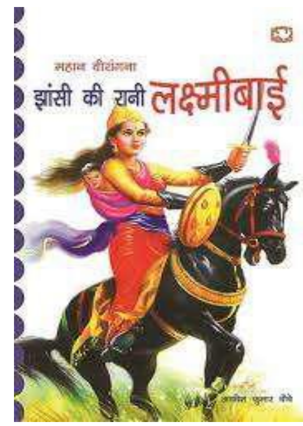
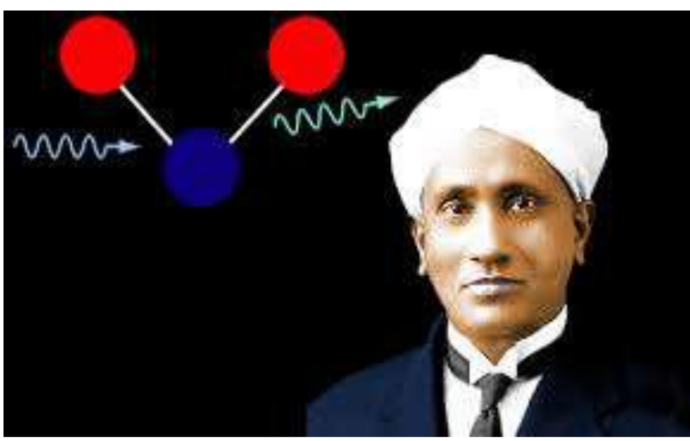
FREQUENTLY ASKED TWENTY QUESTION
SUBJECT-PHYSICS

"The science that deals with matter, energy, motion, and force"

CLASS-XII





- **SUNEEL KUMAR VISHWAKARMA**
- **M.Sc(Physics), M.Ed**
- **PGT (PHYSICS)**

- **Physics: The branch of science concerned with the properties of matter and energy and the relationships between them. It is based on mathematics and traditionally includes mechanics, optics, electricity and magnetism, acoustics, and heat. Modern physics, based on quantum theory, includes atomic, nuclear, particle, and solid-state studies. It can also embrace applied fields such as geophysics and meteorology.**

"Success is not permanent and failure is not final, so never stop working after success and never stop trying after A failure"

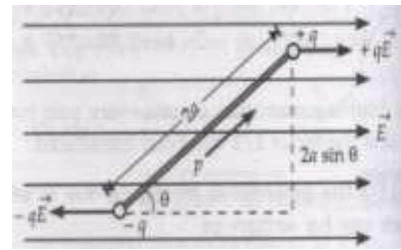
suneel19761976@gmail.com SUNEEL KUMAR VISHWAKARMA

1. How will the (i) energy stored and (ii) the electric field inside the air capacitor be affected when it is completely filled with a dielectric material of dielectric constant K ? **CBSE (AI)-2012**

[**Ans. (i)** $U_0 = \frac{q^2}{2C_0}$ & $U = \frac{q^2}{2C} = \frac{q^2}{2KC_0}$ ⇨ $U = \frac{U_0}{K}$ **(ii)** $E_0 = \frac{\sigma}{\varepsilon_0}$ & $E = \frac{\sigma}{K\varepsilon_0}$ ⇨ $E = \frac{E_0}{K}$

2. (i) An electric dipole is held in a uniform electric field. Using suitable diagram show that it does not undergo any translatory motion. Derive the expression for the torque acting on it.
(ii) What would happen if the field in non-uniform ?
(iii) What would happen if the external electric field E is increasing
(a) parallel to $\vec{p}$ and (b) anti-parallel to $\vec{p}$? **CBSE (AI)-2016,2014,2008,(F)-2016,(DC)-2015**

[**Ans. (i)** Let an electric dipole of dipole moment $\vec{p}$ is placed in a uniform electric field $\vec{E}$ as shown in figure.



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Force : Force on $+q$, $F_1 = qE$

Force on $-q$, $F_2 = -qE$

Hence net force on the dipole

$F = qE - qE = 0$

Torque : Two equal and opposite forces $-qE$ and $+qE$ forms a couple which tries to rotate the dipole. Torque due to this couple

τ = either force X ⊥ distance = qE x $2a\sin\theta$

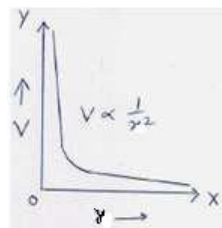
= qE x $2a\sin\theta$

⇨ $\tau = pE\sin\theta = \vec{p} \times \vec{E}$

(ii) If the electric field is non-uniform, the net force on the dipole will not be zero hence there will be the translator motion of the dipole.

(iii) (a) Net force will be in the direction of increasing electric field.

(b) Net force will be in the direction opposite to the increasing field



3 (i) Derive the expression for the potential energy of an electric dipole of dipole moment $\vec{p}$ placed in a uniform electric field $\vec{E}$.
(ii) Find out the orientation of the dipole when it is in (a) stable equilibrium (b) unstable equilibrium.
CBSE (AI)-2016,2015,2012

[**Ans. (i)** Two equal and opposite forces $-qE$ and $+qE$ forms a couple which tries to rotate the dipole. Torque due to this couple

τ = either force X ⊥ distance = qE x $2a\sin\theta$

$\tau = pE\sin\theta$

Work done in rotating the dipole through an angle $d\theta$

$dW = \tau\, d\theta = pE\sin\theta\, d\theta$

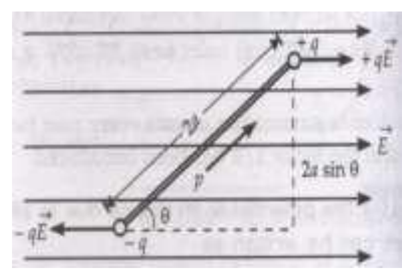
⇨ $W = \int_{\theta_1}^{\theta_2} pE\sin\theta\, d\theta = pE\int_{\theta_1}^{\theta_2}\sin\theta\, d\theta = pE\,[-\cos\theta]_{\theta_1}^{\theta_2}$

⇨ $W = pE\,(\cos\theta_1 - \cos\theta_2)$ -------(1)

When $\theta_1 = 90^0$ and $\theta_2 = \theta$, then $W = U$

⇨ $U = pE\,(\cos 90^0 - \cos\theta) = pE\,(0 - \cos\theta) = \mathbf{-pE\cos\theta}$

⇨ $\boldsymbol{u(\theta) = -\vec{p}.\vec{E}}$



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(ii) (a) When $\theta = 0^0$, $U = -pE\cos 0 = -pE$

In this case P.E. is minimum hence it is the orientation of stable equilibrium.

(b) When $\theta = 180^0$, $U = -pE\cos 180 = +pE$

In this case P.E. is maximum hence it is the orientation of unstable equilibrium.

3a. Using Gauss's law, derive an expression for the electric field intensity due to an infinitely long, straight wire of linear charge density λ C/m. **CBSE (AIC)-2017,(AI)-2007,2006,2005,(D)-2009,04**

[**Ans**. Charge enclosed by Gaussian surface, $q = \lambda l$

At the part I and II of Gaussian surface $\vec{E}$ and $\hat{n}$ are ⊥, so flux through surfaces I and II is zero.

By Gauss's law, $\oint \vec{E}.\vec{ds} = \frac{q}{\varepsilon_0}$

⇨ $\oint E ds\, cos0 = \frac{q}{\varepsilon_0}$

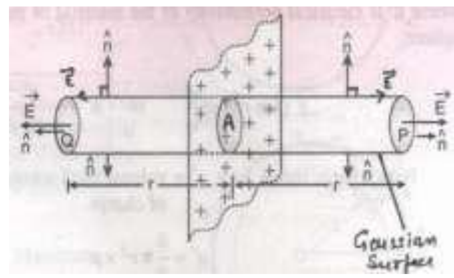
⇨ $E \oint ds = \frac{q}{\varepsilon_0}$

⇨ $E(2\pi r l) = \frac{\lambda\, l}{\epsilon_0}$ ⇨ $\boldsymbol{E = \frac{\lambda}{2\pi\varepsilon_0\, r}}$

3b. Using Gauss's law, obtain the expression for electric field intensity at a point due to an infinitely large, plane sheet of charge of charge density σ C/m^2. How is the field directed if the sheet is (i) positively charged (ii) negatively charged? **CBSE (AI)-2015,2010,2005,2004,(D)-2012,2009,06,(DC)-2002,01,(F)-2003**

[**Ans**. Let us consider a Gaussian surface as shown.

At the curved part of Gaussian surface $\vec{E}$ and $\hat{n}$ are ⊥, so flux through curved surface is zero.



By Gauss's law, $\oint \vec{E}.\vec{ds} = \frac{q}{\varepsilon_0}$

⇨ $\oint E ds\, cos0 = \frac{q}{\varepsilon_0}$

⇨ $E \oint ds = \frac{q}{\varepsilon_0}$

⇨ $E(2A) = \frac{q}{\varepsilon_0}$

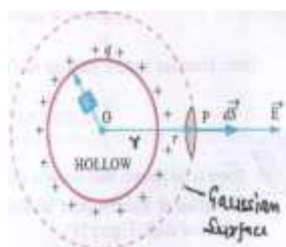
⇨ $\boldsymbol{E} = \frac{q}{2\varepsilon_0\, A} = \frac{\sigma}{2\varepsilon_0}$

Direction of field : (i) If the sheet is positively charged the field is directed away from it
(ii) If sheet is negatively charged the field is direct towards it

3c. Using Gauss's law, deduce the expression for the electric field due to uniformly charged spherical conducting shell of radius R at a point (i) outside and (ii) inside the shell.
Plot a graph showing variation of electric field as a function of r > R and r< R.
CBSE (AI)-2015,2013,2007,2004,(D)-2011,2009,2008,2006,2004

[**Ans**. **(i) Outside the shell** $(r > R)$

Let us consider the Gaussian surface as shown



by Gauss's law, $\oint \vec{E}.\vec{ds} = \frac{q}{\varepsilon_0}$

⇨ $\oint E ds\, cos0 = \frac{q}{\varepsilon_0}$

⇨ $E \oint ds = \frac{q}{\varepsilon_0}$

⇨ $E\,(4\pi r^2) = \frac{q}{\epsilon_0}$

⇨ $\boldsymbol{E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}}$

(ii) Inside the shell $(r < R)$

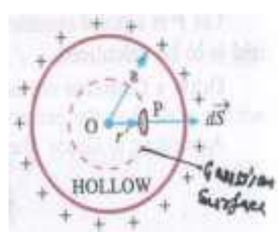
Let us consider the Gaussian surface as shown

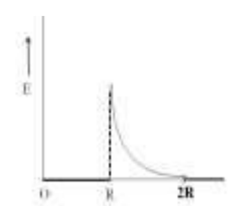
By Gauss's law

$\oint \vec{E}.\vec{ds} = \frac{q}{\varepsilon_0}$

But, charge inside the spherical shell, i,e, q = 0

⇨ $\oint E\, ds\, cos\, 0 = 0$ ⇨ $\boldsymbol{E = 0}$



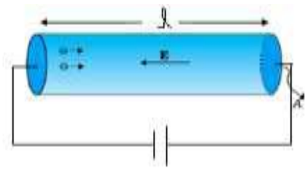


4. Deduce Ohm's law using the concept of drift velocity. **CBSE(AI)-2013**

OR

On the basis of electron drift, derive an expression for resistivity of a conductor in terms of number density of free electrons and relaxation time. **CBSE (D)-2016,(AI)-2012**

[Ans. Let a potential difference V is applied across the ends of a conductor as shown.



Electric field produced, $E = \frac{V}{l}$

⇨ $v_d = \frac{eE}{ml}\tau = \frac{eV}{ml}\tau$

⇨ $I = neAv_d = neA\left(\frac{eV}{ml}\tau\right) = \frac{ne^2\tau}{m}\left(\frac{A}{l}\right)V$

⇨ $\frac{V}{I} = \frac{m}{ne^2\tau}\left(\frac{l}{A}\right)$ ---------(1)

If the physical conditions of conductor such as temperature etc. remains constant then

$\frac{m}{ne^2\tau}\left(\frac{l}{A}\right) = constant = R$ --------(2)

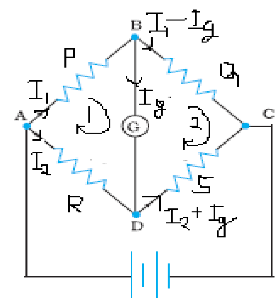
⇨ from (1) $\frac{V}{I} = R$ ⇨ $V = IR$, Now, $R = \frac{\rho l}{A}$ ⇨ from (2) $\rho = \frac{m}{ne^2\tau}$

5. What is Wheatstone bridge ? When is the bridge said to be balanced ? Use Kirchhoff's rules to obtain conditions for the balanced condition in a Wheatstone bridge. **CBSE(D)-2015**

[Ans. Wheatstone bridge : It is an arrangement of four resistances which is used to determine one of these resistance in terms of the remaining three resistances

Balanced condition : If the resistances in the Wheatstone bridge are so arranged that current in the galvanometer (I_g) is zero then the bridge is said to be balanced and in this balanced condition

$\frac{P}{Q} = \frac{R}{S}$



Proof : In the balanced condition, $I_g = 0$

Applying Kirchhoff's loop rule to ABDA

$I_1 P + 0 - I_2 R = 0$

⇨ $I_1 P = I_2 R$ -------(1)

Again applying Kirchhoff's loop rule to BCDB

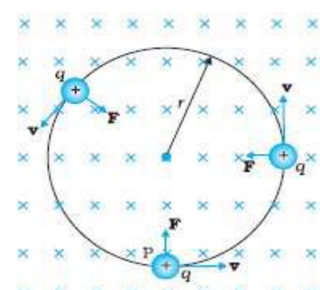
$I_1 Q - I_2 S - 0 = 0$

⇨ $I_1 Q = I_2 S$ -------(2)

⇨ from (1) & (2), $\frac{I_1 P}{I_1 Q} = \frac{I_2 R}{I_2 S}$ ⇨ $\frac{P}{Q} = \frac{R}{S}$

6. A particle of charge $'q'$ and mass $'m'$ is moving with velocity $\vec{v}$. It is subjected to a uniform magnetic field $\vec{B}$ directed perpendicular to its velocity. Show that it describes a circular path. Obtain the expression for its radius and show that frequency of revolution is independent of velocity. **CBSE (AI)-2014,(F)-2012**

[Ans. Motion of a charged particle in a uniform magnetic field :



Charged particle will experience a force,

$F_m = B\,q\,v\sin 90^0$

As this force acts perpendicular to both $\vec{v}$ & $\vec{B}$, particle will be deflected sideways continuously without changing its speed and hence it will move along a circular path. Thus F_m provides centripetal force

i,e, $B\,q\,v = \frac{mv^2}{r}$

⇨ $r = \frac{mv}{qB}$

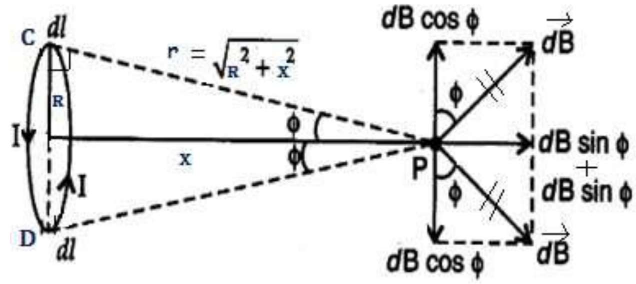
Now the time period,

$T = \frac{2\pi r}{v} = \frac{2\pi}{v} \text{ X } \frac{mv}{qB} = \frac{2\pi m}{qB}$

& $f = \frac{1}{T} = \frac{qB}{2\pi m}$ Which is independent of velocity

7. Using Biot-Savart law, deduce the expression for the magnetic field at a point (x) on the axis of a circular current carrying loop of radius R. How is the direction of the magnetic field determined at this point ?

[Ans. Magnetic field due to a current carrying loop at a point on its axis : **CBSE (F)-2017,(AI)-2016**



According to Biot-Savart's law the magnetic field at P due to current element $I\,\overrightarrow{dl}$ at C

$$dB = \frac{\mu_0}{4\pi}\frac{I\ dl \sin 90^0}{r^2}$$

⇨ $$dB = \frac{\mu_0}{4\pi}\frac{I\ dl}{r^2}$$

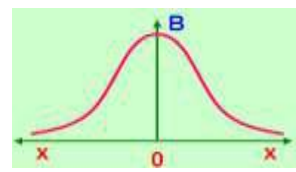
Resolving $\overrightarrow{dB}$ in to horizontal and vertical Components, resultant magnetic field at P

$$B = \int dB\ \sin\phi = \int \frac{\mu_0}{4\pi}\frac{I\ dl}{r^2}\sin\phi = \frac{\mu_0}{4\pi}\frac{I}{r^2}\sin\phi\ \int dl$$

⇨ $$B = \frac{\mu_0}{4\pi}\frac{I}{r^2}\ \left(\frac{R}{r}\right)\ (2\pi R)$$

⇨ $$B = \frac{\mu_0}{4\pi}\frac{I\,R}{r^3}\,(2\pi R)$$

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



For a coil of N turns

$$\boldsymbol{B} = \frac{\mu_0\, N\, I\, R^2}{2\,(R^2 + x^2)^{3/2}}$$

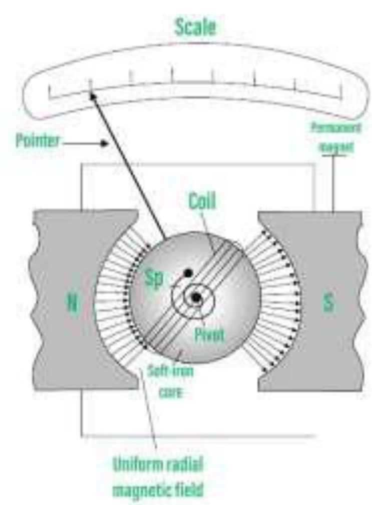
Direction of this magnetic field can be determined by the right hand thumb rule

8. With the help of a neat and labelled diagram, explain the principle and working of a moving coil galvanometer.
(i) What is the function of uniform radial field and how is it produced ?
(ii) Why is it necessary to introduce a cylindrical soft iron core inside the coil of a galvanometer ?

CBSE (D)-2017,2015,(F)-2016,2012,(AI)-2014,2010

[Ans. Moving coil galvanometer : It is a device used to detect small currents in an electric circuit.

Principle : When a current carrying coil is placed in a uniform magnetic field, it experiences a torque (τ = BINA $\sin\theta$) which tends to rotate the coil and produces an angular deflection



Working : When current I is passed in the coil, it experiences a torque, known as deflecting torque

τ = BINA $\sin 90^0$ [∵ for radial field, θ = 90^0]

⇨ τ = BINA

This magnetic torque tends to rotate the coil. Spring S_p provides the counter torque known as restoring torque which balances this magnetic torque and is given by

τ' = K ϕ

Where K is the restoring torque per unit twist or torsional Constant of the spring

i,e, In equilibrium, $\tau = \tau'$

⇨ BINA = K ϕ

⇨ $$I = \frac{K}{BNA}\phi$$

⇨ $I \propto \phi$

Hence, deflection of coil is directly proportional to the current flowing in the coil which can be measured by the linear scale.

(i) Function of radial magnetic field : It makes the scale of galvanometer linear or $I \propto \phi$

Production of radial magnetic field : It can be produced by making the pole pieces of the magnet cylindrical in shape

(ii) Necessity of soft iron core : (i) to increases the strength of the magnetic field hence increases the sensitivity of the galvanometer, and

(ii) to make the field more radial

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8a.-Define the terms (i) current sensitivity and (ii) Voltage sensitivity of a galvanometer. How is current sensitivity increased ? **CBSE (F)-2016,(AI)-2015**

[Ans. (i) **Current Sensitivity** : It is defined as the deflection produced in the galvanometer, when unit current flowing in it

i,e, $I_s = \frac{\phi}{I}$

(ii) **Voltage Sensitivity** : It is defined as the deflection produced in the galvanometer, when unit potential difference is applied across its ends

i,e, $V_s = \frac{\phi}{V}$

Current sensitivity can be increased by increasing the number of turns

8b.-"Increasing the current sensitivity of a galvanometer may not necessarily increase its voltage sensitivity." Justify this statement. **CBSE (AI)-2015,2014,2001,(D)-2009**

[Ans. Current sensitivity $I_s = \frac{\phi}{I} = \frac{NBA}{K}$ & Voltage sensitivity $V_s = \frac{\phi}{V} = \frac{NBA}{KR}$

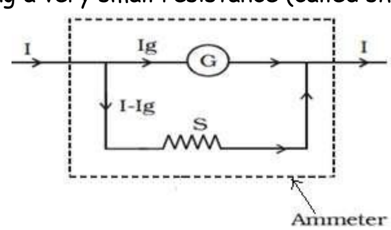
8c. How is a galvanometer converted into a voltmeter and an ammeter ? Draw the relevant diagrams and find the resistance of the arrangement in each case. Take resistance of galvanometer as G. **CBSE (AI)-2016**

[Ans. (i) Conversion of galvanometer in to Ammeter :

A galvanometer is converted in to an ammeter by connecting a very small resistance (called shunt) in parallel with it.

$(I - I_g) \ X \ S = I_g \ X \ G$

⇨ $S = \frac{I_g \, X \, G}{(I - I_g)}$



Effective resistance of ammeter

$\frac{1}{R_A} = \frac{1}{S} + \frac{1}{G}$ ⇨ $R_A = \frac{S\,G}{S + G}$

$R_A < G$ always

(ii) Conversion of galvanometer in to Voltmeter :

A galvanometer can be converted in to a voltmeter by connecting a very high resistance in series to it.

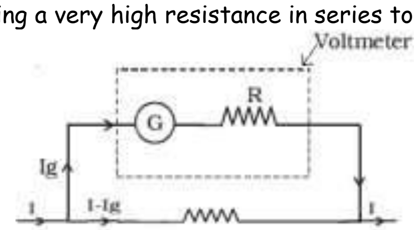
$V = I_g \, (R + G)$

⇨ $R = \frac{V}{I_g} - G$

Effective resistance of voltmeter

$R_V = R + G$

$R_V > G$ always



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9a. Which of the following substances are diamagnetic ? **CBSE (D)-2013,(AIC)-2009**

Bi, Al, Na, Cu, Ca and Ni

[Ans. Bi and Cu both are diamagnetic substances

9b. Which of the following substances are paramagnetic ? **CBSE (D)-2013**

Bi, Al, Cu, Ca Pb and Ni

[Ans. Al is a paramagnetic substance

9c. Define the term intensity of magnetization. **CBSE (AIC)-2006**

[Ans. Intensity of magnetization : It is defined as the magnetic moment per unit volume of the material when placed in a magnetizing field

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

9d. Define the term magnetic susceptibility. **CBSE (AIC)-2006**

[Ans. Magnetic susceptibility(χ_m): It is defined as the ratio of intensity of magnetization (I) to the magnetizing field intensity (H)

$$\chi_m = \frac{\mathrm{I}}{\mathrm{H}}$$

9e. What is Curie point ? **CBSE (AIC)-2001**

[Ans. Curie Point : It is the temperature above which a ferromagnetic substance becomes paramagnetic

9f. State Curie law. **CBSE (AIC)-2001**

[Ans. Curie Law : The susceptibility of a paramagnetic material is inversely proportional to the absolute temperature

i,e, $\chi_m = \frac{C}{T}$

9g. The permeability of a magnetic material is 0.9983. Name the type of magnetic material it represents.

[Ans. As $\mu < 1$, so the given material is diamagnetic **CBSE (D)-2011**

9h. The susceptibility of a magnetic material is $-4.2 \text{ X } 10^{-6}$. Name the type of magnetic material it represents.

[Ans. As susceptibility is negative, so the given material is diamagnetic **CBSE (D)-2011**

9i. The susceptibility of a magnetic material is 1.9 X 10^{-5}. Name the type of magnetic material it represents.

[Ans. As susceptibility is positive, so the given material is Paramagnetic **CBSE (D)-2011**

9j. How does the intensity of magnetization of a paramagnetic material vary with increasing applied magnetic field ?

[Ans. for small magnetic field, intensity of magnetization increases with magnetic field ($\mathrm{I} \propto \mathrm{B}$) **CBSE (AIC)-2006**

but at strong magnetic field, intensity of magnetization gets saturated and becomes independent of B

9k. How does the intensity of magnetization of a paramagnetic sample vary with temperature ? **BSE (AI)-2001**

[Ans. Intensity of magnetization decreases with increase in temperature $\mathrm{I} \propto \frac{1}{\mathrm{T}}$

Reason : on increasing the temperature, tendency to disrupt the alignment of atomic dipoles increases

9l. Draw the magnetic field lines distinguishing between diamagnetic and paramagnetic materials. Give a simple explanation to account for the difference in the magnetic behaviour of these materials.

[Ans. **CBSE (DC)-2017,(F)-2016,(AI)-2015,2014**

(i) Diamagnetic **(ii) Paramagnetic**

Explanation : When a diamagnetic material is placed in an external magnetic field, atoms acquire net magnetic moment opposite to field, and material acquires a slight magnetism in the opposite direction of field. Hence, magnetic field lines are repelled or expelled.

When a paramagnetic material is placed in an external magnetic field, atomic magnets align themselves along the field direction and material acquires a slight magnetism in the direction of field. Hence, magnetic field lines are attracted.

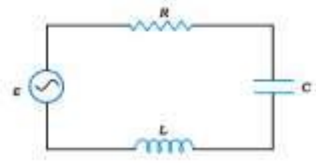
10. A series LCR circuit is connected to an a.c. source having voltage $V = V_0 \sin \omega t$. Using phasor diagram, derive expressions for impedance, instantaneous current and its phase relationship to the applied voltage. Also draw graphs of V and I versus ωt for the circuit **CBSE (AI)-2016**

[Ans. AC through LCR circuit :

We have the applied a.c. voltage

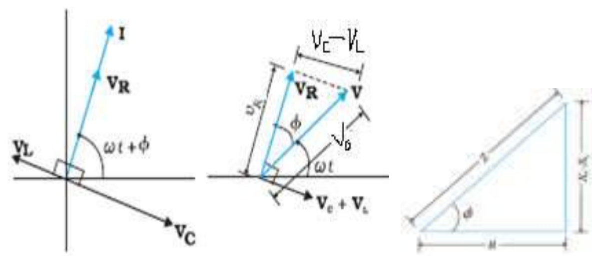
$V = V_0 \sin \omega t$ -------(1)

From phasor diagram



$\boldsymbol{V} = \sqrt{V_R^2 + (V_C - V_L)^2} = \sqrt{(IR)^2 + (IX_C - IX_L)^2} = I\sqrt{R^2 + (X_C - X_L)^2}$

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



Obviously, effective resistance of the circuit, known as impedance is given by

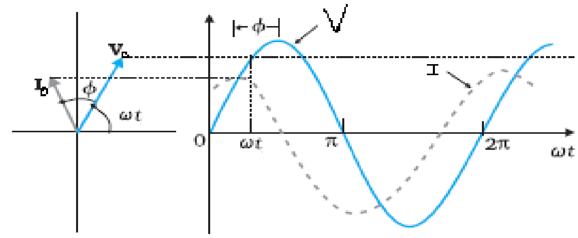
$Z = \sqrt{(R)^2 + (X_C - X_L)^2}$

Obviously, $\mathrm{I} = \mathrm{I}_0 \sin(\omega t + \phi)$ ----(2)

Where, $\tan\phi = \frac{V_C - V_L}{V_R} = \frac{I_0 X_C - I_0 X_L}{I_0 R} = \frac{X_C - X_L}{R}$

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

From (1) & (2) we conclude that current in the circuit leads the voltage in phase by ϕ.



10a. Define the term power factor. State the condition under which it is (i) maximum and (ii) minimum. **CBSE (D)-2010**

[Ans. Power factor : It is the ratio of resistance to the impedance of an a.c. circuit

i,e, $\cos\phi = R/Z$

(i) when, $Z = R$, $\cos\phi = R/Z = 1 =$ maximum

i,e, when the circuit is purely resistive, power factor is maximum

(ii) when, $R = 0$, $\cos\phi = R/Z = 0 =$ minimum

i,e, when the circuit is purely inductive or capacitive, power factor is minimum]

10b. Define the term 'Wattless current'. **CBSE (AI)-2015, (D)-2011**

[Ans. Wattless current : The current which flows in a circuit without consuming any electrical power is called Watt less current

In a purely inductive or capacitive circuit, $\cos\phi = R/Z = 0$

⇨ $\overline{P} = V_{rms} X I_{rms} X \cos 0 = 0$

10c. The power factor of an a.c. circuit is 0.5. What is the phase difference between the voltage and current in the circuit ?

[Ans. 60^0 **Reason :** $\cos\phi = 0.5$ ⇨ $\phi = 60^0$ **CBSE (AI)-2016**

10d. In a series LCR circuit, $V_L = V_C \neq V_R$. What is the value of power factor ? **CBSE (AI)-2015**

[Ans. $V_L = V_C$ ⇨ $IX_L = IX_C$ ⇨ $X_L = X_C$

⇨ $Z = \sqrt{(R)^2 + (X_C - X_L)^2} = R$ ⇨ Power factor, $\cos\phi = R/Z = 1$

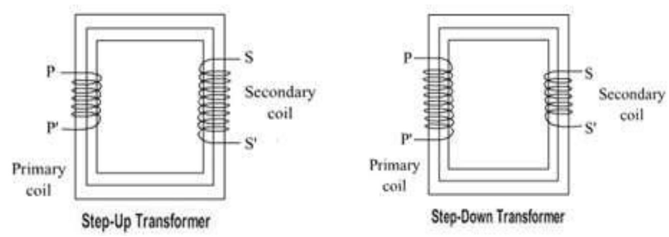
11. Draw a schematic diagram of a step up/step down transformer. Explain its working principle. Deduce the expression for the secondary to primary voltage in terms of the number of turns in the two coils. In an ideal transformer, how is this ratio related to the currents in the two coils ?

CBSE (F)-2017,2012,2009,(AI)-2015,2010,(D)-2016

[**Ans. Transformer :** It is an electrical device which, which is used to increase or decrease the voltage in a.c. circuits.

Principle : It is based on the principle of **mutual induction,** i,e, whenever there is change in magnetic flux linked with a coil, an emf is induced in the neighbouring coil

Working :



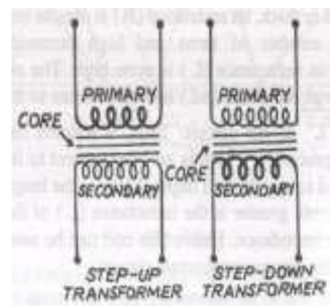
When an alternating voltage is applied to the primary, magnetic flux linked with it changes which links to the secondary and induces an emf in it due to mutual induction.

Back emf induced in Primary

$$e_p = -\,N_p \frac{d\phi}{dt}$$

Similarly, emf induced in the secondary

$$e_s = -\,N_s \frac{d\phi}{dt}$$



$$\Rightarrow \quad \frac{e_s}{e_p} = \frac{-\,N_s \frac{d\phi}{dt}}{-\,N_p \frac{d\phi}{dt}} = \frac{N_s}{N_p} \qquad \text{---------(1)}$$

As the primary has negligible resistance, $e_p = V_p$ and if secondary is in an open circuit then $e_s = V_s$, Then from (1) we have

$$\frac{e_s}{e_p} = \frac{V_s}{V_p} = \frac{N_s}{N_p} = r \qquad \text{--------(2)}$$

Where, $r = \frac{N_s}{N_p}$, is called transformation ratio

Now, if the transformer is ideal, then
power input = power output

$\Rightarrow \quad V_P \times i_p = V_s \times i_s \qquad \Rightarrow \quad \frac{i_s}{i_p} = \frac{V_p}{V_s} = \frac{N_p}{N_s} = \frac{1}{r}$ It shows that when voltage is stepped-up, the current is correspondingly reduced in the same ratio, and vice-versa .

11b. Describe briefly any two energy losses, giving the reason of their occurrence in actual transformer. How are these reduced ?

CBSE (D)-2016, (AI)-2015, 2010, (F)-2012, 2009

[**Ans. Energy losses in a transformer :**

(i) Copper loss : Energy loss as heat due to resistance of primary and secondary is called copper loss and can be minimized by using thick copper wires

(ii) Iron loss : Energy loss as heat due to eddy currents in the iron core is called Iron loss and can be reduced by using a laminated iron core

(iii) Hysteresis loss: Magnetisation of iron core is repeatedly reversed by the alternating magnetic field and energy is lost in the form of heat in the core. This is called hysteresis loss and can be minimized by using a core of a material having low hysteresis loop.

(iv) Flux leakage : There is always some flux leakage; i,e, all of the flux due to primary does not passes through the secondary. It can be minimized by winding primary and secondary coils one over the other

11c. How is the transformer used in large scale transmission and distribution of electrical energy over long distances ?

CBSE (AI)-2016,2010,2008,(AIC)-2014,(F)-2009

[**Ans.** (a) output voltage of the power generator is stepped-up so that current is reduced and as a result, line loss I^2R is also reduced

(b) It is then transmitted over long distances to an area sub-station, where voltage is stepped down.

12a. Name the following constituent radiations of electromagnetic spectrum which- **CBSE (AI)-2016,2005**
(i) are used in satellite communication/in radar and geostationary satellite **CBSE (D) -2010, 2004**
(ii) are used for studying crystal structure of solids **CBSE (AI)-2007, (F)-2012,2005**
(iii) are similar to the radiations emitted during decay of radioactive nuclei **CBSE (AI)-2005, (AIC)-2005**
(iv) used for water purification/ are absorbed from sunlight by ozone layer **CBSE (AI)-2007, (F)-2005**
[**Ans**. (i) microwaves (ii) x- rays (iii) γ- rays (iv) UV rays

==

12b. Name the following constituent radiations of electromagnetic spectrum which- **CBSE (AI)-2016,2005**
(i) has its wavelength range between 390 nm to 770 nm **CBSE (AI)-2005, (AIC)-2005**
(ii) produce intense heating effect/ used in warfare to look through fog **CBSE (AI)-2007, (F)-2005**
(iii) are used for radar systems used in aircraft navigation **CBSE (D)-2015,(F)-2012,(AI)-2007**
[**Ans**. (i) visible light (ii) Infrared rays (iii) microwaves

==

12c. Name the following constituent radiations of electromagnetic spectrum which-
(i) are adjacent to the low frequency end of electromagnetic spectrum **CBSE (F)-2010**
(ii) produced by nuclear reactions/used to destroy cancer cells/treatment of cancer **CBSE (F)-2010**
(iii) produced by bombarding a metal target by high speed electrons. **CBSE (AI)-2016, (F)-2009**
(iv) maintains the earth's warmth/ used in remote sensing **CBSE (F) -2012 ,(AI) -2007**
[**Ans**. (i) microwaves (ii) γ- rays (iii) x- rays (iv) Infrared rays

==

12d. Which constituent radiations of electromagnetic spectrum is used - **CBSE (F)-2004**
(i) in Radar
(ii) in photographs of internal parts of human body/as a diagnostic tool in medicine **CBSE (D) -2015**
(iii) for taking photographs of sky, during night and fog conditions. **CBSE (D)-2004**
(iv) has the largest penetrating power **CBSE (D) -2010, 2004**
Give reason for your answer in each case.
[**Ans**. (i) microwaves because they go straight and are not absorbed by the atmosphere
(ii) x- rays because they can penetrate light elements (flesh)
(iii) Infrared rays, because they penetrate fog and are not absorbed by the atmosphere
(iv) $\gamma - rays$ as they have the highest frequency and hence highest energy

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12e. Electromagnetic waves with wavelengths- **CBSE (Sample Paper)-2009**
(i) λ_1 are used to treat muscular strain **CBSE (D) -2015**
(ii) λ_2 are used by a F.M. radio station for broadcasting
(iii) λ_3 are used to detect fractures in bones **CBSE (D) -2015**
(iv) λ_4 are absorbed by ozone layer of the atmosphere **CBSE (D) -2010, 2004**
Identify the name and part of electromagnetic spectrum to which these radiations belong. Arrange these wavelengths in order of magnitude.
[**Ans**. (i) Infrared rays (ii) radio waves (iii) x- rays (iv) UV rays, $\lambda_2 > \lambda_1 > \lambda_4 > \lambda_3$

==

12f. Identify the electromagnetic waves whose wavelength vary as and also write one use for each. **CBSE (AI)-2017**
(i) $10^{-12}\, m < \lambda < 10^{-8}\, m$ (ii) $10^{-3}\, m < \lambda < 10^{-1}\, m$
[**Ans**. (i) X-rays/ $\gamma - rays$ used for medical purposes/ nuclear reactions (ii) Microwaves used for radar systems

12g. Identify the electromagnetic waves whose wavelength vary as and also write one use for each. **CBSE (AI)-2017**
(i) $10^{-11}\, m < \lambda < 10^{-14}\, m$ (ii) $10^{-4}\, m < \lambda < 10^{-6}\, m$
[**Ans**. (i) X-rays/ $\gamma - rays$ used for medical purposes/ nuclear reactions
(ii) Infrared/ visible used for muscular treatment/ vision

13. What is total internal reflection of light ? **CBSE (AI)-2016,2001**

[**Ans. Total internal reflection** : When a ray of light travelling from denser to a rarer medium is incident on the interface at an angle greater than the critical angle, it is totally reflected back in to the denser medium. This phenomenon is called total internal reflection of light.

13a. State the conditions for the phenomenon of total internal reflection to occur. **BSE (AI)-2016,(D)-2010**

[**Ans. Conditions for TIR** :

(i) light ray must travel from denser to a rarer medium

(ii) angle of incidence must be greater than the critical angle ($i > i_c$)

13b. Name one phenomenon which is based on total internal reflection. **CBSE (AI)-2016**

[**Ans.** Mirage/ sparkling of diamond/ optical fibre/ totally reflecting prisms

13c. Can total internal reflection occur when light goes from rarer to a denser medium ? **CBSE (D)-2007**

[**Ans.** No

13d. Define critical angle.What is the relationbetween refractive index & critical angle for a given pair of optical media ?

[**Ans. Critical angle** : The angle of incidence in the denser medium for which the angle of refraction in the rarer medium is 90^0 is called critical angle. **CBSE (AI)-2009**

Relation : $\mu = \frac{1}{\sin i_c}$

13e. When light travels from an optically denser medium to a rarer medium, why does the critical angle of incidence depend on the colour/wavelength of light ? **CBSE (AI)-2015,2009**

[**Ans.** $\mu = \frac{1}{\sin i_c}$ ⇨ $i_c = \sin^{-1}\left(\frac{1}{\mu}\right)$

As $\mu = a + \frac{b}{\lambda^2}$. Hence critical angle would also be different for different colours/wavelengths of light

13f. What is the critical angle for a material of refractive index $\sqrt{2}$? **CBSE (AI)-2010**

[**Ans.** $\sin i_c = \frac{1}{\mu} = \frac{1}{\sqrt{2}}$ ⇨ $i_c = 45^0$ 620. Velocity of light in glass is $2 \text{ X } 10^8$ m/s and in air is $3 \text{ X } 10^8$ m/s.

If the ray of light passes from glass to air, calculate the value of critical angle. **CBSE (F)-2015**

[**Ans.** $\mu = \frac{c}{v} = \frac{3\,X10^8}{2\,X10^8} = 1.5$

$\mu = \frac{1}{\sin i_c}$ ⇨ $i_c = \sin^{-1}\left(\frac{1}{\mu}\right) = \sin^{-1}\left(\frac{1}{1.5}\right) == \sin^{-1}\left(\frac{2}{3}\right) = 41.8^0$

13g. Calculate the speed of light in a medium whose critical angle is 30^0. **CBSE (AI)-2012,2010**

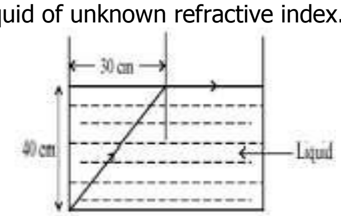
[**Ans.** $\mu = \frac{1}{\sin i_c} = \frac{1}{\sin 30} = \frac{1}{1/2} = 2$ Now, $\mu = \frac{c}{v}$ ⇨ $v = \frac{c}{\mu} = \frac{3\,X10^8}{2} = 1.5\,X10^8 \; m/s$

13h. In the following ray diagram, calculate the speed of light in the liquid of unknown refractive index. **CBSE (AIC)-2017**

[**Ans.** $\mu = \frac{c}{v} = \frac{1}{\sin i_c}$

⇨ $\frac{3 \text{ X } 10^8}{v} = \frac{1}{30/50}$

⇨ $v = \frac{30}{50} \text{ X } 3\,X10^8 = 1.8 \text{ X} 10^8 \; m/s$

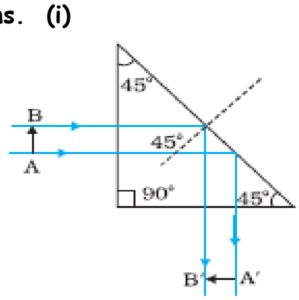


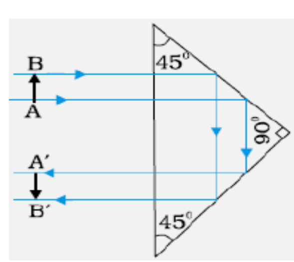
13i. Draw a ray diagram to show how a right angled isosceles prism can be used to- **CBSE (AI)-2015,(DC)-2001**

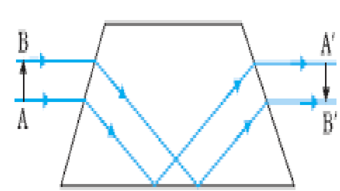
(i) deviate a light ray through (i) 90^0, (ii) deviate a light ray through 180^0/ to obtain the inverted image

(iii) to invert an image without the deviation of the rays ?

[**Ans. (i)** **(ii)** **(iii)**

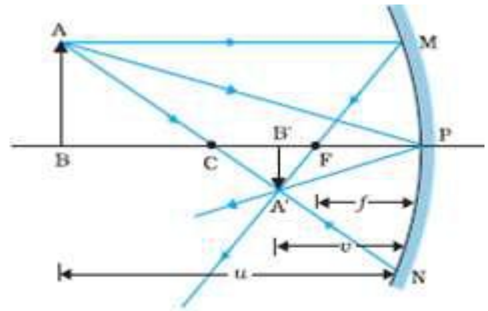






14. A concave mirror produces a real and magnified image of an object kept in front of it. Draw a ray diagram to show The image formation and use it to derive the mirror equation. **CBSE (AI)-2015**

[**Ans. Derivation of mirror formula:**



ΔABC and $\Delta A'B'C$ are similar

$\therefore \quad \frac{B'A'}{BA} = \frac{B'C}{CB} = \frac{PC-PB'}{PB-PC}$ -----------(1)

ΔABP and $\Delta A'B'P$ are also similar

$\therefore \quad \frac{B'A'}{BA} = \frac{PB'}{PB}$ ----------(2)

⇨ from equation (1) and (2)

$\frac{PC-PB'}{PB-PC} = \frac{PB'}{PB}$

⇨ $\frac{-2f-(-v)}{-u-(-2f)} = \frac{-v}{-u}$ ⇨ $\frac{v-2f}{2f-u} = \frac{v}{u}$ ⇨ $uv - 2uf = 2vf - uv$

⇨ $2uv = 2vf + 2uf$

Dividing by $2uvf$ on both sides we get, $\frac{2uv}{2uvf} = \frac{2vf}{2uvf} + \frac{2uf}{2uvf}$

⇨ $\boxed{\frac{1}{f} = \frac{1}{u} + \frac{1}{v}}$

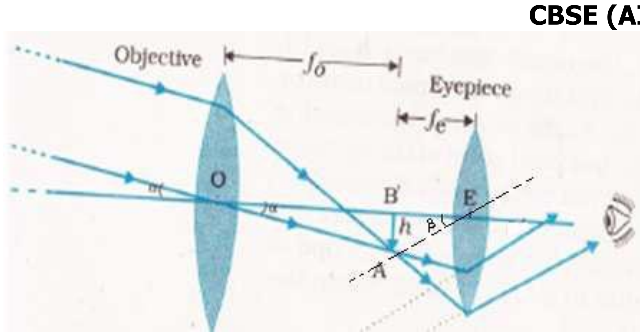
==

14a. (i) Draw a labelled ray diagram to show the image formation by an astronomical telescope in normal adjustment.

(ii) Define magnifying power of an astronomical telescope in normal adjustment (i,e, when the final image is formed at infinity).

(iii) Derive the expression for its magnifying power in normal adjustment.

[**Ans.** **CBSE (AI)-2017,2016,(F)-2016,2009**



Magnifying power : It is defined as the ratio of the angle subtended at the eye by the final image to the angle subtended at the eye by the object, when both are at infinity

$$m = \frac{\beta}{\alpha} \approx \frac{\tan\beta}{\tan\alpha} = \frac{B'A'/EB'}{B'A'/OB'} = \frac{OB'}{EB'} = \frac{f_0}{-f_e}$$

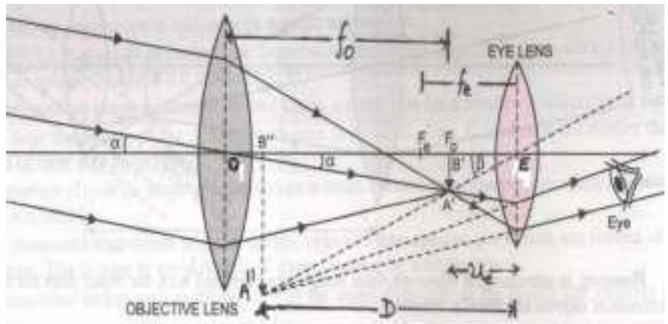
⇨ $m = -\frac{f_0}{f_e}$

==

14b. (i) Draw a labelled ray diagram of an astronomical telescope when the final image is formed at least distance of distinct vision.

(ii) Define its magnifying power and deduce the expression for the magnifying power of telescope.

[**Ans**. **CBSE (F)-2015,2014,(AI)-2013**



Magnifying power : It is defined as the ratio of the angle subtended at the eye by the image at the least distance of the distinct vision to the angle subtended at the eye by the object at infinity, when seen directly

$$m = \frac{\beta}{\alpha} = \frac{\tan\beta}{\tan\alpha} = \frac{A'B'/EB'}{A'B'/OB'} = \frac{OB'}{EB'} = -\frac{f_0}{u_e} \quad \text{-------(1)}$$

But for eye lens,

$$\frac{1}{f_e} = \frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{-D} - \frac{1}{-u_e} = \frac{1}{-D} + \frac{1}{u_e}$$

⇨ $\frac{1}{u_e} = \frac{1}{f_e} + \frac{1}{D} = \frac{1}{f_e}\left(1 + \frac{f_e}{D}\right)$

⇨ from (1), $m = -\frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right)$

14c. (i) Draw a schematic diagram of a reflecting telescope. State the advantages of reflecting telescope over refracting telescope.

(ii) What is its magnifying power ? **CBSE (AI)-2016,2015,(D)-2016,2009**

[**Ans**. **Advantages of reflecting telescope**

(i) No chromatic aberration

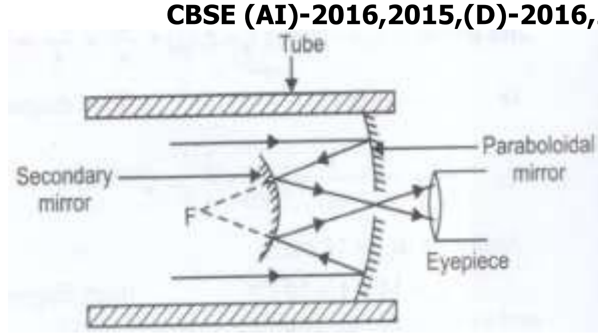
(ii) No spherical aberration

(iii) Brighter image

(iv) large magnifying power

(v) High resolving power

$$m = \frac{angle\ subtended\ at\ the\ eye\ by\ image}{angle\ subtended\ at\ the\ eye\ by\ object} = \frac{f_o}{f_e}$$



14d. You are given the following three lenses. Which two lenses will you use as an eyepiece and as an objective to construct a compound microscope ? Give reason. **CBSE (AI)-2017**

Lenses	Power (D)	Aperture (cm)
L_1	3	8
L_2	6	1
L_3	10	1

[**Ans**. **Objective lens** : Lens L_3 **Eye piece** : Lens L_2

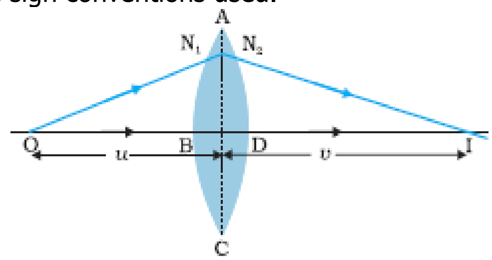
Reason : Objective of a microscope should have small aperture and smallest focal length eye piece of a microscope should have small aperture and small focal length (but longer focal length than aperture

15. Derive expression for the lens maker's formula using necessary ray diagrams. **CBSE (AI)-2016,2014,2012,2011**

$$\frac{1}{f} = (\mu_{21} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

Also state the assumptions in deriving the above relation and the sign conventions used.

[Ans. For the refraction at the interface ABC,

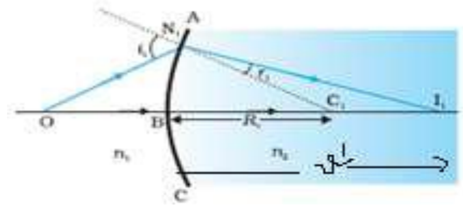


$$\frac{\mu_2}{v'} - \frac{\mu_1}{u} = \frac{(\mu_2 - \mu_1)}{R_1} \qquad \text{---------(1)}$$

For the refraction at ADC, image I_1 will act as an imaginary object and if the lens is very thin, then

$$\frac{\mu_1}{v} - \frac{\mu_2}{v'} = -\frac{(\mu_2 - \mu_1)}{R_2} \qquad \text{---------(2)}$$

on adding (1) & (2) we get

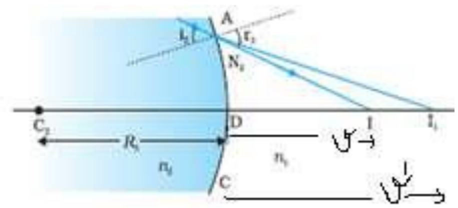


$$\frac{\mu_1}{v} - \frac{\mu_1}{u} = (\mu_2 - \mu_1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\Rightarrow \frac{1}{v} - \frac{1}{u} = \frac{(\mu_2 - \mu_1)}{\mu_1}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\Rightarrow \frac{1}{v} - \frac{1}{u} = (\mu_{21} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

But when $u = -\infty$ then $v = f$



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

$$\boxed{\frac{1}{f} = (n_{21} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)}$$

Assumptions used :

(i) lens used is very thin.
(ii) Aperture of the lens is very small
(iii) Object is a point object placed at the principal axis.
(iv) All the rays are paraxial.

New Cartesian sign conventions used :

(i) All distances are measured from the optical centre of the lens
(ii) Distances measured in the direction of incident ray are positive
(iii) Distances measured in the opposite direction of incident ray are negative.

15a. A biconvex lens made of transparent material of refractive index 1.25 is immersed in water of refractive index 1.33. Will the lens behave a converging or diverging lens ? Give reason. **CBSE (AI)-2014**

[Ans. Diverging lens.

Reason : $\frac{1}{f_m} = \left(\frac{\mu_g}{\mu_m} - 1\right)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$ As $\mu_m > \mu_g$ $\Rightarrow$ $\frac{1}{f_m} = -\text{ve}$ $\Rightarrow$ $f_m < 0$

15b. A biconvex lens made of transparent material of refractive index 1.5 is immersed in water of refractive index 1.33. Will the lens behave a converging or diverging lens ? Give reason. **CBSE (AI)-2014**

[Ans. Converging lens.

Reason : $\frac{1}{f_m} = \left(\frac{\mu_g}{\mu_m} - 1\right)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$ As $\mu_m < \mu_g$ $\Rightarrow$ $\frac{1}{f_m} = +\text{ve}$ $\Rightarrow$ $f_m > 0$

15c. A convex lens made up of glass of refractive index 1.5 is dipped, in turn, in **CBSE (AI)-2011**

(i) a medium of refractive index 1.65, (ii) a medium of refractive index 1.33

Will the lens behave a converging or diverging lens in the two cases ? Give reason.

[Ans. (i) Diverging lens.

Reason : $\frac{1}{f_m} = \left(\frac{\mu_g}{\mu_m} - 1\right)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$ As $\mu_m > \mu_g$ $\Rightarrow$ $\frac{1}{f_m} = -\text{ve}$ $\Rightarrow$ $f_m < 0$

(ii) Converging lens.

Reason : $\frac{1}{f_m} = \left(\frac{\mu_g}{\mu_m} - 1\right)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$ As $\mu_m < \mu_g$ $\Rightarrow$ $\frac{1}{f_m} = +\text{ve}$ $\Rightarrow$ $f_m > 0$

16. Define a wavefront. How is it different from a ray ? **CBSE (AI)-2017,2016,2015,2010,(D)-2013,2011**

[**Ans. Wavefront :** Continuous locus of all the particles of a medium vibrating in the same phase is called wavefront

Difference from a ray :

(i) A ray is always normal to the wavefront at each point.

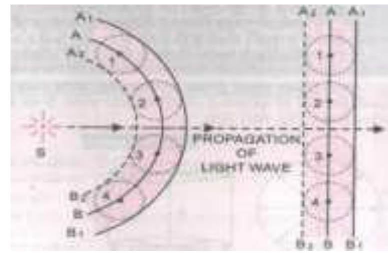
(ii) A ray gives the direction of propagation of light wave while the wavefront is the surface of constant phase

16a. State Huygen's principle. **CBSE (AI)-2016,2015,2010,2006,(D)-2013,2011,2008**

[**Ans. Huygen's Principle :**

(i) Each point on the wave front acts as a fresh source of new disturbance, called secondary wavelets, which spread out in all directions with the same velocity as that of the original wave

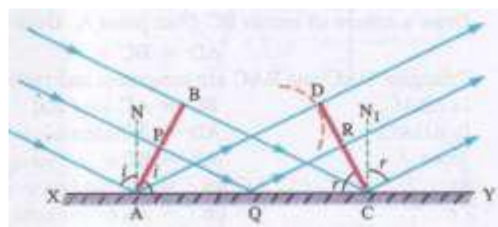
(ii) The forward envelope of these secondary wavelets drawn at any instant, gives the shape and position of new wave front at that instant



16b. Using Huygen's construction draw a figure showing the propagation of a plane wavefront reflecting at a plane surface. Show that the angle of incidence is equal to the angle of reflection. **CBSE (D)-2008,2003**

[**Ans.** **<u>Explanation of reflection on the basis of Huygen's wave theory</u>**

Let a plane wavefront AB is incident on a reflecting surface XY as shown. By the Huygens's principle, in the time disturbance reaches from B to C, secondary wavelets from A must have spread over a hemisphere of radius AD = BC = ct. Hence tangent CD be the reflected wavefront



In Δ ABC & Δ ADC,

AC = common

$\angle B = \angle D = 90^0$

AD = BC = c t

⇨ Δ ABC ≅ Δ ADC

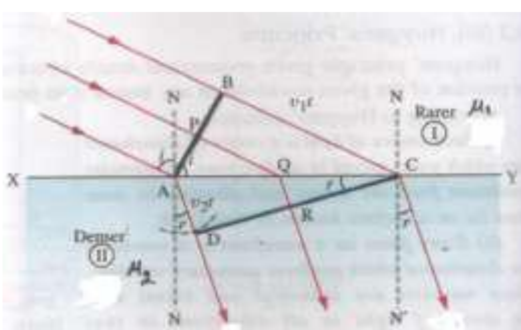
∴ $\angle i = \angle r$

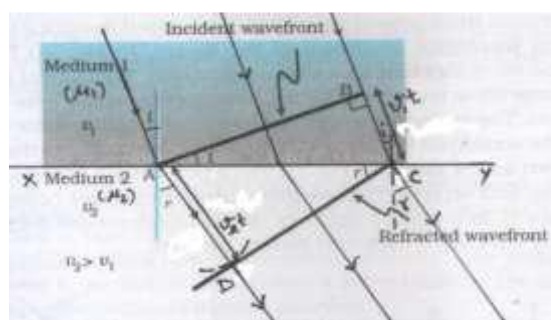
16c. Use Huygens' principle to verify the laws of refraction. **CBSE (AI)-2017**

OR

Derive Snell's law on the basis of Huygen's wave theory when light is travelling from a **rarer to a denser** medium/ **Denser to rarer** medium. **CBSE (AI)-2016,2015,2006,2002,(D)-2013,2011,2008,2005 (AIC)-2011**

[**Ans.** **<u>Explanation of refraction on the basis of Huygen's wave theory</u>**





Let a plane wavefront AB is incident on a refracting surface XY as shown. By the Huygens's principle, in the time $\left(t = \frac{BC}{v_1}\right)$ disturbance reaches from B to C, secondary wavelets from A must have spread over a hemisphere of radius $AD = v_2$t. Hence tangent CD be the refracted wavefront

Obviously, $\frac{\sin i}{\sin r} = \frac{BC/_{AC}}{AD/_{AC}} = \frac{BC}{AD} = \frac{v_1 t}{v_2 t} = \frac{v_1}{v_2}$ = constant

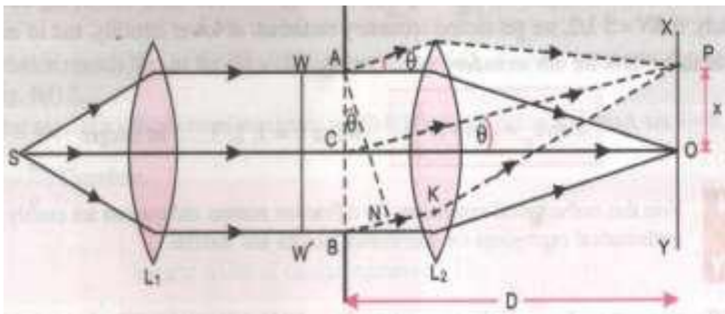
This is Snell's law of refraction.

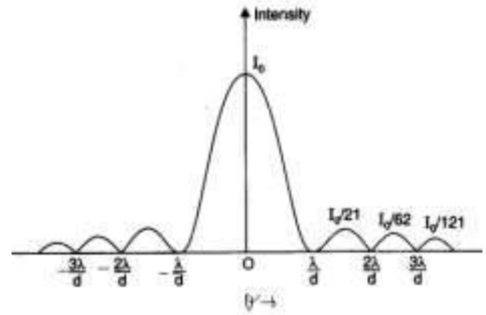
17. When a parallel beam of monochromatic source of light of wavelength λ is incident on a single slit of width a, show how the diffraction pattern is formed at the screen by the interference of the wavelets from the slit.

(i) Show that, besides the central maximum at $\theta = 0$, secondary maxima are observed at $\theta_n = \left\{n + \frac{1}{2}\right\}\lambda/a$ & minima at $\theta_n = n\lambda/a$

(ii) Show that angular width of central maximum is twice the angular width of secondary maximum and hence find the relation for linear width of central maximum. **CBSE (F)-2017,2016,2013,2012,2011,(AI)-2016,2014,(D)-2012**

[**Ans.** When a parallel beam of monochromatic light is incident on a single slit, By the Huygen's principle, secondary wavelets from each point on the slit superpose on each other and diffraction pattern is obtained on the screen.





Central maximum : Wavelets from any two corresponding points of the two halves of the slit reach the central point in the same phase to produce maxima ($\theta = 0$). The entire incident wavefront contributes to this central maxima

Positions of minima :

Path difference, $\Delta x = BN = AB\ \sin\theta = a\sin\theta$

Wavelets from upper half of the slit and the corresponding points in the lower half is received with path difference $\frac{\lambda}{2}$ at P. Thus destructive interference takes place and we get first minimum.

i,e, for first secondary minimum

$$a\sin\theta_1 = \frac{\lambda}{2} + \frac{\lambda}{2} = \lambda$$

⇨ for n^{th} secondary minimum ,

$$a\sin\theta_n = n\lambda \qquad \text{where } n = 1,2,3,\text{-------}$$

If θ is very small then for n^{th} secondary minima

$$\theta_n = n\lambda/a$$

Positions of secondary maxima :

Dividing the slit in to three equal parts, wavelets from two parts will meet with phase difference $\frac{\lambda}{2}$ each and produce destructive interference and the wavelets from third part will produce first secondary maximum

i,e, for first secondary maximum

$$a\sin\theta_1 = \frac{3\lambda}{2}$$

⇨ for n^{th} secondary maximum

$$a\sin\theta_n = \left\{n + \frac{1}{2}\right\}\lambda \qquad \text{where } n = 1,2,3,\text{-------}$$

If θ is very small then for n^{th} secondary maxima

$$\theta_n = \left\{n + \frac{1}{2}\right\}\lambda/a$$

Width of central maximum :

for the first minima, $\theta_1 = \lambda/a$

& for the second minima, $\theta_2 = 2\lambda/a$

⇨ linear width of first minimum y_1 = D $\theta_1 = D\lambda/a$

Angular width of central maximum $\theta_0 = \theta_1 - \theta_{-1} = \frac{\lambda}{a} - \left(-\frac{\lambda}{a}\right) = \frac{2\lambda}{a} = 2\theta_1$

Angular width of secondary maxima $= \theta_2 - \theta_1 = \frac{2\lambda}{a} - \frac{\lambda}{a} = \frac{\lambda}{a} = \frac{1}{2}$X Angular width of central maxima

⇨ linear width of central maxima $\boldsymbol{y_0} = D\,(2\theta_1) = \boldsymbol{2D\lambda/a}$ ⇨ $\boxed{y_0 = 2D\lambda/a}$

18. (i) Using photon picture of light, show how Einstein's photoelectric equation can be established.
(ii) Write three salient features observed in photoelectric effect which can be explained using this equation.

CBSE (AI)-2017,2013,(D)-2012

[**Ans. (i)** In the photon picture, energy of light is assumed to be in the form of photons, each carrying an energy $h\nu$
Einstein assumed that-

(a) Photoelectric emission is the result of interaction of a photon of incident radiation and a bound electron of metal surface

(b) When a photon falls on a metal surface, the energy $h\nu$ of a photon is completely absorbed by an electron and is partly used as work function and rest is carried as its kinetic energy

i,e, ,$h\nu = W + E_{K_{max}}$

⇨ $E_{K_{max}} = h\nu - W = h\nu - h\nu_0$ [$\because W = h\nu_0$]

⇨ $E_{K_{max}} = h(\nu - \nu_0)$ This is Einstein's photoelectric equation

(ii) Three salient features explained by the Einstein's photoelectric equation

(a) Existence of threshold frequency In the equation $E_{K_{max}} = h(\nu - \nu_0)$

If $\nu < \nu_0$, $E_{K_{max}}$ will be negative, which is not possible. Hence ν must be greater than ν_0.

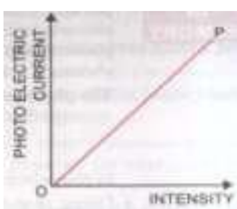
(b) The K.E. of photoelectrons is independent of intensity of incident light.

(c) The K.E. of photoelectrons increases with the frequency of incident light

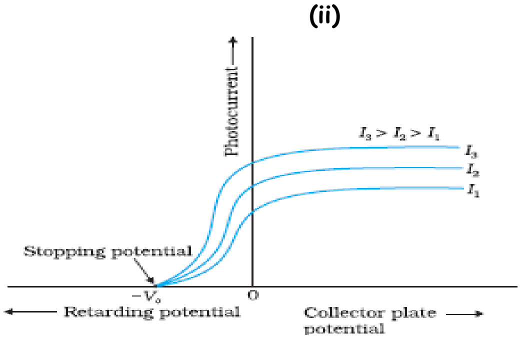
18a. (i) Plot a graph showing the variation of photoelectric current with intensity of light.
(ii) Show the variation of photocurrent with collector plate potential for different intensity but same frequency of incident radiation
(iii) Show the variation of photocurrent with collector plate potential for different frequency but same intensity of incident radiation

[**Ans.** **CBSE (F) -2016,(D)-2014,(AI)-2010,(AIC)-2011**

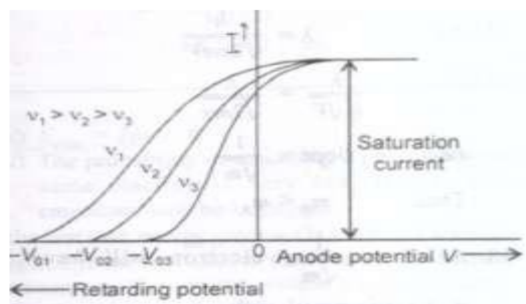
(i)



(ii)



(iii)



18b. The work function for the following metals is given : **CBSE (F)-2016**

Na : 2.75 eV and Mo : 4.175 eV

(i) Which of these will not give photoelectron emission from a radiation of wavelength 3300 A^0 from a laser beam ?
(ii) What happens if the source of laser beam is brought closer ?

[**Ans.** (i) for $\lambda = 3300\ A^0$, energy of photon, $\frac{hc}{\lambda} = \frac{6.6 X 10^{-34} X 3 X 10^8}{3300 X 10^{-10} X 1.6 X 10^{-19}} eV = 3.75\ eV < 4.175$ eV

Hence **Mo will not** give photoelectric emission as $\frac{hc}{\lambda} < W$

(ii) In case of Na, photocurrent will increase but in case of Mo no effect

18c. A proton and an $\alpha - particle$ have the same de-Broglie wavelength. Determine the ratio of-
(i) their accelerating potentials, and (ii) their speeds. **CBSE (D) -2015, (DC)-2009**

[**Ans. (i)** $\lambda = \frac{h}{\sqrt{2\,m\,qV}}$ ⇨ $V = \frac{h^2}{2mq\,\lambda^2}$ & λ = same

⇨ $\frac{V_P}{V_\alpha} = \frac{m_\alpha}{m_P} X \frac{q_\alpha}{q_P} = \frac{4\,m_P}{m_P} X \frac{2q_P}{q_P} = 8 : 1$

(ii) $\lambda = \frac{h}{m\,v}$ ⇨ $v = \frac{h}{m\,\lambda}$ ⇨ $v \propto 1/m$ ⇨ $\frac{v_P}{v_\alpha} = \frac{m_\alpha}{m_P} = \frac{4\,m_P}{m_P} = 4:1$

19. State Bohr's quantization condition for defining stationary orbits. **CBSE (D)-2016,(D)-2012,(F)-2010**

[Ans. Bohr's quantization condition : electrons can revolve only in those orbits in which their angular momentum is an integral multiple of $\frac{h}{2\pi}$

i, e, $m\,v\,r = n\frac{h}{2\pi}$ where $n = 1,2,3, -------$

These orbits are called stationary orbits and electrons do not radiate energy while revolving in these orbits

19a. State Bohr postulate of hydrogen atom that gives the relationship for the frequency of emitted photon in a transition. **OR** **CBSE (F)-2016**

State Bohr's postulate of hydrogen atom which successfully explains emission lines in the spectrum of hydrogen atom.

[Ans. Bohr's postulate of transition : **CBSE (AI)-2015, (D)-2013**

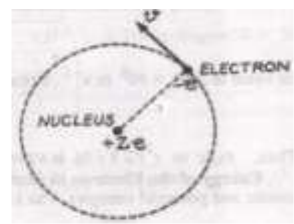
When an electron makes a transition from higher (E_2) to lower energy level (E_1), a photon is emitted which have the energy equal to the energy difference of two levels.

i, e, $h\nu = E_2 - E_1$ This equation is called Bohr's frequency condition

19b. Using Bohr's postulates, derive the expression for the total energy of the electron in the stationary states of the hydrogen atom. Hence, derive the expression for the orbital velocity and orbital period of the electron moving in the n^{th} orbit of hydrogen atom. **CBSE (F)-2017,2014,2012,2011,(AI)-2015,2014,2013,(D)-2013**

[Ans. Bohr's theory of H-atom :

As the electrostatic force of attraction between electron and nucleus provides the necessary centripetal force



i,e, $\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{(Ze)(e)}{r^2}$

⇨ $mv^2 = \frac{1}{4\pi\varepsilon_0}\frac{Z\,e^2}{r}$ ------------(1)

According to Bohr's quantum condition

$m\,v\,r = n\frac{h}{2\pi}$ -----------(2)

on squaring eqn (2) and dividing by eqn (1) we get

$\frac{m^2v^2r^2}{m\,v^2} = \frac{n^2h^2/\,4\pi^2}{\frac{1}{4\pi\varepsilon_0}\frac{Z\,e^2}{r}}$

⇨ $\boldsymbol{r = \frac{\varepsilon_0\, n^2\, h^2}{\pi\, m\, Ze^2}}$ ⇨ $\boldsymbol{r_n \propto n^2}$

For H-atom $Z = 1$ & for innermost orbit $n = 1$,

⇨ $r_0 = \frac{\varepsilon_0 h^2}{\pi\, m\, e^2}$ = 0.53 A^0. This is called **Bohr's orbit**

<u>Energy of electron in stationary orbits</u>

K.E. of electron, $E_K = \frac{1}{2}mv^2 = \frac{1}{2}\left(\frac{1}{4\pi\varepsilon_0}\frac{Z\,e^2}{r}\right)$ $\left[\because mv^2 = \frac{1}{4\pi\varepsilon_0}\frac{Z\,e^2}{r}\right]$

& P.E. $U = \frac{1}{4\pi\varepsilon_0}\frac{(Ze)(-e)}{r} = -\frac{1}{4\pi\varepsilon_0}\frac{(Z\,e^2)}{r}$

⇨ total energy of electron $E = E_K + U = \frac{1}{2}\left(\frac{1}{4\pi\varepsilon_0}\frac{Z\,e^2}{r}\right) - \frac{1}{4\pi\varepsilon_0}\frac{(Z\,e^2)}{r} = -\frac{1}{2}\frac{1}{4\pi\varepsilon_0}\frac{(Z\,e^2)}{r}$

⇨ $E_n = -\frac{1}{2}\frac{1}{4\pi\varepsilon_0}\frac{(Z\,e^2)}{\frac{\varepsilon_0\,n^2\,h^2}{\pi\,m\,Z\,e^2}} = -\frac{m\,Z^2e^4}{8\,\varepsilon_0^2\,h^2}\left(\frac{1}{n^2}\right)$

Where, $R = \frac{m\,e^4}{8\varepsilon_0^2\,ch^3}$ = 1.097 X 10^7 m^{-1} and is called Rydberg's constant.

⇨ $E_n = -\frac{m\,Z^2e^4}{8\,\varepsilon_0^2\,h^2}\left(\frac{1}{n^2}\right) \times \frac{ch}{ch} = -\frac{m\,Z^2e^4}{8\,\varepsilon_0^2\,c\,h^3}\left(\frac{ch}{n^2}\right) = -\boldsymbol{\frac{Z^2Rch}{n^2}}$

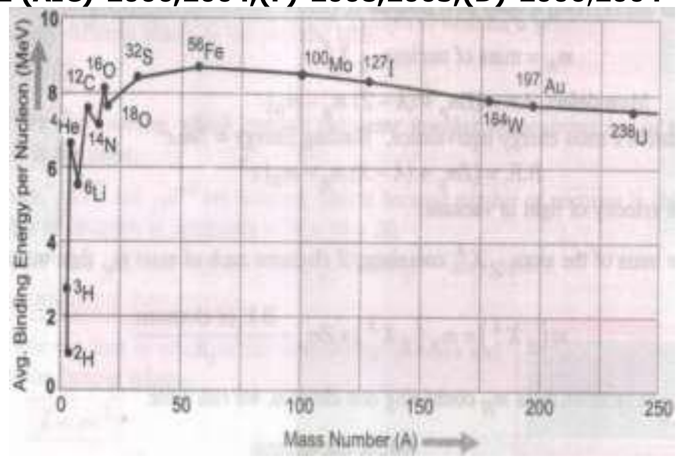
For H- atom $Z = 1$

⇨ $\boldsymbol{E_n} = -\boldsymbol{\frac{Rch}{n^2}} = -\frac{\mathbf{13.6}}{\boldsymbol{n^2}}\text{eV}$

19d. Draw a plot of binding energy per nucleon (B.E/A) as a function of mass number A.
(a) Write salient features of this curve.
(b) Write two important conclusions that can be drawn regarding the nature of nuclear force.
(c) Use this graph to explain the release of energy in both the processes of nuclear fission and fusion.

CBSE (AI)-2016,2013,2011,2009,2004,2001 (AIC)-2006,2004,(F)-2008,2005,(D)-2006,2004

[**Ans. Binding energy curve :**



(a) Salient features :

(i) BE per nucleon (E_{bn}) is practically constant (independent of A) for the nuclei of middle mass number (30 <A<170).

Maximum E_{bn} is about 8.75 MeV for $A = 56$, thus Fe^{56} is most stable.

For A = 238 E_{bn} drops to 7.6 MeV.

(ii) Average B.E. per nucleon is very small for both light nuclei $(A < 30)$ and heavy nuclei$(A > 170)$, so these nuclei are less stable.

(b) Conclusions/Importance of BE curve :

(i) Nuclear force is attractive and sufficiently strong to produce BE of a few MeV per nucleon
(ii) Constancy of BE curve in the range 30 <A <170 is a due to the fact that nuclear force is short – ranged.

(c) Release of energy in fission & fusion :

(i) When a heavy nucleus undergoes nuclear fission, the BE per nucleon of product nuclei is more than that of the original nucleus. This means that the nucleons get more tightly bound. Hence, there is release of energy.

(ii) When two very light nuclei (A ≤10) undergoes nuclear fusion, the BE per nucleon of product nucleus becomes more than that of the original lighter nuclei. This means that the nucleons in the final nucleus get more tightly bound. Hence, there is release of energy.

19e. What are nuclear forces ? State any two characteristic properties of nuclear forces.

CBSE (AIC)-2017,(AI)-2015,2012,2011,2008,2007

[**Ans. Nuclear Forces ;** Very short range strongest attractive forces, which firmly hold the nucleons together inside a nucleus, are called nuclear forces.

Properties: (i) very short range, strongest attractive forces.
(ii) charge independent.
(iii) non-central forces
(iv) do not obey inverse square law

19f. A neutron is absorbed by a $^{6}_{3}\mathrm{Li}$ nucleus with the subsequent emission of an alpha particle. Write the corresponding nuclear reaction. Calculate the energy released in this nuclear reaction. **CBSE (AI)-2006,(D)-2005**

OR

Calculate the energy released in the following nuclear reaction **CBSE (AI)-2006,2002,(D)-2005,2003**

$$^{6}_{3}\mathrm{Li} + ^{1}_{0}\mathrm{n} \longrightarrow ^{4}_{2}\mathrm{He} + ^{3}_{1}\mathrm{H} + Q$$

[**Ans.** 4.78 MeV]

[mass of $^{1}_{0}\mathrm{n}$ = 1.008665 u, mass of $^{6}_{3}\mathrm{Li}$ = 6.015126 u, mass of $^{4}_{2}\mathrm{He}$= 4.002603 u, mass of $^{3}_{1}\mathrm{H}$ = 3.016049 u]

[**Ans.** $\Delta m = [m(^{6}_{3}\mathrm{Li}) + m(^{1}_{0}\mathrm{n})$ –{$m(^{4}_{2}\mathrm{He}) + (^{3}_{1}\mathrm{H})$)]= [6.015126 + 1.008665 – {4.002603 + 3.016049}]

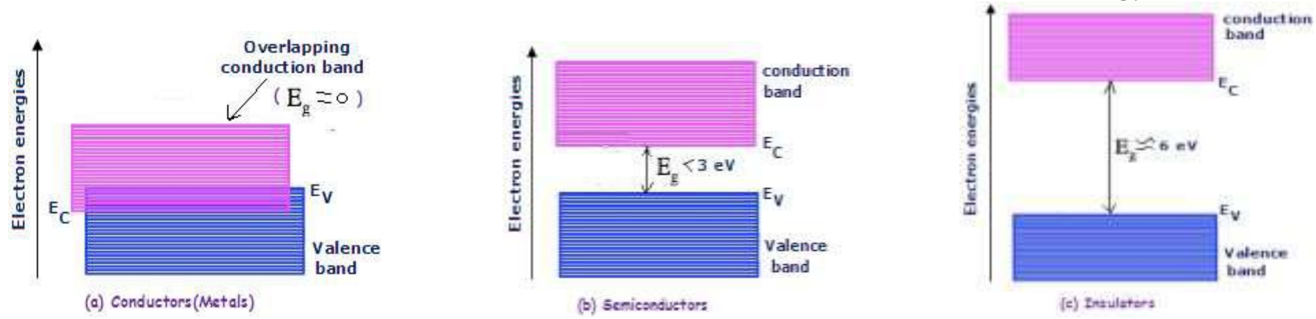
⇨ $\Delta m = 0.005138\ u$

⇨ Q = 0.005138 X 931 = 4.78 MeV

20. Distinguish between a conductor, an insulator and a semiconductor on the basis of energy band diagrams.

CBSE (AI)-2016,2008,2006,(D)-2010,2006,2005,(F)-2003

[Ans. Distinction between Conductors (metals), insulators and semiconductors on the basis of Energy bands



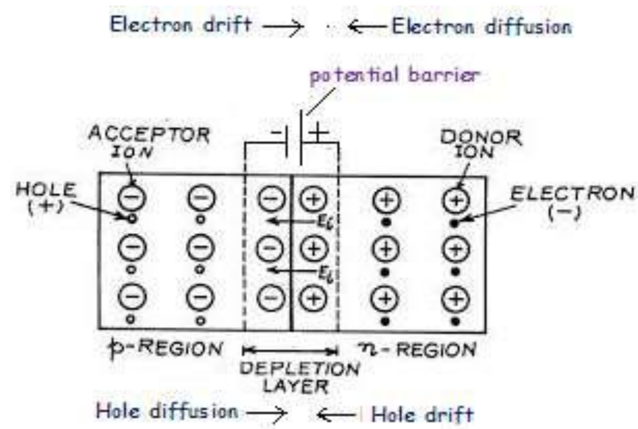
20a. What is p-n junction ? Explain briefly, with the help of suitable diagram, how a p-n junction is formed. Define the term Potential barrier and depletion region.

CBSE (D)-2017,2014,2010,2006,(AI)-2016,2015,2012,2009,2003,(F)-2015,2009,2006

[Ans. p-n junction : When a semiconductor crystal is so prepared that, it's one half is p-type and other is n-type, then the contact surface dividing the two halves, is called p-n junction

Formation of p-n junction : potential barrier & depletion region

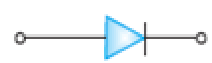
Diffusion and drift are the two important processes involved during the formation of a p-n junction



Due to different concentration gradient of the charge carriers on two sides of the junction, electrons from $n-side$ starts moving towards $p-side$ and holes start moving from $p-side$ to $n-side$. This process is called $\boldsymbol{Diffusion}$.

Due to diffusion, positive space charge region is created on the $n-side$ of the junction and negative space charge region is created on the $p-side$ of the junction. Hence an electric field called Junction field is set up from $n-side$ to $p-side$ which forces the minority charge carriers to cross the junction. This process is called **Drift**.

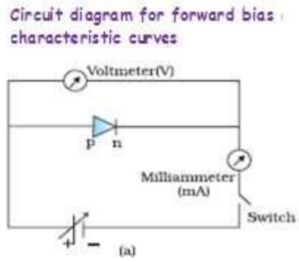
The potential difference developed across the p-n junction due to diffusion of majority charge carriers, which prevents the further movement of majority charge carriers through it, is called potential barrier. For Si, V_B = 0.7 V and for Ge, V_B =0.3 V

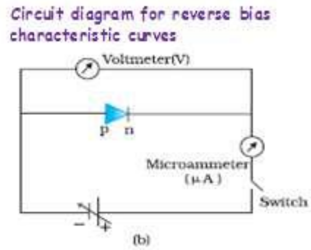


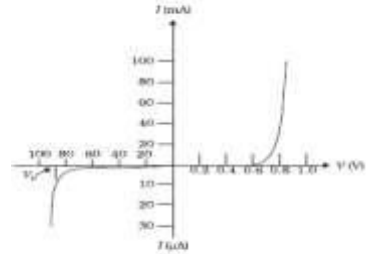
The small space charge region on either side of the p-n junction, which becomes depleted from mobile charge carriers is known as depletion region (10^{-6}m)

20b. Draw the circuit diagram for studying the V-I characteristics of a p-n junction diode in (i) forward bias and (ii) reverse bias. Draw the typical V-I characteristics of a silicon diode. **SE (AI)-2015,2014,2013,2010,2009,(D)-2014**

[Ans. V-I characteristics : A graph showing the variation of current through a p-n junction with the voltage applied across it, is called the voltage – current (V-I) characteristics of that p-n junction.







For different values of voltages, the value of the current is noted. A graph between V and **I** is obtained as in fig.

This V-I graph shows that -

(i) At a certain forward bias voltage, current increases rapidly showing the linear variation. This voltage is known as knee voltage or threshold voltage or cut-in voltage.

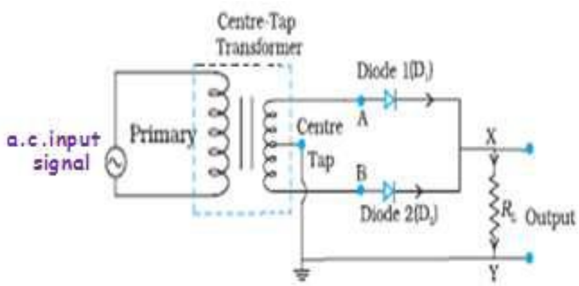
(ii) The ratio of change in forward voltage to the change in forward current is called dynamic resistance (r_d)

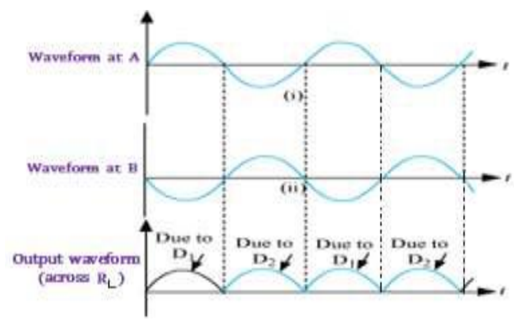
i,e, $r_d = \frac{\Delta V}{\Delta I}$ Ω

(iii) Under reverse bias, the current is very small (~μA) and remains almost constant. However, when reverse bias voltage reaches a high value, reverse current suddenly increases. This voltage is called Zener breakdown voltage

20c. Draw a labelled circuit diagram of a junction diode as a full wave rectifier. Explain its underlying principle and working. Depict the input and output wave forms. **CBSE (AI)-2017,2015,2011,2006,(D)-2012,2009,(F)-2009,2005**

[Ans. Full wave rectifier





During the positive half cycle of a.c. input signal, diode D_1 gets forward biased and conducts while D_2 being reverse biased does not conducts. Hence, there is a current in R_L due to diode D_1 and we get an output voltage.

During the negative half cycle of ac input signal, diode D_1 gets reverse biased and does not conduct while D_2 being forward biased conducts. Hence, now there is a current in R_L due to diode D_2 and again we get an output voltage.

Thus, we get output voltage for complete cycle of a.c. input signal in the same direction

20d. Which characteristic property makes the junction diode suitable for rectification ? **CBSE (AI)-2015**

[Ans. A p-n junction diode allows current to pass only when it is forward biased

20e. Frequency of an a.c. input signal is 50 Hz. What is the output frequency of a - **CBSE (AIC)-2010**

(i) Half wave rectifier (ii) Full wave rectifier

[Ans. (i) 50 Hz **(ii)** 100 Hz

20f. Determine the ac dynamic resistance of diode if current varies from 4 to 19 mA and voltage changes from 0.65 to 0.725 V?

Ans. $r_d = \frac{\Delta V}{\Delta I}$

ΔV = 0.725 – 0.65 = 0.075 V ΔI= 19 – 4 = 15 mA

$r_d = \frac{0.075}{0.015}$ = **5** Ω

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