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3 Mark Questions and Answers

12 PHYSICS

Part III - Selected Questions with Answers

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Exam No :

School :

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UNIT - 1 ELECTROSTATICS

1. Discuss the various aspects in Coulomb's law.

- Coulomb law states that ; $F = K\,\frac{q_1 q_2}{r^2}$
- The force always lie along the line joining the two charges.
- In S.I units, $k = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ N\,m^2 C^{-2}$

  Here $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2 N^{-1} m^{-2}$

  (permittivity of free space or vacuum)
- The magnitude of electrostatic force between two charges each of 1 C separated by a distance of 1 m is $9 \times 10^9\ N$
- The Coulomb law in vacuum and in medium are,

$$\vec{F}_{21} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}\hat{r}_{12}$$

& $$\vec{F}_{21} = \frac{1}{4\pi\varepsilon}\frac{q_1 q_2}{r^2}\hat{r}_{12}$$

where, $\varepsilon = \varepsilon_0\varepsilon_r \longrightarrow$ permittivity of the medium

- Thus the relative permittivity of the given medium is defined as , $\varepsilon_r = \frac{\varepsilon}{\varepsilon_0}$.

  For air or vacuum, $\varepsilon_r = 1$ and for all other media $\varepsilon_r > 1$
- Coulomb's law has same structure as Newton's law of gravitation.
- Electrostatic force obeys Newton's third law. (i.e) $\vec{F}_{21} = -\vec{F}_{12}$

2. Discuss the various aspects of electric field.

- If 'q' is positive, the electric field points away and if 'q' is negative the electric field points towards the source charge.
- The force experienced by the test charge q_o placed in electric field $\vec{E}$ is , $\vec{F} = q_o\,\vec{E}$
- The electric field due to q at a distance r is,

$$\vec{E} = \frac{\vec{F}}{q_0} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}$$

- The electric field is independent of test charge q_o and it depends only on source charge q
- Electric field is a vector quantity.
- Since $\propto \frac{1}{r^2}$, as distance increases the field decreases.
- There are two kinds of electric field. They are
  (1) Uniform or constant field
  (2) Non uniform field

3. Explain how superposition principle explains the interaction between multiple charges.

- According to Superposition principle, the total force acting on a given charge is equal to the vector sum of forces exerted on it by all the other charges.
- Consider a system of 'n' charges $q_1, q_2, \ldots, q_n$
- By Coulomb's law, force on q_1 by $q_2, \ldots, q_n$ are

$$\vec{F}_{12} = k\,\frac{q_1 q_2}{r_{21}^2}\,\hat{r}_{21}$$

$$\vec{F}_{13} = k\,\frac{q_1 q_2}{r_{31}^2}\,\hat{r}_{31}$$

finally. $$\vec{F}_{1n} = k\,\frac{q_1 q_2}{r_{n1}^2}\,\hat{r}_{n1}$$

- By super position principle, the total force acting on q_1 due to all charges,

$$\vec{F}_1^{tot} = \vec{F}_{12} + \vec{F}_{13} + \ldots\ldots + \vec{F}_{1n}$$

$$\vec{F}_1^{tot} = k\left[\frac{q_1 q_2}{r_{21}^2}\hat{r}_{21} + \frac{q_1 q_3}{r_{31}^2}\hat{r}_{31} + \cdots + \frac{q_1 q_n}{r_{n1}^2}\hat{r}_{n1}\right]$$

4. Explain Electric field at a point due to system of charges (or) Super position of electric fields.

- The electric field at any point due to system of point charges is simply equal to the vector sum of the electric fields created by the individual point charges. This is called superposition of electric fields.
- Consider a system of 'n' charges $q_1, q_2, \ldots, q_n$
- The electric field at 'P' due to 'n' charges

$$\vec{E}_1 = \frac{1}{4\pi\,\varepsilon_0}\frac{q_1}{r_{1P}^2}\,\hat{r}_{1P}$$

$$\vec{E}_2 = \frac{1}{4\pi\,\varepsilon_0}\frac{q_2}{r_{2P}^2}\,\hat{r}_{2P}$$

finally, $$\vec{E}_n = \frac{1}{4\pi\,\varepsilon_0}\frac{q_n}{r_{nP}^2}\,\hat{r}_{nP}$$

- The total electric field at 'P' due to all these 'n' charges will be,

$$\vec{E}_{tot} = \vec{E}_1 + \vec{E}_2 + \ldots\ldots + \vec{E}_n$$

$$\vec{E}_{tot} = \frac{1}{4\pi\,\varepsilon_0}\left[\frac{q_1}{r_{1P}^2}\hat{r}_{1P} + \frac{q_2}{r_{2P}^2}\hat{r}_{2P} + \cdots + \frac{q_n}{r_{nP}^2}\hat{r}_{nP}\right]$$

5. List the properties of electric field lines.

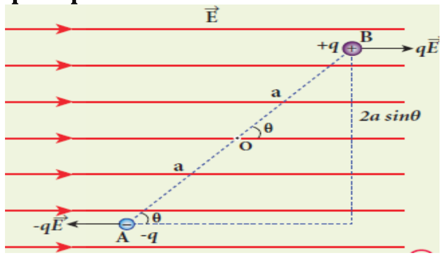
Electric field lines :

- A set of continuous lines which are the visual representation of the electric field in some region of space is called electric field lines.

Properties of electric field lines :

1) They starts from positive charge and end at negative charge or at infinity.
2) The electric field vector at a point in space is tangential to the electric field line at that point.
3) If E is large, the electric field lines are dense and if E is small, the electric field lines are less dense (i.e) the number of lines passing through a given surface area perpendicular to the line is proportional to the magnitude of the electric field.
4) No two electric field lines intersect each other
5) The number of electric field lines that emanate from '+q' or end at '–q' is directly proportional to the magnitude of the charges.

6. Derive an expression for torque experienced by an electric dipole placed in the uniform electric field.



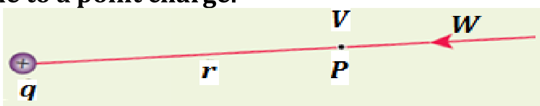
- Let a dipole 'AB' of moment $\vec{p}$ is placed in an uniform electric field $\vec{E}$
- The force on '+q' = $+q\,\vec{E}$

  The force on '-q' = $-\,q\,\vec{E}$
- Then the total force acts on the dipole is zero.
- But these two forces constitute a ***couple*** and the dipole experience a torque which tend to rotate the dipole along the field.
- The total torque on the dipole about the point 'O'

$$\tau = p\,E\sin\theta$$

- where, $2\,a\,q = p \rightarrow$ dipole moment
- In vector notation, $\vec{\tau} = \vec{p} \times \vec{E}$
- The torque is maximum, when $\theta = 90^{\circ}$

7. Obtain an expression electric potential at a point due to a point charge.



- Consider a point charge $+q$ at origin.
- 'P' be a point at a distance 'r' from origin.

- By definition, the electric field at 'P' is

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\,\hat{r}$$

- Hence electric potential at 'P' is

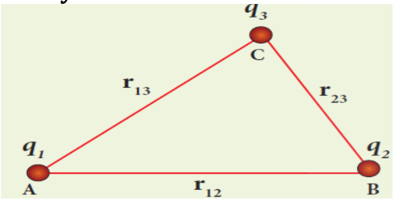
$$V = -\int_{\infty}^{r}\vec{E}\,.\vec{dr} = -\int_{\infty}^{r}\frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\,\hat{r}\,.\vec{dr}$$

$$\boldsymbol{V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}}$$

- If the source charge is negative $(-q)$, then the potential also negative and it is given by

$$\boldsymbol{V = -\frac{1}{4\pi\varepsilon_0}\frac{q}{r}}$$

8. Obtain an expression for potential energy due to a collection of three point charges which are separated by finite distances.



- Electrostatic potential energy of a system of charges is defined as the work done to assemble the charges
- Consider a point charge q_1 at 'A'
- Let potential at 'B' due to q_1 is V_{1B}
- The work done to bring second charge q_2 to 'B' is stored as the energy of system of two charges. (i.e)

$$W = q_2\,V_{1B} = q_2\,\frac{1}{4\pi\varepsilon_0}\frac{q_1}{r_{12}}$$

$$(or)\qquad \boldsymbol{U' = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r_{12}}}$$

- Let the potential at 'C' due to charges q_1 and q_2 will be $(V_{1C} + V_{2C})$
- To bring third charge q_3 to 'C' , the work done is

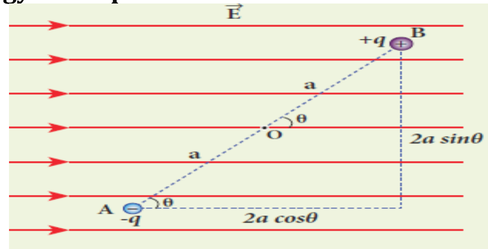
$$W = q_3\,(V_{1C} + V_{2C}) = q_3\,\frac{1}{4\pi\varepsilon_0}\left[\frac{q_1}{r_{13}} + \frac{q_2}{r_{23}}\right]$$

$$(or)\qquad \boldsymbol{U'' = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1q_3}{r_{13}} + \frac{q_2q_3}{r_{23}}\right]}$$

- Hence the the total electrostatic potential energy of system of three point charges is

$$\boldsymbol{U = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1q_2}{r_{12}} + \frac{q_1q_3}{r_{13}} + \frac{q_2q_3}{r_{23}}\right]}$$

9. Obtain an expression for electrostatic potential energy of a dipole in a uniform electric field.



- Let a dipole 'AB' of moment $\vec{p}$ is placed in a uniform electric field $\vec{E}$
- Here the dipole experience a torque, which rotate the dipole along the field.
- To rotate the dipole from θ' to θ against this torque, work has to be done by an external torque (τ_{ext}) and it is given by,

$$W = \int_{\theta'}^{\theta}\tau_{ext}\,d\theta = \int_{\theta'}^{\theta}p\,E\sin\theta\,\,d\theta$$

$$W = p\,E\,[\cos\theta' - \cos\theta]$$

- This work done is stored as electrostatic potential energy of the dipole. (i.e)

$$\boldsymbol{U = p\,E\,[\cos\theta' - \cos\theta]}$$

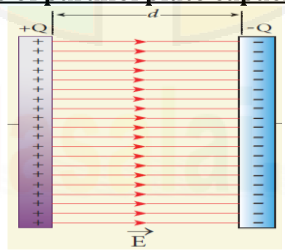
- Let the initial angle be $\theta' = 90°$, then

$$\boldsymbol{U = -\,p\,E\cos\theta = -(\vec{p}\,.\,\vec{E})}$$

- If $\theta = 180°$, then $\boldsymbol{U = \ p\,E}$ = maximum
- If $\theta = 0°$, then $\boldsymbol{U = -\,p\,E}$ = mimimum

10. Derive an expression for capacitance of parallel plate capacitor.

Capacitance of parallel plate capacitor :



- Consider a capacitor consists of two parallel plates each of area 'A' separated by a distance 'd'
- Let 'σ' be the surface charge density of the plates.
- The electric field between the plates,

$$\boldsymbol{E = \frac{\sigma}{\varepsilon_0} = \frac{Q}{A\,\varepsilon_0}} \qquad -------- \quad (1)$$

- Since the field is uniform, the potential difference between the plates,

$$\boldsymbol{V = E\,d = \left[\frac{Q}{A\,\varepsilon_0}\right]d} \qquad ----- \quad (2)$$

- Then the capacitance of the capacitor,

$$C = \frac{Q}{V} = \frac{Q}{\left[\frac{Q}{A\,\varepsilon_0}\right]d}$$

$$\boldsymbol{C = \frac{\varepsilon_0\,A}{d}} \qquad ------- \quad (3)$$

- Thus capacitance is,
  (i) directly proportional to the Area (A) and
  (ii) inversely proportional to the separation (d)

11. Derive an expression for energy stored in capacitor

- Capacitor is a device used to store charges and energy.
- For this work is done by the battery. This work done is strored as electrostatic energy in capacitor.
- To transfer 'dQ' for a potential difference 'V', the work done is

$$dW = V\,dQ = \frac{Q}{C}\,dQ \qquad \left[\because\ V = \frac{Q}{C}\right]$$

- The total work done to charge a capacitor,

$$W = \int_0^Q\frac{Q}{C}\,dQ = \frac{1}{C}\left[\frac{Q^2}{2}\right]_0^Q = \frac{Q^2}{2\,C}$$

- This work done is stored as electrostatic energy of the capacitor, (i.e)

$$\boldsymbol{U_E = \frac{Q^2}{2\,C} = \frac{1}{2}\,C\,V^2} \qquad [\because\ Q = C\,V]$$

- The energy stored per unit volume of space is defined as energy density ($(u_E$).

$$\boldsymbol{u_E = \frac{U_E}{volume} = \frac{1}{2}\,\varepsilon_0\,E^2}$$

12. Explain the principle behind the lightning conductor (Action 0f point).

- ***Action of point*** is the principle behind the lightning conductor.
- We know that smaller the radius of curvature, the larger is the charge density.
- If the conductor has sharp end which has larger curvature (smaller radius), it has a large charge accumulation.
- As a result, the electric field near this edge is very high and it ionizes the surrounding air.

- The positive ions are repelled at the sharp edge and negative ions are attracted towards the sharper edge.
- This reduces the total charge of the conductor near the sharp edge. This is called action of points or corona discharge.

13. Explain the principle, construction and action of lightning conductor.

- This is a device used to protect tall building from lightning strikes;
- It woks on the principle of ***acion of points*** or ***corona discharge***.
- It consists of a long thick copper rod
- Its upper end has a sharp needle and its lower end is connected to the copper plate which is buried deep in to the ground.
- When a negatively charged cloud is passing above the building, it induces a positive charge on the spike.
- Since the charge density is large at the spike, action of point takes place.
- This positive charge ionizes the surrounding air which in turn neutralizes the negative charge in the cloud.
- The negative charge pushed to the spikes passes through the copper rod and is safely diverted to the Earth.
- Thus the lighting arrester does not stop the lightning, but it diverts the lightning to the ground safely

14. Give the applications and disadvantage of capacitors

<u>Applications of capacitor</u>:

- Flash capacitors are used in digital camera to take photographs
- Capacitor of 175 μF is used in heart defibrillator which produce electric energy applied patient's chest to retrieve the normal heart function.
- Capacitors are used in the ignition system of automobile engines to eliminate sparking.
- Capacitors are used to reduce power fluctuations in power supplies and to increase the efficiency of power transmission.

<u>Disadvantages</u> :

- Even after the battery or power supply is removed, the capacitor stores charges and energy for some time. It caused unwanted shock.

15. Define equipotential surface. Give its properties.

<u>Equipotential surface</u>:

- An equipotential surface is a surface on which all the points are at the same potential.
  1) For a point charge the equipotential surfaces are concentric spherical surfaces.
  2) For a uniform electric field, the equipotential surfaces form a set of planes normal to the electric field.

<u>Properties</u> :

- The wor kdone to move a charge 'q' between any two points A and B is $W = q\,(V_A - V_B)$. If A and B lie on the same equipotential surface then $V_A = V_B$ Hence work done is zero ($W = 0$)
- The electric field is always normal to an equipotential surface.

UNIT - 2 CURRENT ELECTRICITY

1. Obtain an expression for drift velocity. How it is related with the mobility?

- *The average velocity acquired by the free electrons inside the conductors, when it is subjected to the electric field is called drift velocity* ($\vec{v}_d$)
- If the conductor is subjected to an electric field ($\vec{E}$) free electrons experinces a force given by,

$$\vec{F} = -e\,\vec{E} \qquad ------(1)$$

- So all the free electrons are accelerated and it is given by

$$\vec{a} = \frac{\vec{F}}{m} = \frac{-e\,\vec{E}}{m} \qquad ------(2)$$

- But the positive ions scatter this electrons and due to this collisions the electrons moves in zig-zag path.
- The average time between successive collision is called the mean free time or relaxation time (τ).
- Hence the drift velocity is given by,

$$\vec{v}_d = \vec{a}\,\tau = \frac{-e\,\vec{E}}{m}\,\tau = -\,\mu\,\vec{E}$$

- *The drift velocity acquired by the free electron per unit electric field is called mobility* ($\boldsymbol{\mu}$).
- Its unit is $m^2V^{-1}s^{-1}$

2. Write a note on carbon resistors.

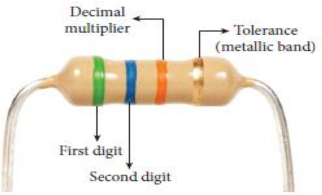
- Carbon resistors consists of a ceramic core on which a thin layer of crystalline carbon is deposited.
- They are inexpensive, stable and compact in size.
- Colour rings drawn over it are used to indicate the value of the resistance according to the rules in the table.

Colour	Number	Multiplier
Black	0	1
Brown	1	10^1
Red	2	10^2
Orange	3	10^3
Yellow	4	10^4
Green	5	10^5
Blue	6	10^6
Violet	7	10^7
Grey	8	10^8
White	9	10^9

Colour	Tolerance
Gold	5 %
Silver	10 %
No ring (colourless)	20 %

- There is three coloured bands on its left and one metallic coloured band on its right side.
- The first and second rings are the *significant figures* of the resistance and the third ring indicate the *decimal multiplier* after them. The fourth metallic ring shows the *tolerance* of the resistor.

Example :



- For the given carbon resistor,
  First ring (Green) = 5
  Second ring (Blue) = 6
  Third ring (Orange) = 10^3
  Fourth metallic ring (Gold) = 5%
- Value of the resistor = $\mathbf{56 \times 10^3\ \Omega = 56\ k\,\Omega}$
  Tolerance = **5 %**

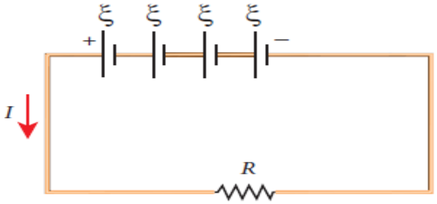
3. Define temperature coefficient of resistivity. Obtain an expression for it.

- Resistivity of the substance depends on the temperature. Let
- Resistivity at T_o°C $= \rho_o$
  Resistivity at T°C $= \rho_T$
  $\therefore \quad \rho_T = \rho_o [1 + \alpha (T - T_o)] \quad ----(1)$
  Where, $\alpha \to$ Temperature coefficient of resistivity
- From equation (1)

$$\boldsymbol{\alpha = \frac{\rho_T - \rho_o}{\rho_o \ (T - T_o)} = \frac{\Delta\rho}{\rho_o \ \Delta T}}$$

  Where, $\Delta\rho = \rho_T - \rho_o \to$ change in resistivity
  $\Delta T = T - T_o \to$ Change in temperature
- It is defined as the ratio of increase in resistivity per degree rise in temperature to its resistivity at T_o . Its unit is ***per*** °C
- For conductors α is positive
- For semiconductor, α is negative
- A semiconductor with a negative temperature coefficient of resistance is called a ***thermistor***.

4. Write a note on electric cells in series.



- Let 'n' cells each of emf ξ and internal resistance 'r' are connected in series with an external resistance 'R'.
- Total emf of the battery $= n\,\xi$
  Total resistance of the circuit $= n\,r + R$
- By Ohm's law,

$$I = \frac{Total\ emf}{Total\ resistance} = \frac{n\,\xi}{n\,r + R} \quad --- (1)$$

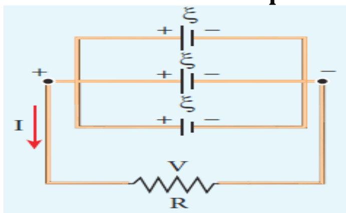
- If $r \ll R$, equation (1) becomes,

$$I = \frac{n\,\xi}{R} \approx n\,I_1 \qquad \left[\because \ \frac{\xi}{R} = I_1\right]$$

- $r \gg R$, equation (1) becomes,

$$I = \frac{n\,\xi}{n\,r} = \frac{\xi}{r} \approx I_1$$

5. Write a note on electric cells in parallel.



- Let 'n' cells each of emf ξ and internal resistance 'r' are connected in parallel with an external resistance 'R'.
- Total emf of the battery $= n\,\xi$
  Total resistance of the circuit $= \frac{r}{n} + R$
- By Ohm's law,

$$I = \frac{Total\ emf}{Total\ resistance} = \frac{\xi}{\frac{r}{n} + R} = \frac{n\,\xi}{n\,r + R} \quad --(1)$$

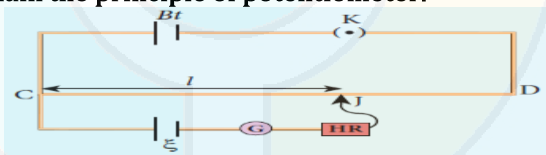
- If $r \ll R$, equation (1) becomes,

$$I = \frac{n\,\xi}{R} \approx n\,I_1 \qquad \left[\because \ \frac{\xi}{R} = I_1\right]$$

- $r \gg R$, equation (1) becomes,

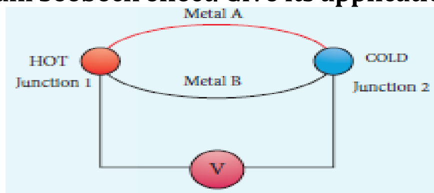
$$I = \frac{n\,\xi}{n\,r} = \frac{\xi}{r} \approx I_1$$

6. Explain the principle of potentiometer.



- A battery (Bt), key (K) and potentiometer wire (CD) are connected in series forms the primary circuit.
- The positive terminal of primary cell of emf 'ξ' is connected to the point C and negative terminal is connected to the point D through galvanometer (G) and high resistance (HR). This forms the secondary circuit.
- Let contact be made at 'J' on the wire by jockey.
- If the potential difference across CJ is equal to the emf (ξ) of the cell, then the galvanometer shows zero deflection. Here 'CJ' is the balancing length $\boldsymbol{l}$
- If 'r' is the resistance per unit length of the wire, then by Ohm's law,
  Potential difference across CJ $= I\,r\,l$
  Hence, $\boldsymbol{\xi = I\,r\,l}$
- Since I and r are constants, , $\boldsymbol{\xi \propto l}$

7. Explain Seebeck effect. Give its applications.



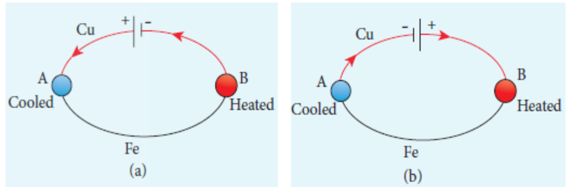
- Seebeck discoved that in a closed circuit consisting of two dissimilar metals, when the juctions are maintained at different temperatures an *emf (potential difference) is developed*. This is called Seebeck effect.
- The current that flows due to the emf developed is called ***thermoelectric current***.
- The two dissimilar metals connected to form two junctions is known as ***thermocouple***.
- If hot and cold juntions are interchanged, the direction of current also reversed. Hence Seebeck effect is ***reversiable***.
- The magnitude of emf developed in thermocouple depends on,
  (i) Nature of the metals forming thermocouple
  (ii) Temperature difference between the junctions

Applications :

- Seebeck effect is used in thermoelectric generators (Seebeck generators).
- This effect is utilized in automobiles as automotive thermoelectric generators.
- Seebeck effect is used in thermocouples and thermopiles.

8. Explain Peltier effect.

- When an electric current is passed through a circuit of a thermocouple, heat is evolved at one junction and absorbed at the other junction. This is known as Peltier effect.



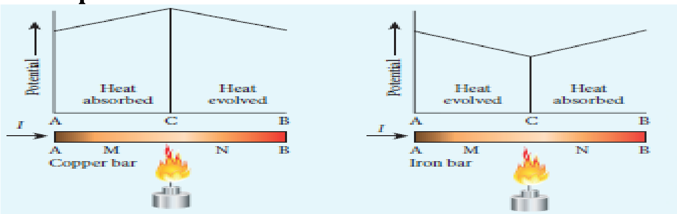
- In Cu - Fe thermocouple, the junctions A and B are maintained at the same temperature.
- Let a current flow through the thermocouple.

- At junction 'A', where the current flows from Cu to Fe, heat is absorbed and it becomes cold.
- At juction 'B', where the current flows from Fe to Cu, heat is liberated and it becomes hot.
- When the direction current is reversed, junction 'A' becomes hot and junction 'B' becomes cold. Hence peltier effect is ***reversiable***.

9. Distinguish between Peltier effect and Joule's effect.

Peltier effect	Joule's effect
1) Both heat liberated and absorbed occur	1) Heat liberated only occur
2) Occurs at junctions	2) Occurs all along the conductor
3) Reversiable effect	3) Irreversiable effect

10. Explain Thomson effect.



(a) Positive thomson effect (b) Negative thomson effect

- Thomson showed that, if two points in a conductor are at different temperatures, the density of electrons at these points will differ and as a result the potential difference is created between these points. This is known as Thomson effect.
- Thomson effect is reversiable.
- If current passed through ***copper bar*** AB which is heated at its mid point C, the point C will be at higer potential. This indicates that the heat is absorbed along AC and evolved along CB. Thus heat is transferred in the direction of the current. It is called ***positive Thomson effect***.
  (e.g) Ag, Zn. Cd
- When the copper bar is replaced by an ***iron bar***, heat is evolved along CA and absorbed along BC. Thus heat is transferred in the direction opposite to the current. It is called ***negative Thomson effect***.
- (e.g.) Pt, Ni, Co, Hg

UNIT - 5 ELECTROMAGNETIC WAVES

1. Discuss briefly the experiment conducted by Hertz to produce and detect electromagnetic spectrum.

- The theoritical prediction of existence of electromagnetic wave by Maxwell was experimentally confirmed by Henrich Hertz.
- His experimental set up consists of two metal electrodes which are made of small spherical metals.
- These are connected to larger spheres and the ends of them are connected to induction coil which produce very high emf.
- Due to this high voltage, the air between the electrodes gets ionized and spark is produced.
- A receiver (ring electrode) kept at a distance also gets spark which implies that the energy is transmitted from electrode to the receiver as a wave known as electromagnetic waves.
- If the receiver is rotated by 90°, then no spark is observed by the receiver.
- This confirms that electromagnetic waves are transverse waves as predicted by Maxwell.
- Hertz detected radio waves and also computed the speed of radio waves which is equal to the speed of light ($3\ X\ 10^8\ m\ s^{-1}$).

2. Obtain an expression for energy density associated with an electromagnetic wave propagating in vacuum or free space.

- The energy per unit volume (i.e.) the energy density of electromagnetic wave is,

$$u = u_E + u_B$$

$$u = \frac{1}{2}\varepsilon_o E^2 + \frac{1}{2\,\mu_o} B^2 \quad --- \quad (1)$$

- The velocity of electromagnetic waves,

$$C = \frac{1}{\sqrt{\varepsilon_o\,\mu_o}} \quad (or) \quad C^2 = \frac{1}{\varepsilon_o\,\mu_o}$$

- If $E = B\,C$ then, $u_E = u_m$
- Hence equation (1) becomes,

$$\boldsymbol{u = \varepsilon_o E^2 = \frac{1}{\mu_o} B^2}$$

- The average energy density for electromagnetic waves,

$$\boldsymbol{\langle u \rangle = \frac{1}{2}\varepsilon_o E^2 = \frac{1}{2\,\mu_o} B^2}$$

3. Explain the sources of electromagnetic waves.

- Any stationary source charge produces only electric field.
- If the charged particle accelerates, in addition to electric field, it also produces magnetic field. Here both electric and magnetic fields are time varying fields.
- The linked electric and magnetic fields have wave property which propagate in the direction perpendicular to the plane containing electric and magnetic field vectors.
- This is known as electromagnetic waves and it is transverse in nature.
- Let, electric and magnetic vectors are given by,

$$E_y = E_o \sin(kz - \omega t)$$
$$B_x = B_o \sin(kz - \omega t)$$

  then the direction of propagation of electromagnetic waves are along Z -axis
- In free space or vacuum, the ratio between $\boldsymbol{E_o}$ and $\boldsymbol{B_o}$ is equal to the speed of electromagnetic wave which is equal to speed of light (c)

$$\boldsymbol{c = \frac{E_o}{B_o}}$$

4. Write a note on Radio waves.

- It is produced by oscillators in electric circuits.
- Wavelength range : $1\ X\ 10^{-4}\ m - 1\ X\ 10^4\ m$
- Frequency range : $3\ X\ 10^9\ Hz\ - 3\ X\ 10^4\ Hz$
- They obey reflection and diffraction
- It is used in,
  (i) radio and television communication systems
  (ii) cellular phones to transmit voice communication in the ultra high frequency band

5. Write a note on infra microwaves.

- It is produced by electromagnetic oscillators in electrical circuits
- Wavelength range: $1\ X\ 10^{-3}\ m - 3\ X\ 10^{-4}\ m$
- Frequency range : $3\ X\ 10^{11}\ Hz\ - 1\ X\ 10^9\ Hz$
- They obey reflection and polarization
- It is used in,
  (i) radar system for aircraft navigation,
  (ii) speed of the vehicle,
  (iii) microwave oven for cooking
  (iv) very long distance wireless communication through satellites

6. **Write a note on infra red rays.**
- It is produced from hot bodies and also when the molecules undergo rotational and vibrational transitions.
- Wavelength range : $8\ X\ 10^{-7}\ m - 5\ X\ 10^{-3}\ m$
- Frequency range : $4\ X\ 10^{14}\ Hz\ - 6\ X\ 10^{10}\ Hz$
- It provides electrical energy to satellites by means of solar cells
- It is used in,
  (i) producing dehydrated fruits
  (ii) green housed to keep the plants warm,
  (iii) heat therapy for muscular pain or sprain
  (iv) TV remote as a signal carrier, to look through haze fof or mist
  (v) night vision or infrared photography

7. **Write a note visible light.**
- It is produced by incandescent bodies and also it is radiated by excited atoms in gases.
- Wavelength range : $4\ X\ 10^{-7}\ m - 7\ X\ 10^{-7}\ m$
- Frequency range : $7\ X\ 10^{14}\ Hz\ - 4\ X\ 10^{14}\ Hz$
- It obeys the laws of reflection, refraction, interference, diffraction, polarization, photo -electric effect and photographic action.
- It can be used to,
  (i) study the structure of molecules
  (ii) arrangement of electrons in eternal shells of atoms and
  (iii) sensation of our eyes

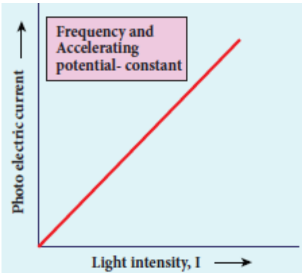
8. **Write a note on ultra violet rays.**
- It is produced by Sun, arc and ionized gases.
- Wavelength range : $6\ X\ 10^{-10}\ m - 4\ X\ 10^{-7}\ m$
- Frequency range : $5\ X\ 10^{17}\ Hz\ - 7\ X\ 10^{14}\ Hz$
- It has less penetrating power
- It can be absorbed by atmospheric ozone and harmful to human body.
- It is used to,
  (i) destroy bacteria
  (ii) sterilizing the surgical instruments,
  (iii) burglar alarm
  (iv) detect the invisible writing, finger prints and
  (v) study of molecular structure

9. **Write a note on X - rays.**
- It is produced when there is a sudden deceleration of high speed electrons at high atomic number target.
- Also by electronic transitions among the innermost orbits of atoms.
- Wavelength range : $1\ X\ 10^{-13}\ m - 1\ X\ 10^{-8}\ m$
- Frequency range : $3\ X\ 10^{21}\ Hz\ - 1\ X\ 10^{16}\ Hz$
- It has more penetrating power than UV - rays.
- It is used in,
  (i) studying structures of inner atomic electron shell and crystal structures.
  (ii) detecting fracture, diseased organs, formation of bones and stones, observing the progress of healing bones
  (iii) detect faults, cracks, flaws and holes in a finished metal product

10. **Write a note on gamma rays.**
- It is produced by transitionsof atomic nuclei and decay of certain elementary particles.
- Wavelength range : $1\ X\ 10^{-14}\ m - 1\ X\ 10^{-10}\ m$
- Frequency range : $3\ X\ 10^{22}\ Hz\ - 3\ X\ 10^{18}\ Hz$
- They produce chemical reactions on photographic plates, fluorescence, ionization, diffraction.
- Its penetrating power is higher than X-rays and UV rays.
- It has no charge but harmful to human body.
- It is used in,
  (i) providing information about the structure of atomic nuclei
  (ii) radio therapy for the treatment of cancer and tumour
  (iii) food industry to kill pathogenic micro organism

UNIT - 7 DUAL NATURE OF RADIATION AND MATTER

1. **How does photo electric current vary with the intensity of the incident light?**
- Keeping ν and V as constant, the intensity of incident light is varied and the corresponding photo eletric current is measured



- A graph is drawn between intensity along X-axis and the photo current along Y-axis.
- From the graph, *the photo current (i.e) the number of electrons emitted per second is directly proportional to the intensity of incident light*.

2. **State the laws of photo electric effect.**
- For a given frequency of incident light, the number of photoelectrons emitted is directly proportional to the intensity of the incident light. The saturation current is also directly proportional to the intensity of incident light.
- Maximum kinetic energy of the photo electrons is independent of intensity of the incident light.
- Maximum kinetic energy of the photo electrons from a given metal is directly proportional to the frequency of incident light.
- For a given surface, the emission of photoelectrons takes place only if the frequency of incident light is greater than a certain minimum frequency called the threshold frequency.
- There is no time lag between incidence of light and ejection of photoelectrons.

3. **Explain why photoelectric effect cannot be explained on the basis of wave nature of light**
- According to wave theory, light of greater intensity should impart greater kinetic energy to the liberated electrons.
  But the experiments show that maximum kinetic energy of the photoelectrons does not depend on the intensity of the incident light.
- According to wave theory, if a sufficiently intense beam of light is incident on the surface, electrons

will be liberated from the surface of the target, however low the frequency of the radiation is.
But photoelectric emission is not possible below a certain minimum frequency called threshold frequency.

- Since the energy of light is spread across the wavefront, each electron needs considerable amount of time (a few hours) to get energy sufficient to overcome the work function and to get liberated from the surface.
But experiments show that photoelectric emission is almost instantaneous process

4. Explain the concept of quantization of energy.

- Max Planck proposed quantum concept in 1900 in order to explain the block body radiations.
- According to Planck, matter is composed of a large number of atomic oscillator.
- Each atomic oscillator which vibrates with its characteristic frequency emits or absorbs electromagnetic radiation of the same frequency.
(i) If an oscillator vibrates with frequency ν, its energy can have only certain discrete values,
$$E_n = n\,h\,\nu \qquad [n = 1,2,3, \ldots.]$$
where h → Planck's constant.
(ii) The oscillators emit or absorb energy in small packets or quanta and the energy of each quantum is $E = h\,\nu$
- This implies that the energy of the oscillator is quantized and not continuous This is called **quantization of energy**.

5. Explain Eienstein's explanation for the particle nature (quanta) of light

Particle nature of light - Eienstein's explanation :

- According to Einstein, the energy in light is not spread out over wavefronts but is concentrated in small packets or energy quanta. Therefore, light of frequency ν from any source can be considered as a stream of quanta
- The energy of each light quantum ; $E = h\,\nu$
- The linear momentum of quanta is ; $p = \frac{h\,\nu}{c}$
- The individual light quantum of definite energy and momentum can be associated with a particle. The light quantum can behave as a particle and this is called ***photon.***

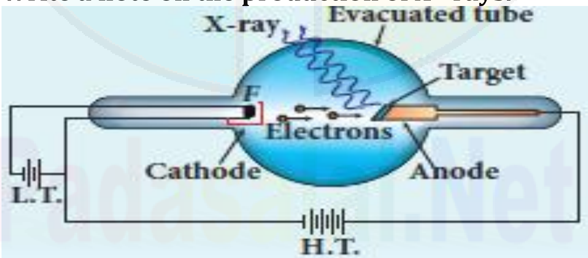
6. Derive the expression of de Broglie wavelength.

- The momentum of photon of frequency 'ν' is,
$$p = \frac{E}{c} = \frac{h\,\nu}{c} = \frac{h}{\lambda} \qquad [c = \lambda\nu]$$
- The wavelength of a photon is,
$$\lambda = \frac{h}{p}$$
- According to de Broglie, this equation is applicable to matter particle also.
- Let '**m**' be the mass and 'v' be the velocity of the particle, then the wavelength
$$\lambda = \frac{h}{m\,v} = \frac{h}{p}$$
- This wavelength of the matter waves is known as ***de Broglie wavelength***.

7. An electron and an alpha particle have same kinetic energy. How are the deBroglie wavelengths associated with them related?

- De Brolgei wavelength of electron beam,
$$\lambda_e = \frac{h}{\sqrt{2\,m_e\,K}}$$
- De Broglei wavelength of alpha particle,
$$\lambda_\alpha = \frac{h}{\sqrt{2\,m_\alpha\,K}}$$
$$\therefore \quad \frac{\lambda_e}{\lambda_\alpha} = \sqrt{\frac{m_\alpha}{m_e}}$$

8. Write a note on the production of X - rays.



- X - rays are produced in a Coolidge tube which is a discharge tube.
- Here a tungsten filament 'F' is heated by L.T, so that electrons are emitted from it by thermionic emission.
- These electrons are accelerated to very high speeds by H.T
- The target material like tungsten is embedded in the face of solid copper anode.
- When high speed electrons strike the target, they are decelarated suddenly and lose their kinetic energy.
- As a result, X -ray photons are produced.
- The face of target is inclined at particular angle, so that the X - rays can leave the tube through its side.
- Since most of the kinetic energy of electrons get converted in to heat, the target made of high melting point and a cooling system are usally employed.

9. Write a note on continuous X - ray spectrum.

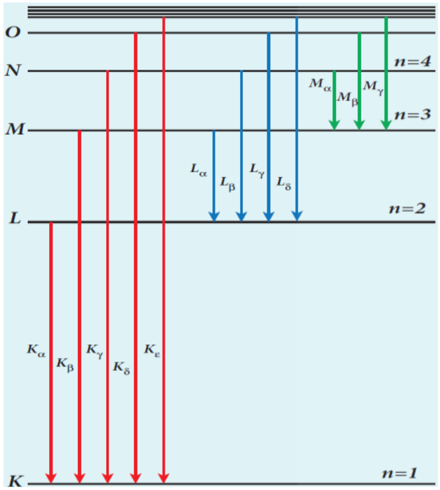
- When a fast moving electron penetrates and approaches a target nucleus, it get accelerates or decelerates
- It may results in a change of path of the electron.
- The radiation produced from such decelerating electron is called ***Bremsstrhlung*** or ***braking radiation***.
- The continuous X -ray spectrum is due to such radiations.
- When an electron gives up all its energy, then the photon is emitted with highest frequency (ν_0) or lowest wavelength (λ_0)
- The intial kinetic energy of an electron = eV where, V → accelerating voltage
- Thus,
$$e\,V = h\,\nu_0 = h\,\frac{c}{\lambda_0}$$
$$(or) \qquad \lambda_0 = \frac{h\,c}{e\,V} = \frac{12400}{V}\,A^\circ$$
- This relation is known as ***Duane - Hunt*** formula.

10. Write a note on characteristic X - ray spectra.

Characteristic X - ray spectra :

- The characteristic X -ray spectrum is due to the ***electronic transitions*** within the atoms.
- For example, when an energetic electron penetrates in to the target atom and removes the electrons in various shells and create a vacancy in it.
- So the electrons from outer orbits jump to fill up that vacancies.
- During the downward transition, the energy difference between the levels is given out in the form of X - ray photon of definite wavelength.

- Such wavelengths, characteristic of the target, consitute the line spectrum.
- It is evident that **K - series** of lines in the X - ray spectrum arise due to the electronic transistions from L, M. N, O, ... shells to K - shell.



- Similarly **L - series** originates due to electronic transition from M, N, O, ... shells to L - shell.

11. **Explain the applications of X -rays.**

(1) **Medical diagnosis** :
- X - rays can pass through flesh more easily than through bones. Thus X -ray radiograph containing a deep shadow of the bones and a light shadow of flesh. So X -rays radiographs ae used to detect fractures, foreign bodies, diseased organs etc.,

(2) **Medical therapy** :
- X - ray can kill diseased tissues. So they are employed to cure skin diseases, malignant tumours etc.,

(3) **Industry** :
- They are used to check for flaws in welded joints, motor tyres, tennis balls and wood,
- At the custom post, they are used for detection of contraband goods.

(4) **Scientific Research** :
- X - ray diffraction is important tool to study the structure of the crystalline materials (i.e) the arrangement of atoms and molecules in crystals.

12. **Give the application of photo cells .**
- Photo cells have many applications especially as switches and sensors.
- Automatic lights that turn on when it gets dark use photocells, as well as street lights that switch on and off according to whether it is night or day.
- Photo cells are used for reproduction of sound in motion pictures
- They are used as timers to measure the speeds of athletes during a race.
- Photo cells of exposure meters in photography are used to measure the intensity of the given light and to calculate the exact time of exposure.

13. **Derive an expression for de Broglie wavelength of electrons.**
- An electron of mass m is accelerated through a potential difference of V volt.
- The kinetic energy acquired by the electron is given by

$$\frac{1}{2}\, m\, v^2 = e\, V$$

- Hence the speed of the electron is.

$$v^2 = \frac{2\, e\, V}{m}$$

$$(or) \qquad v = \sqrt{\frac{2\, e\, V}{m}}$$

- The de Broglie wavelength of electron is

$$\lambda = \frac{h}{m\, v} = \frac{h}{m\sqrt{\frac{2\, e\, V}{m}}}$$

$$\boldsymbol{\lambda = \frac{h}{\sqrt{2\, m\, e\, V}} = \frac{12.27}{\sqrt{V}}\, A^o}$$

ADDITIONAL IMPORTANT QUESTIONS AND ANSWER

1. **List the properties of Diamagnetic materials.**
- Magnetic susceptibility is negative.
- Relative permeability is slightly less than one
- The magnetic field lines are excluded by diamagnetic materials when placed in a magnetic fields.
- Susceptibility is nearly temperature independent.

2. **List the properties of Paramagnetic materials.**
- Magnetic susceptibility is small positive value.
- Relative permeability is greater than one
- The magnetic field lines are attracted in to paramagnetic materials when placed in a magnetic field.
- Susceptibility is inversely proportional to temperature.

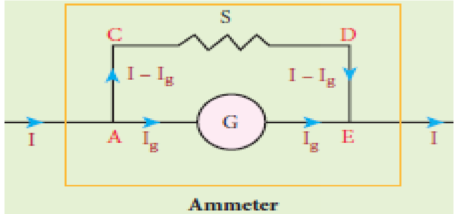
3. **List the properties of Ferromagnetic materials.**
- Magnetic susceptibility is positive and large
- Relative permeability is very very greater than one
- The magnetic fleld lines are stronglyattracted in to the ferromagnetic materials when placed in a magnetic field.
- Susceptibility is inversely proportional to temperature.

4. **Define Lorentz force. Give the properties of Lorentz magnetic force.**
- When an electric charge $'q'$ moves in the magnetic field $\vec{B}$, it experience a force called Lorentz magnetic force.

$$\boldsymbol{F_m = B\, q\, v \sin\theta \quad (or) \quad \vec{F}_m = q\,(\vec{v}\, X\, \vec{B})}$$

(i) $\vec{F}_m$ is directly proportional to the magnetic field $(\vec{B})$
(ii) $\vec{F}_m$ is directlty proportional to the velocity $(\vec{v})$
(iii) $\vec{F}_m$ is directly proportional to sine of the angle between the velocity and magnetic field.
(iv) $\vec{F}_m$ is directly proportional to the magnitude of the charge
(v) The direction of $\vec{F}_m$is always perpendicular to $\vec{v}$ and $\vec{B}$
(vi) The direction of $\vec{F}_m$ on negative chanrge is opposite to the direction of $\vec{F}_m$ on positive charge
(vii) If the of the charge is along the manetic field, then $\vec{F}_m$ is zero.

5. How Galvanometer can be converted in to Ammeter.



Ammeter

- A galvanometer is converted into an ammeter by connecting a low resistance called shunt in parallel with the galvanometer.
- Galvanometer resistance $= R_G$
  Shunt resistance $= S$
  Current flows through galvanometer $= I_G$
  Current flows through shunt resistance $= I_S$
  Current to be measured $= I$
- Here, $V_{Galvanometer} = V_{shunt}$

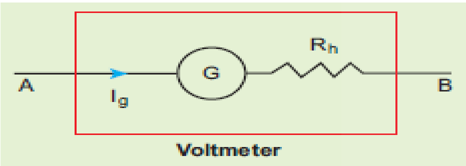
$$I_G \ R_G = I_S \ S$$
$$I_G \ R_G = (I - I_G) \ S$$
$$\boldsymbol{S = \frac{I_G}{I - I_G} R_G}$$

- Let R_a be the resistance of ammeter, then

$$\frac{1}{R_a} = \frac{1}{R_G} + \frac{1}{S}$$
$$(or) \quad \boldsymbol{R_a = \frac{R_G \ S}{R_G + S}}$$

- Here, $R_G > S > R_a$
- An ***ideal ammeter has zero resistance.***

6. How Galvanometer can be converted in to voltmeter?



Voltmeter

- A galvanometer is converted in to voltmeter by connecting high resistance in series with the galvanometer.
- The scale is calibrated in volts.
- Galvanometer resistance $= R_G$
  High resistanc $= R_h$
  Current flows through galvanometer $= I_G$
  Voltage to be measured $= V$
  Total resistance of this circuit $= R_G + R_h$
- Here, $I_G = I$

$$I_G = \frac{V}{R_G + R_h}$$
$$(or) \quad R_G + R_h = \frac{V}{I_G}$$
$$\therefore \quad \boldsymbol{R_h = \frac{V}{I_G} - R_G}$$

- Let R_v be the resistance of voltmeter, then

$$\boldsymbol{R_v = R_G + R_h}$$

- Here, $R_G < R_h < R_v$
- An ***ideal ammeter has zero resistance.***

7. Explain various energy losses in a transformer.

(i) <u>**Core loss or Iron loss**</u> :
- Hysterisis loss and eddy current loss are known as core loss or Iron loss.
- When transformer core is magnetized or demangnetized repeatedly by the appled ac, hyterisis takes place and some energy lost in the form of heat. It is minimized by using ***silicone steel*** in making transformer core.
- Alternating magnetic flux in the core induces eddy currents in it. Therefore there is energy loss due to the flow of eddy current called eddy current loss. It is minimized by using ***very thin laminations*** of transformer core.

(ii) <u>**Copper loss**</u> :
- When an electric current flows through primary and secondary coils, some amount of energy is dissipated due to Joule's heating and it is known as copper loss. It is minimized by using ***wires of larger diameter (thick wire)***

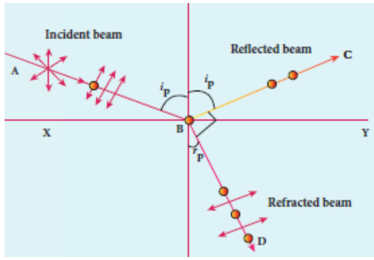
(iii) <u>**Flux leakage**</u> :
- The magnetic flux linked with primary coil is not completely linked with secondary. Energy loss due to this flux leakage is minimize by ***winding coils one over the other.***

8. State Huygen's principle.
- Each point of the wavefront is the source of secondary wavelets which spreading out in all directions with speed of the wave.
- The envelope to all this wavelets gives the position and shape of the new wavefront at a later time.

9. Distinguish between Fresnel and Fraunhofer diffraction.

Fresnel diffraction	Fraunhofer diffraction
Spherical or cylindrical wave front undergoes diffraction	Plane wavefront undergoes diffraction
The source of light is finite distance from the obstacle	The source of light is infinite distance from the obstacle
Convex lenses need not be used	Convex lenses are to be used
Difficult to observe and analyse	Easy to observe and analyse

10. State and prove Brewster's law
- ***Sir David Brewster*** found that, at polarizing angle, the reflected and transmitted rays are perpendicular to each other.
- Let, incident polarizing angle $= i_P$
  Angle of refraction $= r$



- From the figure,

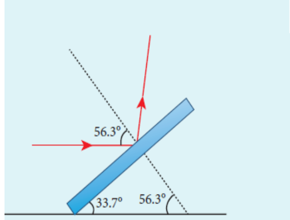
$$i_P + 90° + r_P = 180°$$
$$\boldsymbol{r_P = 90° - i_P} \quad ----(1)$$

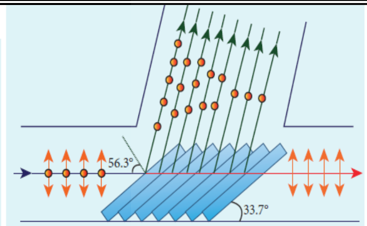
- From Snell's law

$$\frac{\sin i_P}{\sin r_P} = n$$
$$\frac{\sin i_P}{\sin(90° - i_P)} = n$$
$$\frac{\sin i_P}{\cos i_P} = n$$
$$\boldsymbol{\tan i_P = n}$$

- Thus, ***the tangent of the polarizing angle for a transparent medium is equal to its refractive index.*** This is known as Brewster's law

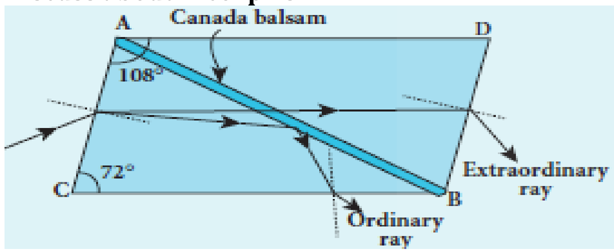
11. Write a note on pile of plates.
- It work on the principle of polarization by reflection.
- It consists of a number of glass plates placed one over the other in a tube.





- These plates are inclined at an angle **33.7°** to the axis of the tube.
- A beam of unpolarized light is allowed to fall on the pile of plates along the axis of the tube. So the angle of incidence of light will be **56.3°,** which is the polarizing angle for glass.
- The vibrations perpendicular to the plane of incidence are reflected at each surface and those parallel to it are transmitted.
- The pile of plates is used as a polrizer and also as an analyser.

12. Discuss about Nicol prism.



- Nicol prism is made by calcite crystal with its length is three times of its breadth.
- The face angles are **72°** and **108°**
- It is cut in to two halves along the diagonal AB and joined together by a layer of ***canada balsam***, a transparent cement.
- Let an unpolarized light from monochromatic source is incident on the face AC of the Nicol prism.
- Here double refraction takes place, and the ray split in to ordinary ray and extraordinary ray.
- For this calcite crystal.
  refractive index for the ordinary ray = 1.658
  refractive index for the extraordinary ray = 1.486
- The refractive index of canada balsam = 1.523
  Here canada balsam does not polarize light
- The ordinary ray is totally internally reflected at the layer of canada balsam.
- The extraordinaty ray alone is transmitted through the crystal which is plane polarized.

13. What are the uses and drawbacks of Nicol prism?

<u>Uses</u> :
- It produces plane polarized light and funcitons as a polarizer.
- It can also used as an analyser.

<u>Drawbacks</u> :
- It cost is very high due to scarity of large and flawless calcite crystal.
- Due to extraordinary ray passing obliquely through it, the emergent ray is always displaced a little to one side.
- The effective field of view is quite limited.
- Light emerging out of it is not uniformly plane polarized.

14. Distinguish between near point focusing and normal focusing.

Near point focusing	Normal focusing
The image is formed at near point	The image is formed at infinity
In this position, the eye feel little strain	In this position, the eye is most relaxed to view the image
Magnification is high $m = 1 + \frac{D}{f}$	Magnification is low $m = \frac{D}{f}$

15. What is myopia? What is its remedy?
- A person suffering from myopia or nearsightedness cannot see distant objects clearly.
- It occurs when the eye lens has too short focal length due to thickening of the lens or larger diameter of the eyeball than usual.
- Using ***concave lens*** this defect can be rectified.

16. What is hypermetopia? What is its remedy?
- A person suffering from hypermetopia or farsightedness cannot see objects close to the eye.
- It occurs when the eye lens has too long focal length due to thinning of eye lens or shortening of the eyeball than normal.
- Using ***convex lens*** this defect can be rectified.

17. What is presbyopia?
- The least distance for clear vision for aged people is appreciably more than 25 cm and the person has to keep the object inconveniently away from the eye.
- Thus reading or viewing smaller things held in the hands is difficult for them.
- This kind of farsightedness arising due to aging is called ***presbyopia***.

18. What is astigmatism?
- Astigmatism is the defect arising due to different curvatures along different planes in the eye lens.
- Astigmatic person cannot see all the directions equally well.
- Lenses with different curvatures in different planes called ***cylindrical lens*** is used to rectify astigmatism defect.

19. Give the properties of cathode rays.
- Cathode rays possess energy and momentum
- They affect the photographic plates
- They produce fluorescence
- When the cathode rays fall on a material of high atomic weight, ***x-rays*** are produced.
- They produce ionization.
- They deflected by both electric and magnetic fields and the direction of deflection indicates that they are ***negatively charged*** particles.

20. Calculate the energy equivalent to one atomic mass unit (1 u). Give the answer in eV unit.
- According to Eienstein's mass - energy relation
  $E = m\,c^2 = (1\,u)\,X\,(3\,X\,10^8)^2$
  $E = 1.66\,X\,10^{-27}\,X\,9\,X\,10^{16}$
  $E = 14.94\,X\,10^{-11}\,J$
- But we have, $1\,eV = 1.602\,X\,10^{-19}\,J$
  $\therefore \quad \boldsymbol{E = 931\,MeV}$

21. List the properties of neutrons.
- Mass of the neutron is little greater than the mass of the proton and had no charge.
- Neutrons are stable inside the nucleus. But free
- neutron has half life of 13 minutes. Then it decays with emission of proton, electron and anti neutrino.
- Neutrons are classified according to their kinetic energy as
  (1) slow neutrons (0 to 1000 eV)
  (2) fast neutrons (0.5 MeV to 10 MeV).
- The neutrons with average energy of about ***0.025 eV*** in thermal equilibrium are called thermal neutron.

22. Give the relation between α and β

- Forward current gain in common base mode,

$$\alpha = \left[\frac{\Delta I_C}{\Delta I_E}\right]_{V_{CE}}$$

- Forward current gain in common emitter mode,

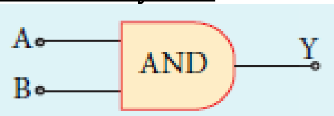
$$\beta = \left[\frac{\Delta I_C}{\Delta I_B}\right]_{V_{CE}}$$

- From the above two equations, we have

$$\alpha = \frac{\beta}{1+\beta} \qquad (or) \qquad \beta = \frac{\alpha}{1-\alpha}$$

23. Give the circuit symbol, Boolean expression, logical operation and truth table of AND gate .

AND gate - circuit symbol :



Boolean expression :

- A and B are the inputs and Y be the output, then

$$Y = A \cdot B$$

Logical operation :

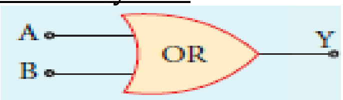
- The output of AND gate is high (1) only when all the inputs are high (1).
- The rest of the cases the output is low (0)

Truth table :

Inputs		Output
A	B	Y = A . B
0	0	0
0	1	0
1	0	0
1	1	1

24. Give the circuit symbol, Boolean expression, logical operation and truth table of OR gate .

OR gate - circuit symbol :



Boolean expression :

- A and B are the inputs and Y be the output, then

$$Y = A + B$$

Logical operation :

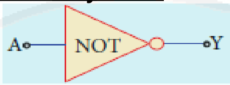
- The output of OR gate is high (1) when either of the inputs or both are high (1)

Truth table :

Inputs		Inputs
A	B	$Y = A + B$
0	0	0
0	1	1
1	0	1
1	1	1

25. Give the circuit symbol, Boolean expression, logical operation and truth table of NOT gate .

NOT gate - circuit symbol :



Boolean expression :

- If A be the input and Y be the output, then $Y = \overline{A}$

Logical operation :

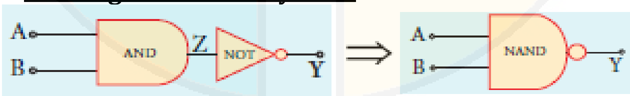
- It is also called as inverter.
- The output Y is high (1), when input is low (0) and vice versa.

Truth table :

Input	Output
A	$Y = \overline{A}$
0	1
1	0

26. Give the circuit symbol, Boolean expression, logical operation and truth table of NAND gate .

NAND gate - circuit symbol :



Boolean expression :

- A and B are the inputs and Y be the output, then

$$Y = \overline{A \cdot B}$$

Logical operation :

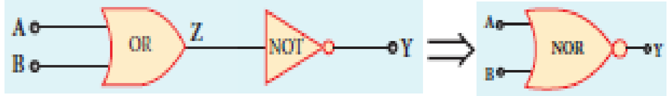
- The output is at low (0) only when all the inputs are high (1).
- The rest of the cases, the output is high (1)

Truth table :

Input		Output (AND)	Output (NAND)
A	B	Z = A . B	$Y = \overline{A \cdot B}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

27. Give the circuit symbol, Boolean expression, logical operation and truth table of NOR gate .

NOR gate - circuit symbol :



Boolean expression :

- A and B are the inputs and Y be the output, then

$$Y = \overline{A + B}$$

Logical operation :

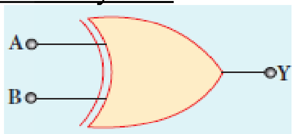
- The output is high (1) when all the inputs are low (0).
- The rest of the cases, the output is low (0)

Truth table :

Input		Output (OR)	Output (NOR)
A	B	Z = A + B	$Y = \overline{A + B}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

28. Give the circuit symbol, Boolean expression, logical operation and truth table of EX-OR gate .

EX-OR gate - circuit symbol :



Boolean expression :

- A and B are the inputs and Y be the output, then

$$Y = A \cdot \overline{B} + \overline{A} \cdot B = A \oplus B$$

Logical operation :

- The output Y is high (1) only when either of the two inputs is high (1).
- In the case of an Ex-OR gate with more than two inputs, the output will be high (1) when odd number of inputs are high (1)

Truth table :

Input		Output
A	B	$Y = A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0