculate the emf and terminal p.d. across the combination. (March, 2014)

Soln: *Given:* $r = 3\Omega$; $R = 20\Omega$; $V = 10V$; $\in = ?$

Case (i): $I = \frac{\varepsilon}{R+r}$

$$\frac{V}{R} = \frac{\varepsilon}{R+r}$$

$$\in = \frac{V(R+r)}{R}$$

$$= \frac{10\,(20+3)}{26} = \frac{23}{2} = 11.5V$$

Case (ii): $Rs = 20+30 = 50\Omega$; $r = 3\Omega$; $V = ?$

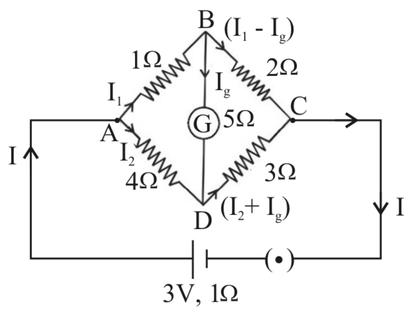
$$I = \frac{\varepsilon}{R+r}$$

$$\frac{V}{Rs} = \frac{\varepsilon}{(R+r)}$$

$$V = \frac{\varepsilon\,.\,Rs}{(R+r)} = \frac{11.5\times 50}{(50+3)} = 10.849\,V$$

2. In the given circuit, calculate the current through the galvonometer.

Soln: Apply loop rule to ABDA.



$$I_1 \times 1 + I_g \times 5 - I_2 \times 4 = 0$$

$$I_1 + 5I_g - 4I_2 = 0 \qquad \ldots(1)$$

Apply loop rule to BCDB,

$$(I_1 - I_g)\,2 - (I_g + I_2)\,3 - I_g\,.\,5 = 0$$

$$2I_1 - 2I_g - 3I_g - 3I_2 - 5I_g = 0$$

$$2I_1 - 10I_g - 3I_2 = 0 \qquad \ldots(2)$$

Apply loop rule to ADCA,

$$I_2\,.\,4 + 3(I_2 + I_g) + (I_1 + I_2)\,1 - 3 = 0$$

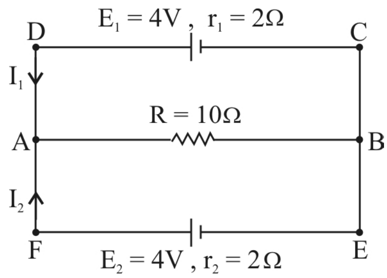
$$4I_2 + 3I_2 + 3I_g + I_1 + I_2 = 3$$

$$I_1 + 8I_2 + 3I_g = 3 \qquad \ldots(3)$$

Solving equation (1), (2) and (3), we get, $I_g = \frac{15}{230} = 0.0652A$

3. Two cells of emf 2V and 4V and internal resistance 1Ω and 2Ω respectively are connected in parallel so as to send the current in the same direction through an external resistance of 10Ω. Find the potential difference across 10Ω resistor. (March, 2015)

Soln: i) Apply KVL to mesh CDABC,



$$11I_1 + 10I_2 = 2 \quad \ldots (1)$$

ii) Apply KVL to mesh ABEFA

$$10I_1 + 12I_2 = 4 \quad \ldots (2)$$

Solving (1) and (2)

$$I_1 = -0.5A$$

$$I_2 = 3/4A$$

Potential drop across 10Ω R is,

$$V = (I_1 + I_2) R$$
$$= (-0.5 + 0.75) 10$$
$$V = 2.5 V$$

4. Two identical cells either is series or in parallel combination, gives the same current of 0.5A through external resistance of 4Ω. Find emf and internal resistance of each cell. (January, 2015)

Soln: Given: $I_s = I_p = 0.5A$; $R = 4\Omega$; $E = ?$; $r = ?$

1) $I_s = \dfrac{nE}{(R + nr)} = \dfrac{2E}{(R + 2r)}$ ... (1) $[\because n = 2]$

2) $Ip = \dfrac{nE}{(nR + r)} = \dfrac{2E}{(2R + r)}$ ... (2)

$$Is = Ip$$
$$\frac{2E}{R + 2r} = \frac{2E}{2R + r}$$
$$2R + r = R + 2r$$
$$2(4) + r = 4 + 2r$$
$$r = 8 - 4$$
$$r = 4\Omega$$

Put 4 = 4 in (1)

$$0.5 = \frac{2E}{4 + 2(4)}$$
$$2E = 0.5(12)$$
$$E = \frac{6}{2}$$
$$E = 3V$$

5. A wire having length 2m, diameter 1 mm and resistivity $1.963 \times 10^{-6}\ \Omega m$ is connected in series with a battery of emf 3V and internal resistance 1Ω. Calculate the resistance of the wire and current in the circuit.

Soln: *Given:* $l = 2m$; $d = 1\,mm = 1 \times 10^{-3}\,m$; $\rho = 1.963 \times 10^{-6}\ \Omega m$; $E = 3V$; $r = 1\Omega$; $R = ?$; $I = ?$

i) **To find R :** $R = \frac{\rho l}{A} = \frac{1.963 \times 10^{-6} \times 2}{A}$ . . . (1)

ii) **To find A :** For cylindrical wire, $A = \pi r^2 = \pi \frac{d^2}{4}$

$$= \frac{22}{7} \times \frac{(1 \times 10^{-3})^2}{4} = 0.7857 \times 10^{-6}\, m^2$$

Substitute in (1), $R = \frac{1.963 \times 10^{-6} \times 2}{0.7857 \times 10^{-6}} = 4.9968\,\Omega = 5\,\Omega$

To find I : $I = \frac{E}{R + r} = \frac{3}{5+1} = \frac{3}{6} = 0.5A$

6. 100mg mass of nicrome metal is drawn into a wire of area of cross section 0.05mm². Calculate the resistance of this wire. Given: Density of nicrome is 8.4×10^3 kg m^{-3} **and resistaivity of the material is** $1.2 \times 10^{-6}\, \Omega m$.

Soln: *Given:* m = 100 mg = $10 \times 10^{-3} g = 10 \times 10^{-6}$ kg

$A = 0.05\, mm^2 = 0.05 \times (10^{-3})^2 = 0.05 \times 10^{-6}\, m^2$

Density (D) = 8.4×10^3 kg / m^3 ; R = Resistivity $\rho = 1.2 \times 10^{-6}\, \Omega m$

To find R: $R = \frac{\rho l}{A}$ . . . (1)

'l' is unknown.

To find 'l' : Density (D) $= \frac{Mass}{Volume} = \frac{Mass}{Area \times Length}$; Length $= \frac{Mass}{(A \times D)}$

Eqn (1) $\Rightarrow R = \frac{\rho}{A} = \frac{Mass}{(A \times D)}$

$$R = \frac{1.2 \times 10^{-6} \times 10 \times 10^{-6}}{0.05 \times 10^{-6} \times 8.4 \times 10^3} = 5.7142\,\Omega.$$

7. In Wheatstone's network $P = 20\Omega$, $Q = 25\Omega$, $S = 30\Omega$ **and R =** 15Ω **are connected in a cyclic order. Is the network balanced? If not how do you vary (i) R and (ii) S to balance the network?**

Soln: *Given:* $P = 20\Omega$, $Q = 25\Omega$, $S = 30\Omega$, $R = 15\Omega$.

For balanced = $\frac{P}{Q} = \frac{R}{S}$; $\frac{20}{25} = \frac{15}{30} \Rightarrow \frac{4}{5} \neq \frac{3}{6}$

Hence, network is not balanced.

R must be increased : $\frac{20}{25} = \frac{15 + R^1}{30}$

$$(15 + R^1) = \frac{20 \times 30}{25}$$

$$R^1 = 24 - 15 \quad \Rightarrow \quad R^1 = 9\Omega$$

9 Ω is connected in series with R = 15 Ω.

$\therefore$ R = 15 + 9 24 Ω.

* * *

Chapter-4

Moving Charges and Magnetism

ONE MARK QUESTIONS

1. **Does a neutron experience a force in magnetic field.**

Ans: No. Since charge of neutron is zero.

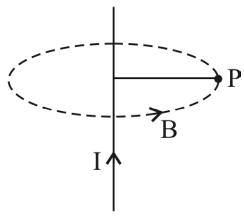
2. **Write the expression for force experienced by a straight conductor of length $\vec{l}$ carrying current I, placed in a uniform magnetic field $\vec{B}$.**

Ans: $\vec{F} = I(\vec{l} \times \vec{B}) = BIl\sin\theta$.

3. **State and explain Awper's circuital law.**

Ans: It states that the integral value of the magnetic field over a closed conductor is equal to μ_0 times the net current in the conductor.

Consider a conductor carrying current 'I'.
Let an amperian loop of radius 'r' be constructed,
then according to the law,



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

4. **Define 'Ampere' the SI unit of current by writing expression for the force between the parallel conductors.**

Ans: $\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi d}$

"The one ampere is defined as the current which when flowing in each of two infinetely long straight conductors separated by a distance of one metre in free space experience a force of $2 \times 10^{-7}\ N/m$ between them.

5. **What is the nature of the force between two parallel conductors carrying currents in the (a) Same direction; (b) Opposite direction.**

Ans: a) Attraction for same direction.

b) Repulsion for opposite direction.

TWO MARK QUESTIONS

6. **Write the expression for magnetic force acting on a charged particle moving in a uniform magnetic field and explain the terms.**

Ans: F = Bq V sin θ
where, B = Magnetic field strength; q = Charge; V = Velocity of the charged particle.

7. When the force on a charge moving in a magnetic field is (a) Maximum; (b) Minimum.

Ans: F = Bq V sin θ

a) If $\theta = 90°$ $\rightarrow$ F is maximum.

b) If $\theta = 0°$ $\rightarrow$ F is minimum.

8. What is Lorentz force? Write the expression for it?

Ans: Force experienced by moving charged particle in a region containing both electric and magnetic field is called Lorentz force.

Lorentz force = Fe + Fm

$$F = qE + Bq\, V \sin\theta$$

$$F = q\left[\bar{E} + (\bar{V} \times \bar{B})\right]$$

9. Give vector form of Biot-Savart's law and explain the terms?

Ans: $d\vec{B} = \left(\frac{\mu_0}{4\pi}\right)\frac{I\,(d\vec{l} \times \vec{r})}{r^3}$

where, $d\vec{l}$ = length of current element

$\vec{r}$ = position vector of current element

$d\vec{B}$ = magnetic field strength

10. Define Bohr Magneton and mention its value.

Ans: The magnetic dipole moment of electron revolving in the first orbit of hydrogen atom is called Bohr Magnetion. It's value is 9.27×10^{-24} Am^2.

THREE MARK QUESTIONS

11. On what factors the force experienced by charged particle moving in a Magnetic field.

Ans: i) Magnitude of the charge (B)

ii) Velocity of the charged particle (V)

iii) Angle between 'V' and 'B'.

12. Derive the expression for force acting on a current carrying conductor in an uniform magnetic field.

Ans: Let l, A and B are the length, Area of cross-section of conductor and Magnetic field.

Let 'n' be the number density of electrons present in the conductor.

Therefore the total number of free electrons in the conductor = nAl

Total charge on electrons = q nAle

Force on these electrons = $F = q\,(V_d \times B)$

$$F = nA\,le\,(V\bar{d} \times \bar{B})$$

$$F = I\,(\bar{l} \times \bar{B}) \quad (\because\ I = nAeVd)$$

$$\boxed{F = BI\,l\,\sin\theta}$$

13. State and explain Biot-Savarts law.

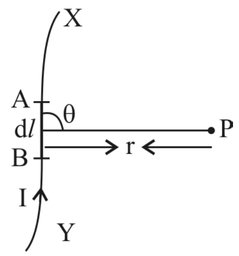
Ans: It states that the magnetic field at a point due to the current element is

i) Directly proportional to strength of current (I)

ii) Directly proportional to length of current element (dl)

iii) Directly proportional to sine of angle between the current element and the line joining the point $(\sin\theta)$.

iv) Inversely proportional to square of the distance between the current element and the point at which magnetic field to be calculated.



$\therefore$ XY $\rightarrow$ Conductor

dl $\rightarrow$ Length of small element

$\therefore dB \propto I$

$dB \propto dl$

$$dB \propto \sin\theta$$

$$dB \propto \frac{1}{r^2}$$

$$\therefore dB \propto \frac{Id\,l\sin\theta}{r^2}$$

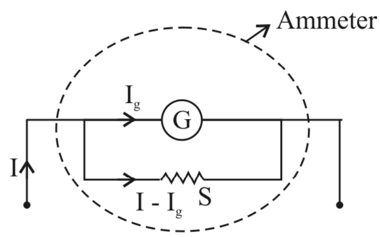
$$dB = K\frac{Id\,l\sin\theta}{r^2}$$

$$K = \frac{\mu_0}{4\pi} = 10^{-7}\ Hm^{-1}$$

$$\boxed{\therefore dB = \frac{\mu_0}{4\pi}\frac{Id\,l\sin\theta}{r^2}}$$

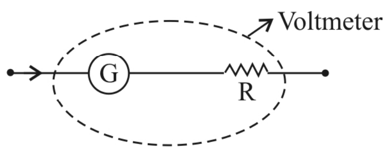
14. How to convert a Galvometer into Ammeter.

Ans: A low resistance called shunt resistance (S) is connected in parallel with the galvonometer.

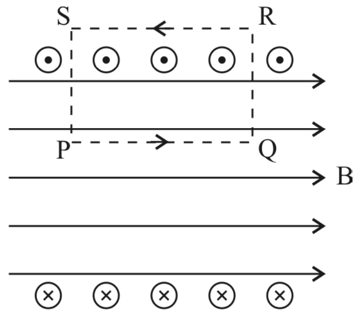


15. How to convert a Galvonometer into Voltmeter.

Ans: A high resistance (R) is connected in series with the galvonometer. Then this modified version is called voltmeter.



16. Derive an expression for magnetic field at a point inside a long current carrying solenoid using Ampere's Circuit law.



Ans: Let n $\rightarrow$ number of turns per unit length
I $\rightarrow$ Current
B $\rightarrow$ Magnetic field inside the solenoid.

Consider a rectangular loop PQRS and PQ = RS = L.

The line integral of $\overline{B}$ over the closed path PQRSP is,

$$\oint \overline{B}.\overline{d}l = \int_P^Q \overline{B}.\overline{d}l + \int_Q^R \overline{B}.\overline{d}l + \int_R^S \overline{B}.\overline{d}l + \int_S^P \overline{B}.\overline{d}l$$

$$\oint_P^Q \overline{B}.\overline{d}l = \int_P^Q \overline{B}.\overline{d}l \cos 0° = BL$$

Now, $\int_Q^R \overline{B}.\overline{d}l = \int_S^P \overline{B}.\overline{d}l = \int_R^S \overline{B}.\overline{d}l = 0$

$$\therefore \oint \overline{B}.\overline{d}l = BL \qquad \ldots (1)$$

According to Ampere's critical law,

$$\oint_P \overline{B}.\overline{d}l = \mu_0 I = \mu_0 n LI \qquad \ldots (2)$$

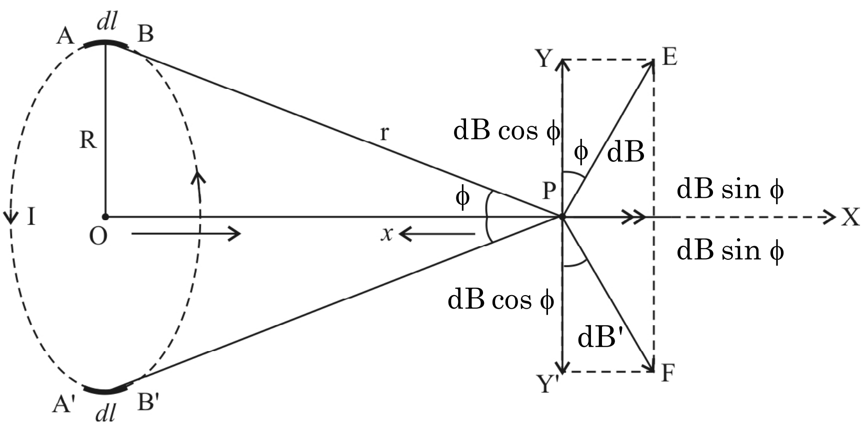
$\therefore$ From (1) and (2), $BL = \mu_0 n I L$

$$\boxed{B = \mu_0 n I}$$

FIVE MARK QUESTIONS

17. Derive an expression for magnitude of the magnetic field at a point along the axis of the circular coil carrying current.

Ans: Consider a circular coil of radius R carrying a current I. Plane of the coil perpendicular to the paper. Let 'P' be a point at a distance 'x' from the centre of the



coil along the axis.

Accorindg to Biot Savarts law, The magnitude of magnetic field at 'P' due to element AB is,

$$dB = \frac{\mu_0}{4\pi} \frac{Id\,l \sin\theta}{r^2} \qquad (\text{R is very small then } \theta = 90°)$$

$$dB = \frac{\mu_0}{4\pi} \frac{Id\,l \sin 90°}{r^2} \text{ along PE}$$

Similarly, magnetic field at 'P' due to A'B' element is,

$$dB' = \frac{\mu_0}{4\pi} \frac{Id\,l}{r^2} \text{ along PF} \quad (db = dB')$$

The magnetic field dB along PE is resolved into two components as $dB \sin\phi$ along X-axis and $dB\cos\phi$ along Y-axis. $dB\cos\phi$ components are cancel each other. $dB\sin\phi$ components gets added up.

$\therefore$ for the entire coil, $B = \Sigma\, dB \sin\phi$

$$B = \Sigma \frac{\mu_0}{4\pi} \frac{Id\,l}{r^2} \sin\phi \qquad \left[\because dB = \frac{\mu_0}{4\pi} \frac{Id\,l}{r^2}\right]$$

$$= \frac{\mu_0}{4\pi} \frac{I}{r^2} \sin\phi\, \Sigma\, dl$$

$\Sigma\, dl = \text{Circumference of the coil} = 2\pi R$

$$B = \frac{\mu_0}{4\pi} \frac{I}{r^2} \sin\phi\, 2\pi R \qquad \ldots (1)$$

From the *fig.* $r^2 = R^2 + x^2 \qquad \ldots (2)$

$$r = \sqrt{R^2 + x^2} = \left(R^2 + x^2\right)^{\frac{1}{2}} \qquad \ldots (3)$$

and $\sin\phi = \dfrac{R}{r}$

$$\sin\phi = \frac{R}{\sqrt{R^2 + x^2}} = \frac{R}{(R^2 + x^2)^{\frac{1}{2}}} \qquad \ldots (4)$$

Substitute (2) and (3) and (4) in (1)

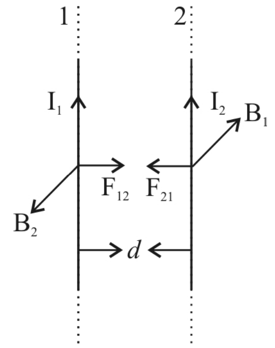
$$B = \frac{\mu_0}{4\pi} \frac{I}{R^2 + x^2} \frac{R}{(R^2 + x^2)^{\frac{1}{2}}} (2\pi R)$$

$$B = \frac{\mu_0}{4\pi} \frac{2\pi I R^2}{(R^2 + x^2)^{\frac{3}{2}}}$$

For 'n' turns, $\boxed{B = \frac{\mu_0}{4\pi} \frac{2\pi I n R^2}{(R^2 + x^2)^{\frac{3}{2}}}}$

18. Derive the expression for force between two straight infinitely long parallel conductors and define one ampere.

Ans: Magnetic field produced by the conductor '1' at a distance 'd' is,



$$B_1 = \frac{\mu_0}{4\pi}\frac{I_1}{d} \qquad \ldots (1)$$

The force on 'conductor '2' due to conductor '1' is,

$$F_{21} = B_1 L I_2 \qquad \ldots (2) \left[\because F = BIL\right]$$

Substitute (1) in (2) we get,

$$F_{21} = \frac{\mu_0}{4\pi}\frac{I_1 I_2 L}{d} \qquad \ldots (3)$$

Similarly magnetic field by the conductor '2' is,

$$B_2 = \frac{\mu_0}{4\pi}\frac{I_2}{d} \qquad \ldots (4)$$

The force on '1' due to '2' is,

$$F_{12} = B_2 L I_1 \qquad \ldots (5)$$

Substitute (4) in (5), we get

$$F_{12} = \frac{\mu_0}{4\pi}\frac{I_2 I_1 L}{d} \qquad \ldots (6)$$

$$\therefore \quad F_{12} = F_{21}$$

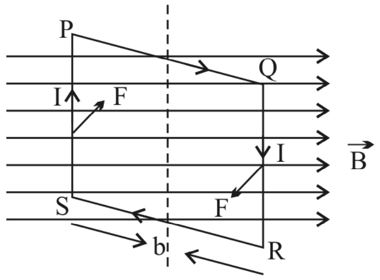
$$f_{21} = f_{12} = \frac{F_{12}}{L} = \frac{\mu_0}{4\pi}\frac{I_1 I_2}{d}$$

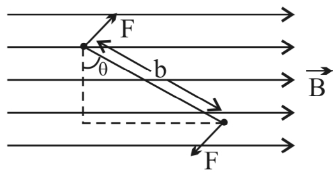
$$\boxed{\therefore \; f_{21} = f_{12} = \frac{\mu_0}{4\pi}\frac{I_1 I_2}{d}}$$

One Ampere: One ampere is defined as that steady current which when flowing in each of two infinitely long straight conductors seperated by one metre in free space experience a force of $2 \times 10^{-7}\ \text{Nm}^{-1}$ betwen them.

19. Obtain the expression for the torque acting on a rectangular current loop placed in an uniform magnetic field.

Ans:





Consider a rectangular loop PQRS is carrying current I.

Let, l = length of the loop; b = breadth of the loop

The arms PS and QR will experience equal and opposite force 'F', when the magnetic field is 'B'.

$\therefore\ F = B I l \sin\theta$

$F = B I l \qquad \ldots (1) \qquad (\theta = 90^\circ)$

But, PQ and SR do not experience any force. ($\because$ PQ and SR are parallel to the field.)

Therefore, torque experienced by the coil,

$$\tau = \text{Force} \times \text{Perpendicular distance}$$

$$\tau = B I l \times b \sin\theta$$

$$= B I A \sin\theta \qquad (\because A = l \times b)$$

$$= m B \sin\theta \qquad (\because m = IA)$$

for 'N' turns of loop, $\boxed{\tau = N B I A \sin\theta.}$

SOLUTIONS TO PROBLEMS

1. **A straight of length $\frac{\pi}{2}$ m is bent into a circular shape O is the center of the circle formed and 'P' is a point on its axis which is at a distance 3 times the radius from O. A current of 1A is passed through it. Calculate the magnitude of magnetic field at the point 'O' and 'P.'**

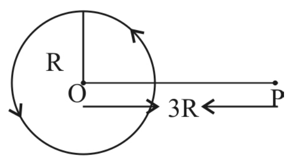
Soln: *Given:* I = 1A; n = 1; x = 3R

$$\text{Circumference} = \frac{\pi}{2}$$

$$2\pi R = \frac{\pi}{2}$$

$$\pi R = \frac{\pi}{4}$$

$$R = \frac{1}{4} = 0.25\,\text{m}$$



$$\therefore\ x = 3R = 3 \times 0.25$$

$$x = 0.75\,\text{m}$$

Therefore magnetic field of the centre of the current loop,

$$B_0 = \frac{\mu_0}{4\pi}\frac{2\pi n I}{R}$$

$$= \frac{10^{-7} \times 2 \times 3.14 \times 1 \times 1}{0.25}$$

$$B_0 = 2.5 \times 10^{-6}\ \text{T}$$

Magnetc field at the point 'P' onthe axis of current loop,

$$B_a = \left(\frac{\mu_0}{4\pi}\right)\frac{2\pi n I R^2}{\left(R^2 + x^2\right)^{\frac{3}{2}}}$$

$$= \frac{10^{-7} \times 2 \times 3.14 \times 1 \times 1 \times (0.25)^2}{\left[(0.25)^2 + (0.75)^2\right]^{\frac{3}{2}}}$$

$$\boxed{B_a = 0.079 \times 10^{-6}\ \text{T}}$$

2. A milli ammeter of resistance $0.5\,\Omega$ gives full scale deflection for a current of 5mA. How to convert it into an ammeter of range (0 – 0.5A) and volt meter of range (0 – 50V).

Soln: *Given:* $G = 0.5\,\Omega$, $I_g = 5\times10^{-3}\,A$, $I = 0.5\,A$

i) WKT, $S = \dfrac{I_g\,G}{I - I_g}$

$= \dfrac{0.5 \times 5 \times 10^{-3}}{0.5 - 5 \times 10^{-3}}$

$= 5 \times 10^{-3}\,\Omega$ in parallel with galvonometer.

ii) Given: V = 50V,

WKT, $R = \dfrac{V}{I_g} - G$

$= \dfrac{50}{5\times10^{-3}} - 0.5$

$R = 9999.5\,\Omega$

$9999.5\,\Omega$ resistance connected in series with galvonometer.

* * *

Chapter-5

Magnetism and Matter

ONE MARK QUESTIONS

1. **Can two magnetic field lines intersect each other?**

Ans: No.

3. **What is 'magnetic dip'?**

Ans: Dip at a place is defined as the angle made by the direction of the Earth's total magnetic field with the horizontal drawn in the magnetic meridian.

4. **What is magnetic 'declination'?**

Ans: The angle between the magnetic meridian and geographic meridian is called declination.

5. **How does the value of B_H varies from equator ot poles.**

Ans: B_H is maximum at equator and zero at poles.

6. **Define magnetisation of a magnetic material.**

Ans: It is defined as the ratio of net magnetic moment developd per unit volume.

7. **Define magnetic susceptibility of a magnetic material.**

Ans: It is the ratio of magnetisation developed in the material to the applied magnetic intensity. $\left(\chi = \frac{M}{H}\right)$

8. **Susceptibility of ferromagnetic substance is 3000. What is its relative permability.**

Ans: $\mu r = 1 + \chi = 1 + 3000 = 3001$

9. **For which meterial susceptibility low and negative?**

Ans: Diamagnetic material.

10. **State Gauss's law in magnetism.**

Ans: The net magnetic flux through any closed surface is always zero.

$$\boxed{\sum \overline{B} \, . \, d\overline{s} = 0}$$

11. **Write the formula for Time period of oscillation of small magnetic needle in a uniform magnetic field.**

Ans: $T = 2\pi \sqrt{\frac{I}{MB}}$

TWO MARK QUESTIONS

1. Mention the properties of magnetic field lines ?

Ans: i) Magnetic field lines form closed loops,

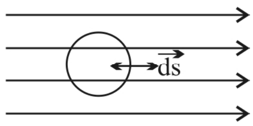
ii) Magnetic field lines do not interestct,

iii) The tangent drawn on magnetic field line represents direction of the magnetic field.

2. State and explain Gause's law in magnetism.

Ans: **Statement:** The net magnetic flux through any closed surface is always zero.

$$\sum \overline{B} . \overline{dS} = 0 .$$



Consider a Gaussion surface enclosed in a magnetic field B. Since the total magnetic flux entering the Gaussian surface is equal to total flux leaving the surface.

3. Define magnetic dipole moment, mention its SI unit.

Ans: "It is the product of the magnetic length and pole strength of the magnet."

$$M = \left(\vec{q} \times \overline{2l}\right)$$

SI unit is Am^2.

* * *

Chapter-6

Electro Magnetic Induction

ONE MARK QUESTIONS

1. **What is the SI unit of magnetic flux.**

Ans: weber (Wb) OR Tesla meter square (Tm^2).

2. **Mention the significance of Lenz's law.**

Ans: Conservation of energy (OR) It gves the polarity of induced emf.

3. **Name the law which gives the polarity of induced emf.**

Ans: Lenz's law.

4. **What is motional emf ?**

Ans: Emf induced in a rod moving in a plane perpendicular to magnetic field is called motional emf.

5. **Mention the expression for motional emf.**

Ans: $e = Blv$,

where B = strength of magnetic field, l = length of the conductor, V = Velocity of the conductor.

6. **On what principle AC generator works?**

Ans: Electromagnetic induction.

7. **Give the expression for energy stored in an induction coil carrying current.**

Ans: $U = \frac{1}{2} LI^2$

where, L = Self inductance of the coil, I = Current in the coil.

TWO MARK QUESTIONS

8. **State and explain Faradys law of electro magnetic induction.**

Ans: The magnitude of induced emf in a circuit is directly proportional to the rate of change of magnetic flux through the circuit.

$$e \ \alpha \ \frac{d\phi}{dt}$$

9. Mention the applications of Eddy current.

Ans: i) Spedometer ii) Induction furnace iii) Magnetic braking in trains

10. Give an expression for self-inductance of a coil and explain the terms.

Ans: $L = \mu_0\mu_r \pi n^2 r^2 l$

where, l = Length of the solenoid ;

n = number of turns per unit length

r = radius of the solenoid

μ_r = relative permiability of medium inside the coil.

11. Mention the factors on which the self inductance of a coil depends.

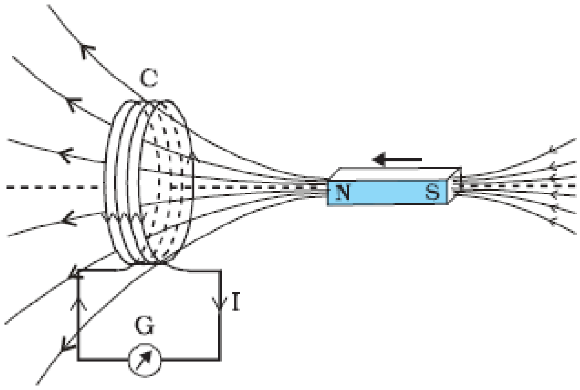
Ans: a) Length of the coil

b) Number of turns per unit length of the coil

c) Medium inside the coil

THREE MARK QUESTIONS

12. Describe the coil magnet experiment of Faraday and Henry to demonstrate electro magnetic induction.



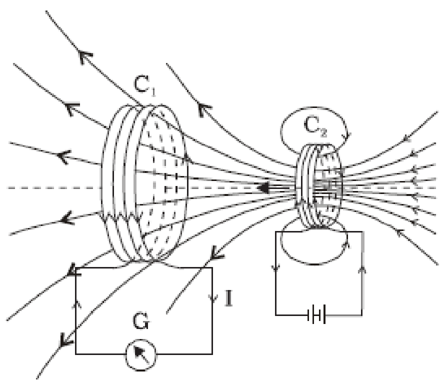
a) When a magnet is moved towards a coil the galvanometer attached to the coil shows deflection on one side.

b) When a magnet is moved away from the coil, galvonometer shows deflection but in opposite side.

c) When there is no relative motion between the magnet and coil, the galvonometer shows no deflection.

It shows that there is a production of current (emf) in the coil when there is a change in magnetic flux.

13. Describe the coil and coil experiment of Faraday and Henry to demonstrate electromagnetic induction.



a) When a current carrying coil is moved towards another coil, the galvanometer attached to it shows deflection on one side.

b) When the current carrying coil moved away from the second coil, galvanometer shows deflection in opposite side.

c) When the current carrying coil held rest near the second coil no deflection observed in the galvanometer.

It shows that the change in magnetic flux is responsible for production of electric current in the coil.

14. State and explain Lenz's law.

Ans: **Statement:** "The polarity of induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produced it."

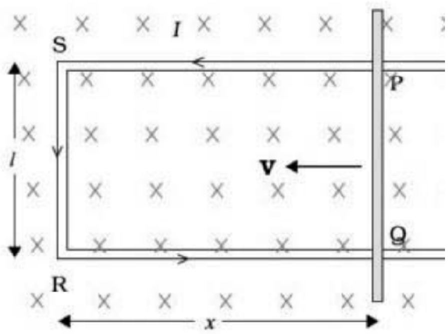
$$e = -\frac{d\phi_B}{dt}$$

15. Derive the expression for electro motive force induced in a rod moving perpendicular to uniform magnetic field. (Expression for motional emf).

Ans: The magnetic flux linked with the area PQRS is, $\phi_B = BA\cos\theta$

$$= B\,lx\,\cos 0°$$

$$\phi_B = B\,lx$$



emf induced = $e = -\frac{d\phi_B}{dt}$

$$= -\frac{d(Blx)}{dt}$$

$$= -Bl\frac{dx}{dt}$$

But, the velocity of the rod, $v = -\frac{dx}{dt}$

$$\therefore e = BlV$$

16. Obtain an expresion for magnetic potential energy stored in a self inductor.

Ans: Power, $P = \frac{dw}{dt} = eI$; But, $e = L\frac{dI}{dt}$

$$\frac{dw}{dt} = L\frac{dI}{dt}$$

$$dw = LI\,DI$$

Total workdone in establishing the current 'I' is given by,

$$W = \int_0^I dw$$

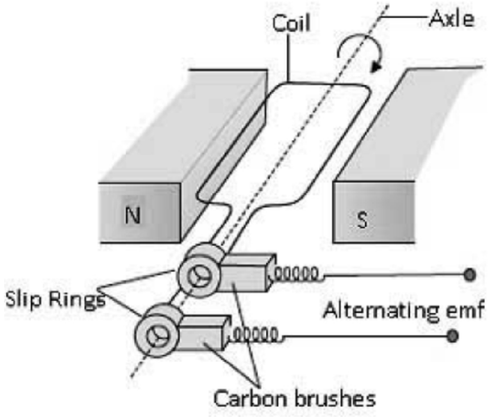
$$= \int_0^I LI\,dI$$

$$= \frac{1}{2}LI^2$$

$$U = \frac{1}{2}LI^2$$

17. Write neat labelled diagram of a AC generator.

Ans:



18. Obtain an expression for the instantaneous emf induced in an AC generator.

Ans: Let, N = Number of turns in the coil.

A = Area of the coil

W = Angular frequency

B = Strenth of magnetic field

When a coil is rotating in magnetic field, the flux through the coil,

$$\phi_B = NAB\cos\omega t$$

But, $e = -\frac{d\phi}{dt} = -\frac{d}{dt}(NAB\cos\omega t) = -NAB\frac{d}{dt}(\cos\omega t)$

$e = NAB\, w \sin\omega t$

$e = e_0 \sin\omega t$

where, $e_0 = NAB\ \omega$ = Peak emf.

* * *

Chapter-7

Alternating Current

ONE MARK QUESTIONS

1. **Write the expression for mean value of alternating voltage.**

Ans: $V_m = \frac{2}{\pi} V_0$

2. **Write the expression for rms value of alternating voltage.**

Ans: $V_{rms} = \frac{1}{\sqrt{2}} V_0$

3. **Write the expression for mean value of alternating current.**

Ans: $I_m = \frac{2}{\pi} I_0$

4. **Write the expression for rms value of alternating current.**

Ans: $I_{rms} = \frac{1}{\sqrt{2}} I_0$

5. **What is electrical resonance in LCR series circuit?**

Ans: It is the condition of maximum current in series LCR circuit.

6. **Write the expression for resonant frequency.**

Ans: $f_0 = \frac{1}{2\pi\sqrt{LC}}$

7. Write the condition for electrical resonance in series LCR circuit.

Ans: $X_L = X_C$ OR $L\omega_0 = \frac{1}{c\omega_0}$.

TWO MARK QUESTIONS

8. **What is quality factor in an LCR series circuit? Write the expression for it.**

Ans: Quality factor is an LCR series circuit is defined as the ratio of resonant frequency to the bandwidth. It is given by,

$$Q = \frac{f_0}{f_2 - f_1}$$

where, f_0 = resonant frequency, $f_2 - f_1$ = band width.

9. What is resonance in LCR series circuit? Obtain the expression for resonant frequency.

Ans: Electric resonance in series LCR circuit is the condition of maximum current through it.

Expression for resonant frequency : When the frequency of AC is equal to resonant frequency then inductive reactance is equal to capacitive reactance.

i.e., when $f = f_0$, $X_L = X_C$

$$L\omega_0 = \frac{1}{C\omega_0}$$

$$\omega_0^2 = \frac{1}{LC}$$

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

$$2\pi f_0 = \frac{1}{\sqrt{LC}}$$

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

10. Mention any three sources of energy loses in transformer?

Ans: i) Magnetic flux leakage.

ii) Ohmic loses due to the resistance of the wire.

iii) Eddy currents losses.

iv) Hysteresis loss.

FIVE MARK QUESTIONS

11. Obtain the expression for impedance and current in a series LCR circuit using phasor diagram.

Ans: Let a pure resistor of resistance 'R', a pure inductor of inductance 'L' and a pure capacitor of capacitance 'C' be connected in series to a AC source as shown in fig (a).

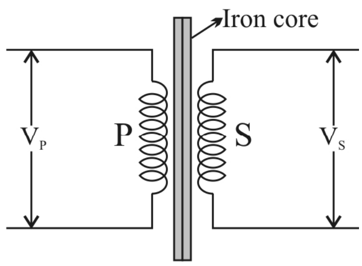


fig. (a)

The instantaneous AC voltage applied is,

$$V = V_0 \sin \omega t \qquad \ldots (1)$$

Since inductor, capacitor and resistor are in series the same current flows through all of them.

Let 'I' be the current in the circuit at any instant of time. Let V_L, V_C and V_R be the potential difference across inductor, capacitor and resistor respectively at the instant. Then,

$$V_L = IX_L,\ V_C = IX_C \text{ and } V_R = I_R$$

where, X_L - inductive reactance,

X_C - capacitive reactance.

The current phasor I is represented by X-axis. V_R is in the phase with current and is represented by OA. V_L leads the current by 90° and is represented by OC as shown in fig. (b), Phasor diagram.

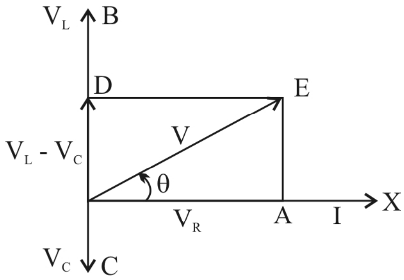


fig. (b)

If $V_L > V_C$, then resultant voltage will be $V_L - V_C$ and is represented by OD. Finally the resultant of V_R and $V_L - V_C$ is V and is represented by OE as shown in fig. (b).

From the Δ^{le} OEA,

$$OE^2 = OA^2 + AE^2$$

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

$$= (IR)^2 + (IX_L - IX_C)^2$$

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

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

$$I^2 = \frac{V^2}{R^2 + (X_L - X_C)^2}$$

$$I = \frac{V}{\sqrt{R^2 + (X_L - X_C)^2}}$$

$$I = \frac{V}{\sqrt{R^2 + \left(L\omega - \frac{1}{c\omega}\right)^2}}$$

$$I = \frac{V}{Z}$$

where, $Z = \sqrt{R^2 + \left(Lw - \frac{1}{c\omega}\right)^2}$ is called as impedance of the series LCR circuit.

Equation (2) represents the current through series LCR circuit.

From the Δ^{le} OEA,

$$\tan\phi = \frac{EA}{OA}$$

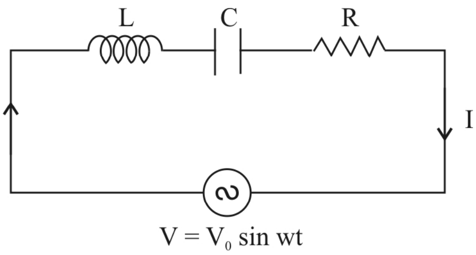
$$= \frac{V_L - V_C}{V_R} = \frac{IX_L - IX_C}{IR} = \frac{I(X_L - X_C)}{IR} = \frac{X_L - X_C}{R} = \frac{\left(Lw - \frac{1}{C\omega}\right)}{R}$$

$$\phi = \tan^{-1}\frac{\left(L\omega - \frac{1}{C\omega}\right)}{R} \qquad \ldots (3)$$

Equation (3) represents the phase angle between voltage 'V' and current 'I'.

SOLUTION TO PROBLEMS

1. **A 50Ω resistor, 0.5H productor and 200 μF capacitor are connected in series with 220V and 50Hz AC source. Find the impedance of the circuit and hence the current.**



Soln: Data: $R = 50\Omega$, L = 0.5H, $C = 200\ \mu F$,

$C = 200\times10^{-6}F$, V = 220V, f = 50Hz,

Z = ?, I = ?

The impedance of the series LCR circuit is,

$$Z = \sqrt{R^2 + \left(L\omega - \frac{1}{c\omega}\right)^2}$$

$$= \sqrt{R^2 + \left(L\,2\pi f - \frac{1}{c\,2\pi f}\right)^2}$$

$$= \sqrt{50^2 + \left(0.5\times2\times3.14\times50 - \frac{1}{200\times10^{-6}\times2\times3.14\times50}\right)^2}$$

$$= \sqrt{2500 + \left(157 - \frac{1}{62800\times10^{-6}}\right)^2}$$

$$= \sqrt{2500 + \left(157 - \frac{1}{0.062800}\right)^2}$$

$$= \sqrt{2500 + (141.077)^2}$$

$$= \sqrt{2500 + 19902.71}$$

$$= \sqrt{22402.71}$$

$$Z = 149.67\,\Omega$$

Current through the series LCR circuit is, $I = \frac{V}{Z} = \frac{220}{149.67} = 1.469A$

2. **Obtain the resonant frequency of a series LCR circuit with L = 4H, C = 27μF and R = 8.4 Ω. What is the Q-value of this circuit? Also find the band width.**

Soln: **Data:** L = 4H, C = 27 μF, $C = 27\times10^{-6}F$, $R = 8.4\Omega$, f_0 = 3, Q = ?, B.W. = ?

The resonant frequency is,

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

$$= \frac{1}{2\times3.14\ \sqrt{4\times27\times10^{-6}}}$$

$$= \frac{1}{6.28\ \times\ \sqrt{108\times10^{-6}}} = \frac{1}{6.28\ \times\ 10.39\times10^{-3}}$$

$$\Rightarrow \frac{1}{65.24\ \times\ 10^{-3}} = 0.0153\ \times10^{3}$$

$$f_0 = 15.3\,Hz$$

The Q -Value of quality factor is, $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$

$$= \frac{1}{8.4}\sqrt{\frac{4}{27\times10^{-6}}}$$

$$= 0.1190 \times \sqrt{0.1481 \times 10^{6}}$$

$$= 0.1190 \times 0.3848 \times 10^{3}$$

$$= 0.1190 \times 384.8$$

$$Q = 45.79$$

Band width is given by, $B.W. = \frac{f_0}{Q} \quad \left(\because Q = \frac{f_0}{B.W.}\right)$

$$= \frac{15.3}{45.79} = 0.3341$$

3. A resistor 100Ω , a pure inductance coil of L = 0.5H and capacitor are in series in a circuit containing an AC of 200V, 500Hz. In the circuit current is ahead of the voltage by 30°. Find the value of the capacitance.

Soln: *Data:* R = 100Ω , L = 0.5H, V = 200V, f = 50Hz, ϕ = 30°, C = ?

The phase angle between voltage and current is a series LCR circuit is,

$$\tan\phi = \frac{L\omega - \frac{1}{C\omega}}{R}$$

$$R\tan\phi = L\omega - \frac{1}{C\omega}$$

$$\frac{1}{C\omega} = L\omega - R\tan\phi$$

$$C = \frac{1}{\omega(L\omega - R\tan\phi)}$$

$$= \frac{1}{L\omega^2 - R\omega\tan\phi}$$

$$= \frac{1}{L \times (2\pi f)^2 - R\,2\pi f\tan\phi}$$

$$= \frac{1}{4\pi^2 f^2 L - R\,2\pi f\tan\phi}$$

$$= \frac{1}{4 \times (3.14)^2 \times (50)^2 \times 0.5 - 100\times2\times3.14\times50\times\tan 30°}$$

$$= \frac{1}{49298 - 31400\times\frac{1}{\sqrt{3}}}$$

$$= \frac{1}{49298 - 18128.79} = \frac{1}{31169.21}$$

$$C = 3.208\times10^{-5}$$

$$C = 32.08 \times 10^{-6}\ F$$

$$C = 32.08\ \mu F$$

4. **A source of alternating emf of 220V, 50Hz is connected in series with a resistance of 200Ω, inductance 0.1H and capacitance of $30\mu F$. Does the current lead lag the voltage. Find the phase angle.**

5. **A 200Ω resistor, 1.5H inductor and $35\mu F$ capacitor are connected in series with a 220V, 50Hz AC supply. Calculate the impedance of the circuit and also find the current through the circuit.**

6. **Calculate the resonant frequency of a series LCR circuit with L = 2H, C = $32\mu F$ and R = 10Ω. What is the quality factor of this circuit.**

* * *

Chapter-8

Electromagnetic Waves

ONE MARK QUESTIONS

1. What are electromagnetic waves?

Ans: The electromagnetic waves are those waves in which these are sinusoidal variation of electric and magnetic field vectors at right angles to each other as well as right angles to the direction of wave propagation.

2. What is electromagnetic spectrum?

Ans: The orderly distribution of electromagnetic radiations arranged according to their wavelength (OR) frequency is called as electromagnetic spectrum.

3. What is the source of an electromagnetic wave?

Ans: An accelerated charged particle is the source of electromagnetic wave.

4. Who has experimentally demonstrated the existence of electromagnetic waves?

Ans: Heinrich Hertz.

5. Arrange IR rays, Gamma rays, Visible rays, X-rays in increasing order of wavelength.

Ans: Gamma rays, X-rays, Visible rays, IR rays.

6. Arrange Micro waves, Gamma rays, Visible rays, X-rays in increasing order of frequency.

Ans: Micro waves, Visible rays, X-rays, Gamma rays.

7. Write the wavelength range for X-rays?

Ans: $0.1A° – 100A°$.

TWO MARK QUESTIONS

8. Write any two uses of gamma rays?

Ans: i) They are used in the treatment of cancer.

ii) They are used to produce nuclear reactions.

9. Write any two uses of X-rays?

Ans: i) They are used to detect bone fractures, stones, bullets etc. in the human body.

ii) They are used to cure skin disease.

10. Write any two uses of UV-rays?

Ans: i) They are used to destroy bacteria.

ii) They are used in eye surgery.

11. Write any two uses of microwaves?

Ans: i) They are used in radar.

ii) They are used in micro ovens.

12. Write any two uses of IF waves?

Ans: i) They are used in remote controlings.

ii) IR rays photographs are used for weather forecasting.

13. Write any two uses of radio waves?

Ans: i) They are used in wireless communication such as radio.

ii) They are used in wireless communication such as television.

14. Mention the expression for the speed of electromagnetic waves in free space? Explain the terms.

Ans: The speed of electromagnetic waves is, $C = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

where, μ_0 - magnetic permeability of free space.

ε_0 - electric permittivity of free space.

* * *

Chapter-9

Ray Optics and Optical Instruments

ONE MARK QUESTIONS

1. **What is the limitation of Snell's law ?**

Ans: Snell's law is not applicable for normal incidence i.e., when i = 0.

2. **Define critical angle of a medium.**

Ans: Critical angle for a medium is the angle of incidence in denser medium for which angle of refraction is 90°.

3. **What is total internal reflection?**

Ans: It is the phenomenon in which light rays travelling from denser medium to rarer medium reflects back completely to the same medium when angle of incidence is greater than critical angle.

4. **Define power of a lens.**

Ans: Power of a lens is its ability to converge or diverge light rays and is measured by the reciprocal of focal length. $P = \frac{1}{f}$

5. **Give the S.I. unit of power of the lens.**

Ans: Dioptre (D).

6. **How does the power of a lens vary with its focal length.**

Ans: Power of a lens varies inversly as focal length. $P \alpha \frac{1}{f}$

7. **Two lenses of power +1.5D and –0.5D are kept in contact on their principal axis. What is the effective power of the combination.** ***(March, 2018)***

Ans: $P = P_1 + P_2 = 1.5 - 0.5 = 1D$.

8. **A blue ray of light enters an optically denser medium from air. What happens to its frequency in denser medium.** ***(June, 2018).***

Ans: The frequency remains same.

TWO MARK QUESTIONS

9. Mention the two conditions for total internal reflection.

Ans: i) The ray of light must travel from denser medium to rarer medium.

ii) The angle of incidence in denser medium must be greater than critical angle.

10. Mention the application of total internal reflection.

Ans: i) Optical fibres

ii) Brilliance of diamond

iii) Total reflecting prisms

11. What are optical fibres? What is the principle of optical fibres?

Ans: Optical fibres are thin transparent fibres of glass or plastic with a coating material of lower refractive index.

It works on the principle of total internal reflection.

12. Mention the applications of optical fibres.

Ans: i) Used to examine internal organs like stomach, intestine etc.

ii) Used in the field of communication.

iii) Used to transmit and receive electrical signals.

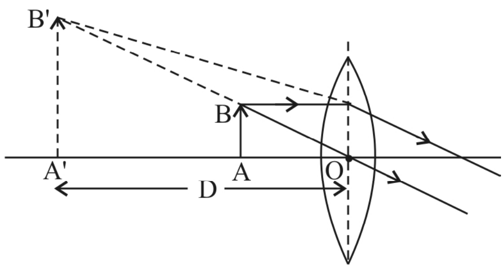
13. What is a thin prism? What is the deviation produced by a thin prism?

Ans: Thin prism is one whose angle is less than 10°. **Deviation** $d = (n - 1)A$

THREE MARK QUESTIONS

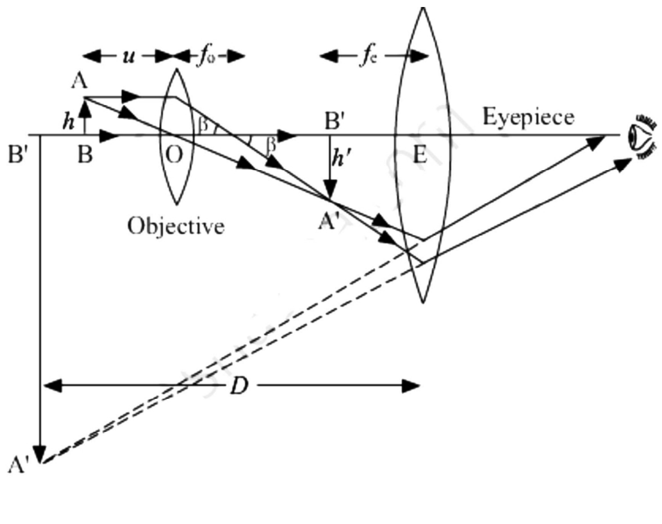
14. Write the ray diagram for formation of image in case of simple microscope.

Ans:



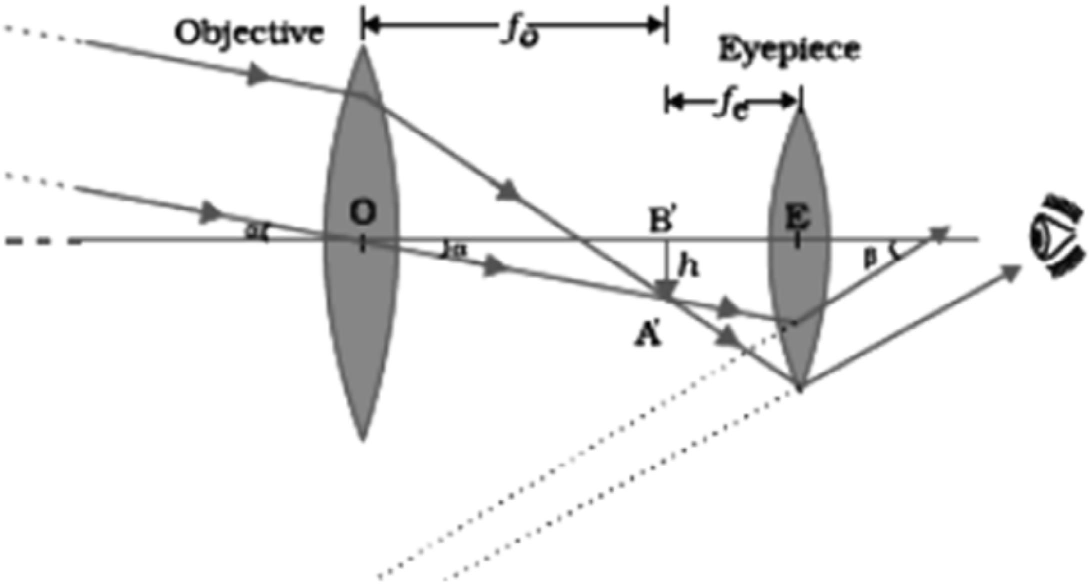
15. Draw a ray diagram of image formation in case of compound microscope.

Ans:



16. Draw a ray diagram of image formation in case of telescope.

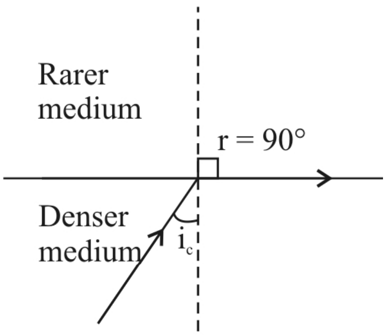
Ans:



17. Obtain the relation between refractive index and critical angle.

Ans: Consider a ray of light travelling from denser medium to rarer medium.

Let the angle of incidence be equal to critical angle, then $i = i_c$ and $\hat{r} = 90°$.



From Snell's law, $\frac{n_2}{n_1} = \frac{\sin i}{\sin r} \Rightarrow \frac{1}{n} = \frac{\sin i}{\sin r}$

$$\Rightarrow 1(\sin r) = n(\sin i)$$

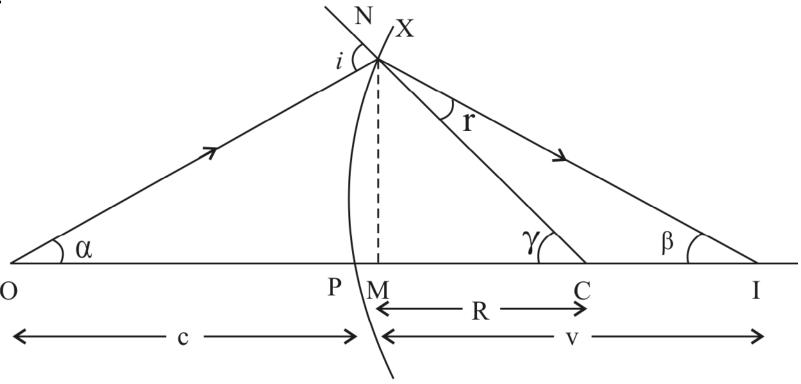
$$\sin 90° = n \sin i_c$$

$$1 = n \sin i_c$$

$$\boxed{n = \frac{1}{\sin i_c}}$$

FIVE MARK QUESTIONS

18. Derive the relation, $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$ where the symbols have their usual meaning



Ans: Consider a spherical surface 'XY.' Let 'O' be the luminous point object at a distance 'v' from P. 'I' be the real image of object 'O' at a distance V from P.

Let $\angle NOM = \alpha$, $\angle NIM = \beta$ and $\angle NCM = \gamma$

In Δ NOC, $\boxed{i = \alpha + \gamma}$ . . . (1)

In Δ NIC, $\gamma = r + \beta \Rightarrow \boxed{r = \gamma - \beta}$ . . . (2)

From Snell's law, $n_1 \sin i = n_2 \sin r$

For small angles $\sin i \simeq i$ and $\sin r \simeq r$

$\boxed{n_1 i = n_2 r}$ . . . (3)

Substituting (1) and (2) in (3),

$n_1 (\alpha + \gamma) = n_2 (\gamma - \beta)$ . . . (4)

For small operture P is close to M.

$\tan \alpha = \frac{NP}{OP}$ for small angle, $\tan \alpha = \alpha \ \therefore \alpha = \frac{NP}{OP}$

$\tan \beta = \frac{NP}{IP}$ for small angle, $\tan \beta = \beta \ \therefore \beta = \frac{NP}{IP}$

$\tan \gamma = \frac{NP}{PC}$ for small angle, $\tan \gamma = \gamma \ \therefore \ \gamma = \frac{NP}{IP}$

Substituting for α, β and γ in (4)

$$n_1 \left[\frac{NP}{OP} + \frac{NP}{PC}\right] = n_2 \left[\frac{NP}{PC} - \frac{NP}{IP}\right]$$

$$\cancel{NP}\left[\frac{n_1}{OP} + \frac{n_1}{PC}\right] = \cancel{NP}\left[\frac{n_2}{PC} - \frac{n_2}{IP}\right] \quad . . . (5)$$

Using Cartesian sign convention :

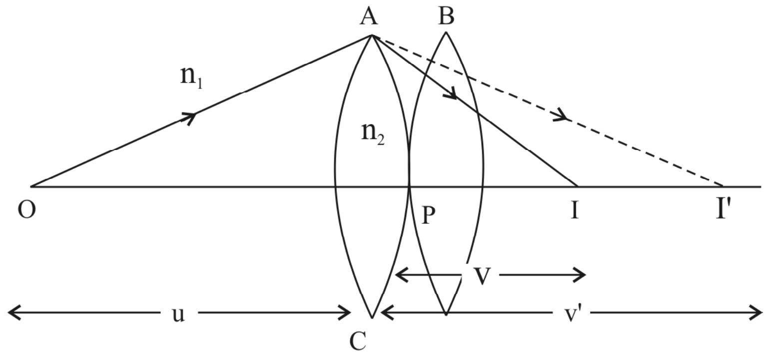
OP = –u, PC = R and IP = V

$$(5) \Rightarrow \frac{n_1}{-u} + \frac{n_1}{R} = \frac{n_2}{R} - \frac{n_2}{V}$$

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2}{R} - \frac{n_1}{R}$$

$$\boxed{\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}}$$

19. Arrive at Lens Maker's formula.



Ans: Let 'O' be the luminous point object. n_1 be the refractive index of surrounding medium and n_2 be the RI of lens. 'I' be the real image. R_1 and R_2 be radii of curvature of surfaces ABC and ADC respectively.

The image formation can be seen in two stages.

Stage-1: Refraction at surface ABC : In the absence of surface ADC, I' can be treated as the real image at a distance v'.

$$\boxed{\therefore \frac{n_2}{v^1} - \frac{n_1}{u} = \frac{n_2 - n_1}{R_1}} \quad \ldots (1)$$

Stage-2: Refraction at surface ADC : For refraction at ADC, I' can be treated as the virtual object and I be the real image,

$$\boxed{\therefore \frac{-n_2}{v^1} + \frac{n_1}{v} = \frac{n_1 - n_2}{R_2}} \quad \ldots (2)$$

Adding (1) and (2),

$$\frac{n_2}{v^1} - \frac{n_1}{u} + \frac{n_1}{v} - \frac{n_2}{v^1} = \frac{n_2 - n_1}{R_1} + \frac{n_1 - n_2}{R_2}$$

$$\frac{n_1}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R_1} - \frac{n_2 - n_1}{R_2}$$

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

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

$$\frac{1}{v} - \frac{1}{u} = (n_{21} - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \qquad \ldots (3)$$

If the object is at infinity, then image will be formed at 'F'. $\therefore\ u = \infty$ and $v = f$.

$$(3) \Rightarrow \frac{1}{f} - \frac{1}{\infty} = (n_{21} - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\boxed{\frac{1}{f} = (n_{21} - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]} \qquad \ldots (4)$$

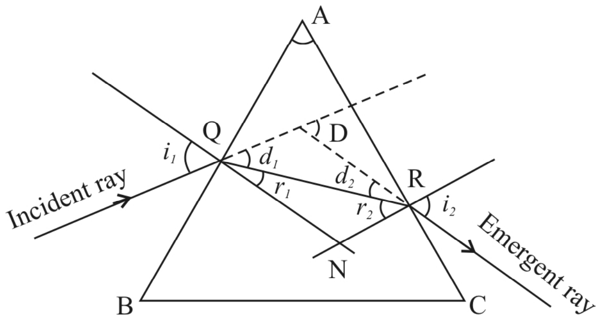
This is Lens Maker's formula.

Note: If the question appears as "Arrive at $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$, then, derive upto Lens makers formula. Finally compare equation (3) and (4), you will arrive at $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$. This equation is the familiar, 'Thin Lens formula.'

20. Obtain an experssion for refractive index of the material of the prism interms of angle of prism and angle of minimum deviation. (OR)

Show that, $n = \dfrac{\sin\left(\dfrac{A + Dm}{2}\right)}{\sin\left(\dfrac{A}{2}\right)}$.

Ans:



In the figure ABC is the principal section of prism. i_1 and r_2 be the angle of incidence at surface AB and AC, r_1 and i_2 be the angle of refraction at surface AB and AC.

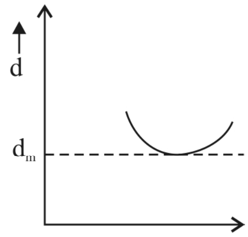
From ΔQNR, $\boxed{r_1 + r_2 + \angle QNR = 180^\circ}$ ... (1)

From quadrilateral AQNR, $\boxed{A + \angle QNR = 180^\circ}$ ... (2)

Comparing (1) and (2), $\boxed{A = r_1 + r_2}$ ... (3)

At the surface AB, $i_1 = r_1 + d_1 \Rightarrow d_1 = i_1 - r_1$

At the surface AC, $i_2 = r_2 + d_2 \Rightarrow d_2 = i_2 - r_2$



Total deviation, $D = d_1 + d_2$

$$D = (i_1 - r_1) + (i_2 - r_2)$$

$$D = (i_1 + i_2) - (r_1 + r_2)$$

$$D = (i_1 + i_2) - A \quad \text{. . . (4)}$$

At minimum deviation, $i_1 = i_2 = i$, $r_1 = r_2 = r$ and $D = D_m$

Therefore equation (3) becomes,

$$A = r + r \Rightarrow A = 2r$$

or $$\boxed{r = \frac{A}{2}} \quad \text{. . (5)}$$

Equation (4) becomes, $Dm = (i + i) - A$

$$Dm = 2i - A$$

$$\boxed{i = \frac{A + Dm}{2}} \quad \text{. . . (6)}$$

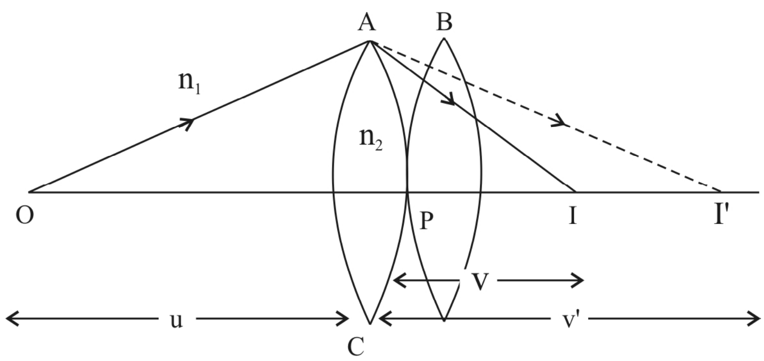
From Snell's law, $$n_{21} = \frac{\sin i}{\sin r} \quad \text{. . . (7)}$$

Substituting (5) and (6) in (7), $$n_{21} = \frac{\sin\left(\frac{A + D_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

21. Obtain an expression for effective focal length of two thin lenses in contact.

Ans: Consider, two thin lenses A and B kept in contact as shown in the figure.

f_1 and f_2 be the focal length of lenses A and B respectively.



Refraction at first lens: 'O' is the luminous point object and I' be the its image. From lens formula,

$$\boxed{-\frac{1}{v^1} + \frac{1}{v} = \frac{1}{f_2}} \quad \text{. . . (1)}$$

Refraction at second lens: For second lens I' be the virtual object and 'I' be the real image. From lens formula,

$$-\frac{1}{v^1} + \frac{1}{v} = \frac{1}{f_2} \quad \ldots (2)$$

Adding, (1) and (2),

$$-\frac{1}{u} + \frac{1}{v^1} - \frac{1}{v^1} + \frac{1}{v} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f_1} + \frac{1}{f_2}$$

If the two lenses are replaced by a equivalent lens of focal length 'f' then,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \quad \ldots (4)$$

From (3) and (4)

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

* * *

Chapter-10

Wave Optics

ONE MARK QUESTIONS

1. Which phenomenon establish the wave natureof light?

Ans: Interference, diffraction, polarization.

2. What is interference of light?

Ans: The modification in the distribution of light energy due to the super position of two or more waves of light.

3. Define fringe width.

Ans: The distance between two consecutive bright (or two consecutive dark) fringes is called fringe width.

4. What is diffraction of light?

Ans: The phenomenon of bending of light around the corners of obstacles or aperture is called diffraction of light.

TWO MARK QUSTIONS

5. State Huygen's principle.

Ans: i) Every point on a given wave front is a source of secondary wavelets. These secondary wavelets spread in all directions with the speed of the wave.

ii) The tangent drawn to all secondary wavelets represent the position of new wave front.

6. What is the shape of wavefront when the source of light is (a) a point source; (b) a linear source.

Ans: a) A point source $\rightarrow$ Spherical wavefront.

b) A linear source $\rightarrow$ Cylindrical wavefront.

7. What are coherent source? Give an example.

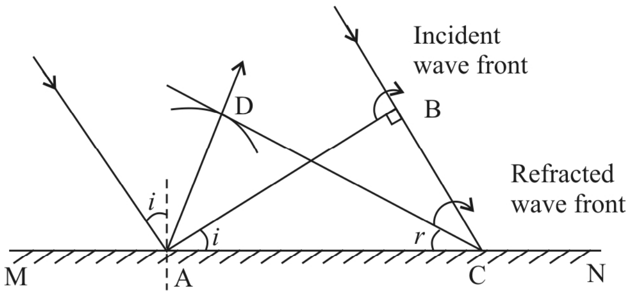
Ans: Two sources continuously emitting wave having zero or constant phase difference are called coherent sources.

Example: Youngs double slit experiment.

THREE MARK QUESTIONS

8. Explain reflection of light on the basis of Huygen's wave theory of light.

Ans: Consider a plane wave front AB incident on the reflecting surface MN. According to Huygens principle, every point on the wave front AB is a source of secondary wavelet.



In a time 't' secondary wavelet from 'B' fall on the surface MN travelling a distance BC.

i.e. $BC = v \times t$

In a time 't' secondary wavelet from 'A' will travel a distance AD (Reflected wave front).

i.e. $AD = v \times t$

From the fig. $\angle BAC = i$ = angle of incidence.

$\angle DAC = r$ = angle of reflection

AC = common for the triangle ABC and ADC.

and $\angle ABC = \angle ADC = 90°$

$\therefore$ Triangle ABC and ADC are congruent.

$\therefore \angle BAC = \angle DAC$

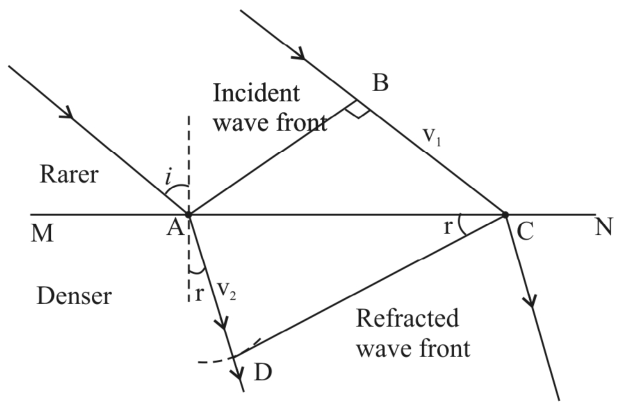
$\angle i = \angle r$

Hence, the incident ray, normal and reflected ray all lie on the same plane.

9. Arrive at Snells law of refraction, using Huygens principle for refractin of a plane wave.

Ans: Consider a plane wave front AB incident on MN, so that $\angle BAC = i$.

According to Hyugen's principle every point on the wave front is a source of secondary wavelet.



In a time 't' secondary wavelet from 'B' falls on the surface MN travelling a distance BC.

$$BC = v_1 \times t$$

In time 't' secondary wavelet from 'A' will travel a distance AD.

$$AD = v_2 \times t$$

From the fig, $\angle BAC = i$; $\angle ACD = r$

In triangle ABC, $\sin i = \frac{BC}{AC} = \frac{v_1 t}{AC}$ . . . (1)

In triangle ADC, $\sin r = \frac{AD}{AC} = \frac{v_2 t}{AC}$ . . . (2)

Divide equation (1) by (2),

$$\frac{\sin i}{\sin r} = \frac{v_1 t}{AC} \times \frac{AC}{v_2 t}$$

$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2}$$

But, $\frac{v_1}{v_2} = \frac{n_2}{n_1}$

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$$

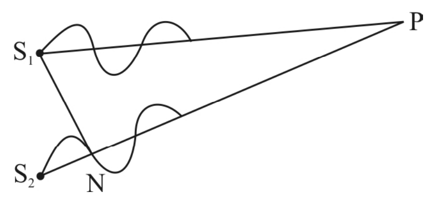
$$\boxed{n_1 \sin i = n_2 \sin r}$$

FIVE MARK QUESTIONS

10. Give the theory of interference.

Ans: S_1 and S_2 are the coherent sources. 'P' is the point of super position.

S_1N is the normal drawn at S_2P.



Let 'a' and 'λ' be the amplitude and wavelength of the waves emitted by S_1 and S_2.

Let 'δx' be the path difference between the waves at the point 'P.'

Let ϕ is the phase difference.

The displacement of the wave at 'P' due to 'S_1' is given by

$$y_1 = a \sin \omega t$$

The displacement of the wave at 'P' due to S_2 is given by,

$$y_2 = a \sin (\omega t + \phi)$$

From the super position principle,

$$\begin{aligned} y &= y_1 + y_2 \\ &= a \sin \omega t + a \sin (\omega t + \phi) \\ &= a [\sin (\omega t + \phi) + \sin (\omega t)] \\ &= a\, 2 \sin\left(\frac{\omega t + \omega t + \phi}{2}\right) \cos\left(\frac{\omega t - \omega t + \phi}{2}\right) \end{aligned}$$

$$= 2a \sin\left(\frac{2\,\omega t + \phi}{2}\right) \cos\left(\frac{\phi}{2}\right)$$

$$= 2a \cos\left(\frac{\phi}{2}\right) \sin\left(\frac{2\,\omega t + \phi}{2}\right)$$

Put, $R = 2a\cos\left(\frac{\phi}{2}\right)$ is the resultant amplitude.

$$y = R\sin\left(\frac{2\,\omega t + \phi}{2}\right)$$

Conditions for constructive interference, R is maximum, when

Phase difference, $\phi = 2\pi n$, where n = 0, 1, 2

Conditions for destructive interference, R is minimum, when

Phase difference, $\phi = (2n+1)\,\pi \quad ; \quad n = 0, 1, 2 \ldots$

11. Derive the expression for fringe width of interference pattern in youngs double slit experiemnt.

Ans: Consider two narrow slits 'A' and 'B'. Separated by a small distance 'd' which are illuminated by a monochromatic light.

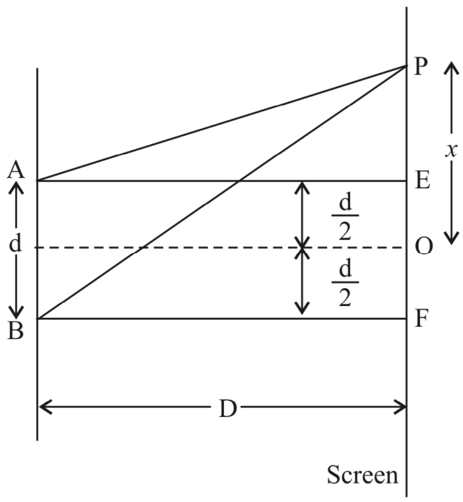
D = Distance between the point 'p' from the central maximum.

'x' is the distance of the paint 'p' from the central maximum.

From the fig,

Paths difference = BP – AP

From the triangle BFP,



$$BP^2 = BF^2 + FP^2$$

$$BP^2 = D^2 + \left(x + \frac{d}{2}\right)^2 \quad \ldots (1)$$

From $\Delta\, AEP$,

$$AP^2 = AE^2 + EP^2$$

$$AP^2 = D^2 + \left(x - \frac{d}{2}\right)^2 \quad \ldots (2)$$

Equation (1) – (2),

$$BP^2 - AP^2 = \left[D^2 + \left(x + \frac{d}{2}\right)^2\right] - \left[D^2 + \left(x - \frac{d}{2}\right)^2\right]$$

$$= \left[D^2 + x^2 + 2x\frac{d}{2} + \frac{d^2}{4}\right] - \left[D^2 + x^2 - 2x\frac{d}{2} + \frac{d^2}{4}\right]$$

$$BP^2 - AP^2 = 2xd$$

$$BP - AP = \frac{2xd}{BP + AP}$$

$BP \approx AP = D$ and $BP - AP = \delta x$ path difference

$$\delta x = \frac{xd}{D}$$

For the bright fringe at 'P', path difference is $\delta x = n\lambda$

$$n\lambda = \frac{xd}{D}$$

$$x = \frac{n\lambda D}{d}$$

The distance of nth bright fringe from 'O' is, $x_n = \frac{n\lambda D}{d}$

The distance of (n+1)th bright fringe from 'O' is, $x_{n+1} = \frac{(n+1)\lambda D}{d}$

Fringe width, $\beta = x_{n+1} - x_n$

$$(n+1)\frac{\lambda D}{d} - \frac{n\lambda D}{d}$$

$$\boxed{\beta = \frac{\lambda D}{d}}$$

where, λ = wave length of light used; D = Distance between slits and screen, d = separation between the slits 'A' and 'B'.

12. Write the differences between interference and diffraction of light.

	Inter-ference	**Diffraction**
i)	Interference is due to super- -position of light waves coming from two coherent sources.	Diffraction is due to super position of secondary wavelets coming from different points of the same wave front.
ii)	All bright fringes are of the same intensity.	The intensity of successive bright fringes goes on decreasing.
iii)	The width of interference fringes may or may not be the same.	In diffraction, fringes are never of the same width.
iv)	Intensity of all bright fringes is equal and intensity of dark fringes is zero.	Intensity of central maximum is highest. But intensity of secondary maxima decreases with increases in order.
v)	In interference, bands are large in number.	In diffraction, bands are a few in number.

SOLUTIONS TO PROBLEMS

1. **In a Youngs double slit experiment distance between the slits is 1 mm. The fringe width is found to be 0.6 mm. When the screen is moved through a distance of 0.25 m away from the plane of the slit, the fringe width becomes 0.75 mm. Find the wave length of light used.**

Soln: *Given:* d = 1 mm = 1×10^{-3} m, $\beta_1 = 0.6$ mm $= 0.6\times10^{-3}$ m, $D_1 = D$ and $D_2 = D + 0.25$, $\beta_2 = 0.75$ mm $= 0.75\times10^{-3}$ m.

Since, $\beta_2 > \beta_1$, $D_2 > D_1$

$$\beta_2 = \frac{\lambda D_2}{d}$$

$$= \lambda\,\frac{(D+0.25)}{d}$$

$$= \frac{\lambda D}{d} + \frac{\lambda\,(0.25)}{d}$$

$$\beta_2 = \beta_1 + \frac{\lambda\,(0.25)}{d}$$

$$\lambda = (\beta_2 - \beta_1)\,\frac{d}{0.25}$$

$$\lambda = \frac{(0.75-0.6)\times10^{-3}\times10^{-3}}{0.25}$$

$$\lambda = 6000\times10^{-10}\,\text{m}$$

$$\lambda = 6000\,\mathring{A}$$

2. **In Young's double slit experiement while using a source of light of wavelength 4500A°, the fringe width is 5 mm. If the distance between the screen and the plane of the slits is reduced to half, what should be the wave length of light to get fringe width 4 mm?**

Soln: *Given :* $\lambda = 4500\times10^{-10}$ m ; $\beta = 5\times10^{-3}$ m ; d = d , D = D

$$\beta = \frac{\lambda D}{d}$$

$$5\times10^{-3} = \frac{4500\times10^{-10}\times D}{d} \quad \ldots (1)$$

When, $D^1 = \frac{D}{2}$; $\beta^1 = 4\times10^{-3}$ m ; d = d ; $\lambda^1 = ?$

$$\beta^1 = \frac{\lambda^1 D^1}{d}$$

$$4\times10^{-3} = \frac{\lambda^1\times D}{2d} \quad \ldots (2)$$

$$\frac{(1)}{(2)} \quad \frac{5\times10^{-3}}{4\times10^{-3}} = \frac{4500\times10^{-10}\times D}{d}\times\frac{2d}{\lambda^1\times D}$$

$$\lambda^1 = \frac{4\times4500\times10^{-10}\times2}{5}$$

$$\lambda^1 = 7200\times10^{-10}\,\text{m}$$

$$\lambda^1 = 7200\,\mathring{A}$$

3. In Young's double slit experiment distance between the slits is 0.5 mm. When the screen is kept at a distance of 100 cm from the slits, the distance of ninth bright fringe from the center of the fringe system is 8.835 mm. Find the wavelength of light used.

Soln: *Given:* $d = 0.5\text{ mm} = 0.5 \times 10^{-3}\text{ m} = 5 \times 10^{-4}\text{ m}$, $D = 100\text{ cm} = 1\text{ m}$,

$x = 8.835\text{ mm} = 8.835 \times 10^{-3}\text{ m}$; $\lambda = ?$

The distance of bright fringe from the central wright fringe is given by,

$$x = \frac{n\lambda D}{d}$$

$$8.835 \times 10^{-3} = \frac{9 \times \lambda \times 1}{5 \times 10^{-4}}$$

$$\lambda = \frac{8.835 \times 10^{-3} \times 5 \times 10^{-4}}{9}$$

$$\lambda = 4908.3 \times 10^{-10}\text{m}$$

$$\lambda = 4908.3\,\mathring{A}$$

4. In Youngs double slit experiment the slits are separated by 0.28 mm and the screen is placed at a distance of 1.4 m away from the slits. The distance between the central bright fringe and fifth dark fringe is measured to be 1.35 cm. Calculate the wavelength of the light used. Also find the fringe width if the screen is moved 0.4m towards the slits, for the same experimental setup.

Soln: *Given:* $d = 0.28 \times 10^{-3}\text{m}$; $D = 1.4\text{ m}$; $x = 1.35 \times 10^{-2}\text{ m}$; $\beta^1 = ?$;

$D^1 = 1.4 - 0.4 = 1.0\text{ m}$

For a dark fringe path difference, $\delta = (2n+1)\dfrac{\lambda}{2}$

Hence, $x = \dfrac{(2n+1)\lambda D}{2d}$; $n = 4$

$$x = \frac{(2 \times 4 + 1)\lambda \times 1.4}{2 \times 0.28 \times 10^{-3}}$$

$$1.35 \times 10^{-2} \times 10^{-3} = \frac{12.6\,\lambda}{0.56}$$

$$\lambda = \frac{1.35 \times 10^{-5} \times 0.56}{12.6}$$

$$\lambda = 0.06 \times 10^{-5}\text{m}$$

$$\lambda = 6000 \times 10^{-10}\text{ m}$$

$$\lambda = 6000\,\mathring{A}$$

* * *

Chapter-11

Dual Nature of Radiation

ONE MARK QUESTIONS

1. What is meant by elactron emission?

Ans: The process of emission of electrons from metal surface when suitable energy falls on it is called electron emission.

2. What is thermionic emission?

Ans: The process of emission of free electrons from metal surface by heating it is called thermionic emission.

3. What is field emission?

Ans: The process of emission of electron from metal surface when strong electric field apply on it is called field emission.

4. Wht is photo electric emission?

Ans: The process of emission of electrons from metal surfaces, when light of suitable frequencies falls on it is called photo electric emission.

5. What is photo electric effect?

Ans: When a light of suitable frequency falls on some metals, free electrons are emitted. This phenomenon is called photo electric effect.

6. Define photo electric work function.

Ans: The minimum energy required to just liberate on electrons from metal surface is called work function.

7. Define threshold frquency.

Ans: The minimum frequency of incident radiation below which photo electric effect does not takes place is called threshold frequency.

8. What is stopping potential?

Ans: The minimum negative potential applied to the Anode to just stop the photo current is called stopping potential or cut-off potential.

9. What are matter waves or de Broglie waves?

Ans: The waves associated with material particles in motion are called matter waves.

10. What is de.Borglie wavelength?

Ans: The length of de.Broglie waves are called de.Broglie wavelength.

11. Write the expression for de.Broglie wavelength of particle of mass m and having speed of V.

$$\lambda = \frac{h}{mV}$$

$$\lambda = \frac{h}{p}$$

where, h = plank's constant; m = mass of moving portion; v = velocity of moving portion; p = momentum.

TWO MARK QUESTIONS

12. Mention any two types of electron emission.

Ans: i) Thermionic emission

ii) Field emission

iii) Photo electric emission

13. Write Einstein's photo electric equation and explain the terms.

Ans: Einstein's photo electric equation is,

$$h\gamma = \phi_0 + K_{max} \qquad \text{OR} \qquad h\gamma = \phi_0 + eV_0$$

where, h = Plank's constant;

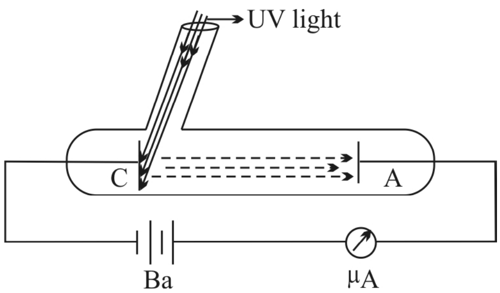
γ = Freqnecy of Incidant radiation

ϕ_0 = Work function

K_{max} = Maximum kinetic energy

THREE MARK QUESTIONS

14. Explain briefly Lenard's observations on photo electric effect.



Ans: Lenard's experimental set up to study photo electric effect as shown in the above figure.

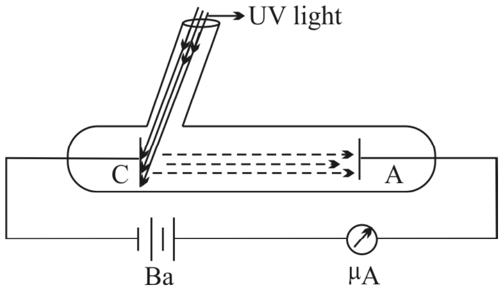
Lenord Observed that,

- As soon as UV light incident on emitter plate the current flows in the circuit.
- As soon as UV light were stopped, the current flow also stopped.

The above observations indicate that when UV light falls on plate C, electrons are emitted and attracted towards the collector plate A.

15. Describe the experimental to study of photoelectric effect.

Ans: The experimental set up to study photo electric effect is as shown in the above figure.



- UV radiations are allowed to fall on plate C.
- Plate C emitts electrons.
- Emitted electrons are collected by plate A.
- The photo electric current flows through circuit and it is recorded by micro ammeter.

16. Write any three characteristics of a photon.

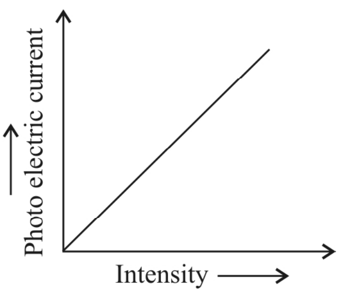
Ans:
- Photon is a packet of light energy.
- The rest mass of photon is zero.
- Photon travel with speed of light.
- Photons are electrically neutral.
- Each photon has energy $E = h\gamma$ and momentum $P = \frac{h\gamma}{C}$. *(Any three)*

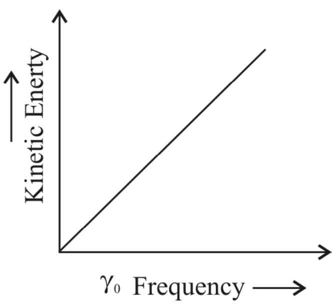
FIVE MARK QUESTIONS

17. Write the experimental observations of photo electric effect. OR

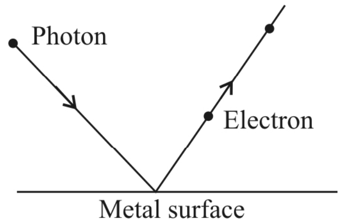
Ans: Laws of photo electric effect.

- The photo electric effect is instantaneous.
- The strength of photo electric current is directly proportional to intensity of incident radiation.
- For a given material there is minimum frequency for incident radiation, below which there is no photo electric emission. It is called threshold frequency.
- Above threshold frequency the kinetic energy of photo electrons is directly proportional to frequency of incident radiation.
- Photo electric current just becomes zero at a particular negative potential called stopping potential.





18. Give the Einstein's explanation of photo electric effect.



Ans: According to Einstein

- Photo emission is a collision between incident photon and free electron of a metal.
- When a photon falls on a metal surface, the electron completely absorbs the energy of photon.
- A part of energy is used to just liberate the electron from metal surface (work function).
- The remainng part of energy is used to provide kinetic energy to emitted electron.

Energy of photon = Work function + K.E. of photo electron

$$h\gamma = \phi_0 + K_{max}$$

The above equation is called as Einstein's photo electric equation,

when, h = Plank's constant

γ = Frequency of incident radiation

ϕ_0 = Work function = $h\gamma_0$

K_{max} = Maximum K.E.

From the above equation,

If $\gamma < \gamma_0$,No photo electric effect.

If $\gamma = \gamma_0$, Velocity of electrons is zero.

If $\gamma > \gamma_0$, The K.E. of photo electrons increases.

* * *

Chapter-12

Atoms

ONE MARK QUESTIONS

1. **Name the spectral series of hydrogen which lies in the ultraviolet region of electromagnetic spectrum.**

Ans: Lyman series.

2. **Name the spectral series of hydrogen atom in the visible region of electromagnetic spectrum.**

Ans: Balmer series.

TWO /THREE MARK QUESTIONS

3. **Mention the Bohr's quantization rule and explain the symbols.**

Ans: The angular momentum of an electron in the stationary orbit is an integral multiple of $\frac{h}{2\pi}$.

$L = \frac{nh}{2\pi}$, where n = 1, 2, 3, . . . and h = Plank's constant.

4. **Write the expression for Rydberg constant and explain the symbols.**

Ans: $R = \frac{me^4}{8 c \varepsilon_0^2 h^3}$

where, m = Mass of electron;
c = Velocity of light in vacuum
ε_0 = Permitivity of free space
h = Plank's constant

5. **Write 3 postulates of Bohr's atom model.**

Ans: i) The electrons revolve only in certain orbits called stationary orbits without the emission of radiant energy.

ii) The angular momentum of an electron in the stationary orbit is an integral multiple of $\frac{h}{2\pi}$.

i.e. $L = \frac{nh}{2\pi}$, where n = 1, 2, 3, . . . and h = Plank's constant.

iii) An electron emits energy only when it jumps from outer stationary orbit to inner stationary orbit. If E_1 and E_2 are the energies of an electron in the inner orbit and outer orbit respectively, then energy of emitted photon is given by,

$$E = E_2 - E_1$$

6. Mention any three limitations of Bohr's theory.

Ans: i) Bohr's theory is applicable only to hydrogen and hydrogen like atoms.

ii) It could not explain the fine structure of spectral lines.

iii) It could not explain elliptical orbits of electron.

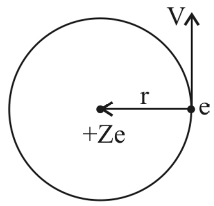
iv) It could not explain stark effect and Zeeman effect.

v) It could not explain wave nature of electrons.

FIVE MARK QUESTIONS

7. Obtain an expression for the radius of nth Bohr orbit of hydrogen atom using Bohr's postulates.

Ans: In the figure,



+Ze is the charge on the nucleus.

'r' is the radius of the circular orbit of an electron
'v' is the orbital velocity of the electron.

m $\rightarrow$ mass of electron.

For a stable orbit,
Centripetal force = Electrostatic force

$$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{Ze.e}{r^2}$$

$$m^2v^2 r = \frac{m\,Ze^2}{4\pi\varepsilon_0} \quad \ldots (1) \quad \text{[multiply 'm' on both sides]}$$

From Bohr's quantization rule, $mvr = \frac{nh}{2\pi}$

Squaring on both the sides, $\Rightarrow m^2 v^2 r^2 = \frac{n^2h^2}{4\pi^2} \quad \ldots (2)$

$$\text{Divide } \frac{(2)}{(1)} \Rightarrow \frac{m^2 v^2 r^2}{m v^2 r} = \frac{\frac{n^2h^2}{4\pi^2}}{\frac{m\,Ze^2}{4\pi\varepsilon_0}} = \frac{n^2 h^2}{4\pi^2} \times \frac{4\pi\varepsilon_0}{m\,Ze^2}$$

$$\boxed{r = \frac{\varepsilon_0 n^2 h^2}{\pi m Ze^2}}$$

For hydrogen atom z = 1 and for n^{th} orbit.

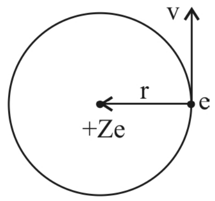
$$r_n = \frac{\varepsilon_0 n^2 h^2}{\pi m e^2}$$

For first orbit, n = 1

$$\therefore\ r_1 = \frac{\varepsilon_0}{\pi m e^2}$$

8. Obtain the expression for the total energy in the nth Bohr orbit of the hydrogen atom by assuming the expression for radius.

Ans: In the figure,



+Ze is the charge on the nucleus.

r is the radius of the circular orbit of an electron.

v is the orbital velocity of the electron.

Total energy, E = KE + PE . . . (1)

For stable orbit,

$$\text{Centripetal force} = \text{Electrostatic force}$$

$$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{Ze.e}{r^2}$$

Multiply $\frac{1}{2}$ on both sides,

$$\Rightarrow \frac{mv^2}{2} = \frac{1}{8\pi\varepsilon_0}\frac{Ze.e}{r}$$

$$\therefore\ KE = \frac{Ze^2}{8\pi\varepsilon_0 r} \quad \ldots(2)$$

We have,

$$PE = \text{Electric potential} \times \text{charge}$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{Ze}{r} \times (-e) \quad \left[\because\ v = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}\right]$$

$$PE = -\frac{Ze^2}{4\pi\varepsilon_0 r} \quad \ldots(3)$$

Equate (2) and (3) in (1) we get,

$$E = \frac{Ze^2}{8\pi\varepsilon_0 r} - \frac{Ze^2}{4\pi\varepsilon_0 r}$$

$$= \frac{Ze^2}{4\pi\varepsilon_0 r}\left(\frac{1}{2} - 1\right)$$

$$E = -\frac{Ze^2}{8\pi\varepsilon_0 r}$$

But, $$r = \frac{\varepsilon_0 n^2 h^2}{\pi m Z e^2}$$

$$\therefore E = -\frac{Ze^2}{8\pi\varepsilon_0 \dfrac{\varepsilon_0 n^2 h^2}{\pi m Ze^2}}$$

$$\boxed{E = -\frac{me^4 Z^2}{8\varepsilon_0^2 n^2 h^2}}$$

For hydrogen atom Z = 1, for nth orbit,

$$E_n = -\frac{me^4}{8\varepsilon_0^2 n^2 h^2}$$

For first orbit n = 1.

$$\therefore E_1 = \frac{-me^4}{8\varepsilon_0^2 h^2}$$

9. Using Balmer's formula, write empirical formulae for wave number of different series of spectral lines of hydrogen atom.

Ans: Balmer formula is $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ where, $n_2 > n_1$

i) Lyman series: $n_1 = 1$ and $n_2 = 2, 3, 4, \ldots \infty$

$$\therefore \frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{n_2^2}\right]$$

ii) Balmer series: $n_1 = 2$ and $n_2 = 3, 4, 5 \ldots \infty$

$$\therefore \frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{n_2^2}\right]$$

iii) Paschen series : $n_1 = 3$ and $n_2 = 4, 5, 6 \ldots \infty$

$$\therefore \frac{1}{\lambda} = R\left[\frac{1}{3^2} - \frac{1}{n_2^2}\right]$$

iv) Brackett series: $n_1 = 4$ and $n_2 = 5, 6, 7 \ldots \infty$

$$\therefore \frac{1}{\lambda} = R\left[\frac{1}{4^2} - \frac{1}{n_2^2}\right]$$

v) Pfund series : $n_1 = 5$ and $n_2 = 6, 7, 8 \ldots \infty$

$$\therefore \frac{1}{\lambda} = R\left[\frac{1}{5^2} - \frac{1}{n_2^2}\right]$$

* * *

Chapter-13

Nuclei

ONE MARK QUESTIONS

1. **What are isotopes?**

Ans: These are the nuclei having same atomic number but different mass number.

Example: ${}_1H^1$, ${}_1H^2$, ${}_1H^3$

2. **What are isobars?**

Ans: These are the nuclei having same mass number but different atomic number.

Example: ${}_1H^3$, ${}_2He^3$

3. **What are isotones?**

Ans: These are the nuclei having same neutron number but different atomic number.

Example: ${}_1H^3$, ${}_2He^4$

4. **What is nuclear charge?**

Ans: It is the total charge of the protons present in the nucleus. i.e., + Ze.

5. **What is nuclear mass?**

Ans: It is the sum of the masses of the protons and neutrons present in the nucleus.

$M_n = Z_{mp} + (A - Z) M_n$

6. **What is nuclear size?**

Ans: The shape of the nucleus is assumed to the spherical. The radius, $R = R_0 A^{\frac{1}{3}}$.

7. **What is nuclear density?**

Ans: It is the ratio of nuclear mass to the nuclear volume. $\rho = 10^{17}\ kg / m^3$.

8. **What is nuclear force?**

Ans: It is the force that holds the nucleons together with in the nucleus.

9. **Define amu.**

Ans: It is defined as the $\left(\frac{1}{12}\right)^{th}$ of the mass of a C^{12} atom.

10. **What is nuclear binding energy?**

Ans: It is the minimum energy required to break the nucleus into its constituents.

$\Delta E = \Delta m \times C^2$

11. Mention Einstein's mass energy relation. Explain the terms.

Ans: $E = mC^2$

where, E - Energy equivalent of mass m, C - the velocity of light in vaccum.

12. Mention the expression for mass defect (Δm). Explain the terms.

Ans: $\Delta m = Z_{mp} + (A - Z)_{mn} - M$

where, z $\rightarrow$ Number of protons each of mass m_p.

(A–Z) $\rightarrow$ Number of neutrons each of mass m_n.

M $\rightarrow$ Rest mass of the nucleus.

13. What is Nucleas fission?

Ans: It is the process of splitting of a heavy nucleus into two light nuclei of comparable masses. During this process, enormous amount of energy is released.

$$_{92}U^{235} + {}_0n^1 \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3{}_0n^1 + E$$

14. What is nuclear fusion?

Ans: It is the process of combining two light nuclei into single nucleus. During this processes, a large amount of energy is released.

$$_1H^2 + {}_1H^2 \rightarrow {}_2He^3 + n + \text{Energy}$$

Ans: Binding energy curve obtained by plotting binding energy per nucleon verses mass number.

15. Show that energy equivalent of mass (1u = 931 MeV)

Ans: We have, $E = mC^2$ . . . (1)

i.e. mass (1u) = 1.660539×10^{-27} kg

$C = 2.997 \times 10^8$ m / s

Equation (1) $\rightarrow$ $E = 1.6605 \times 10^{27} \times (2.997 \times 10^8)^2$

$= 14.92 \times 10^{-11}$ Joules

$= \left(\frac{14.92 \times 10^{-11}}{1.602 \times 10^{-9}}\right)$ eV

$1J = \frac{1}{1.602 \times 10^{-19}}$ eV

$\therefore E = 931.5$ MeV

1 amu = 931.5 MeV.

16. Mention the properties of nuclear forces.

Ans: Nuclear forces are :

- Strongly attractive forces
- Strongest forces in nature
- Extremely short-range forces

- Charge independent
- Spin dependent
- Non-Central

17. Mention the properties of nucleus.

Ans:
- Nuclear charge: (+Ze)
- Nuclear Mass : $M_n = 2_{mp} + (A - Z) M_n$
- Nuclear size : $R = R_0 A^{\frac{1}{3}}$
- Nuclear density : $\rho = 10^{17}\ kg / m^3$

18. Differences between nuclear fission and fusion.

Ans:

	Nuclear Fission	Nuclear Fusion
i)	It is the process of splitting of a heavy nucleus into two light nuclei of comparable masses.	It is the process of combining the two light nuclei into single nucleus
ii)	Energy released per fission is more.	Energy released per fussion is less.
iii)	It can be controlled.	It can not be controlled.
iv)	It tokes place at low temperature.	It takes place at high temperature.
v)	Product are harmful.	Product are harmless.
vi)	It forms the principle of atom bomb.	It forms the principle of hydrogen bomb.

* * *

Chapter-14

Semiconductor Electronics

ONE MARK QUESTIONS

1. **What is rectification?**

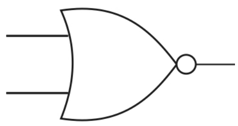
Ans: Process of converting AC into DC is called rectification.

2. **What is a rectifier?**

Ans: Device or circuit used for rectification is called rectifier.

3. **Draw the circuit symbol of NOR gate.**

Ans:



TWO MARK QUESTIONS

4. **What are intrinsic and extrinsic semiconductors? (or) Distinguish between intrinsic and extrinsic semiconductors.**

Ans: **Intrinsic semiconductor:** pure semiconductor is called intrinsic semiconducjtor (or) semiconductor in which number of free electrons is equal to number of holes is called intrinsic semiconductor.

Extrinsic semiconductor: Impure semiconductor is called extrinsic semiconductor (or) semiconductor in which number of free electrons is not equal to number of holes is called extrinsic semiconductor.

5. **Mention the applications of LED.**

Ans: i) They are used in TV remotes

ii) They are used in calculators.

iii) They are used in optical communication.

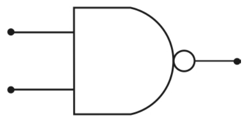
6. **Write any two applications of photo diode.**

Ans: i) Photo diodes are used in optical communication.

ii) They are used in measure intensity of radiation.

iii) They are used in logic circuits.

7. Write the circuit symbol and truth table of of NAND gate.



Symbol

Truth Table :

A	B	$\overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

THREE MARK QUESTIONS

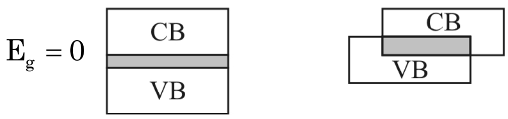
8. Classify metals, semiconductors and insulators based on the band theory of solids with diagrams.

Ans:

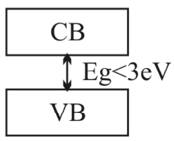
- In conductors, the valence and conduction bands are overlapped. $E_g = 0$

  Example: Sodium, metals.
- In a semiconductor, the energy gap is small (Eg < 3eV).

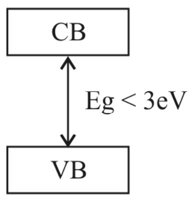
  Example: Sodium, metals.
- In an insulator, the energy gap is large (Eg > 3eV). ***Example:*** Diamond.



Conductors



Semiconductors



Insulators

9. Mention any three differences between p-type and n-type semiconductors.

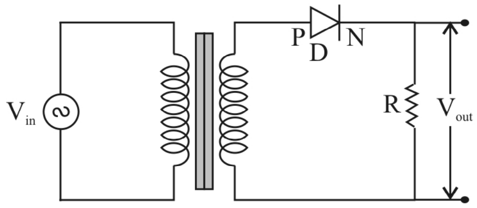
Ans:

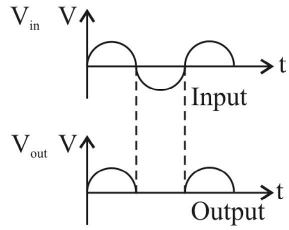
	p-type semiconductor	n-type semiconductor
i)	It is formed when a trivalent impurity is added to pure semiconductor.	It is formed when a pentavalent impurity is added to pure semiconductor.
ii)	Holes are majority charge carriers.	Electrons are majority charge carriers.
iii)	Electrons are minority charge carriers.	Holes are minority charge carriers.
iv)	Impurity atom is an acceptor.	Impurity atom is a donar.

FIVE MARK QUESTIONS

10. Write the neat circuit diagram of a full wave rectifier and explain its working. Draw the input and output waveforms.

Ans: Device or circuit which converts half the AC cycle into DC is called half wave rectifier. Half wave rectifier circuit using diode is as shown below.

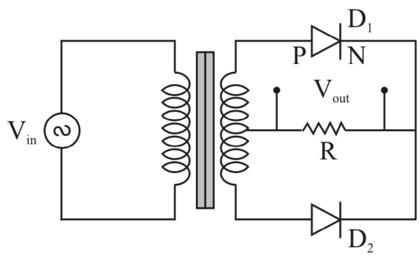


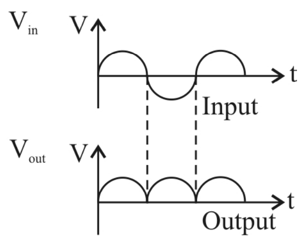


AC to be converted is connected to primary of the transformer and converted DC is obtained across the load resistor in the secondary of the transformer. During positive half cycle of input AC, diode is in forward biased and hence conducts current. During negative half cycle of input AC, diode is in reverse biased and hence does not conduct current. This process continues. Thus current flows in the same direction through the load resistor during positive half cycles of AC.

11. Write the neat circuit diagram of a full wave rectifier and explain its working. Draw the input and output wave forms.

Ans: Device or circuit which converts both the half cycles of AC into DC is called full wave rectifier. Circuit diagram of full wave rectifier is as shown below:





AC to be converted is connected to the primary of the transformer and converted DC is obtained across the load resistor in the secondary of the transformer. During positive half cycle of input AC, diode D_1 is forward baised and D_2 is reverse biased. Hence D_1 conducts current through load resistor. During negative half cycle of input AC, diode D_1 is reverse biased and D_2 is forward biased. Hence D_2 conducts current through load resistor in the same direction. This process continues.

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