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QUESTIONS

All Chapters Formulas

Class 12 Physics

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QUESTIONS

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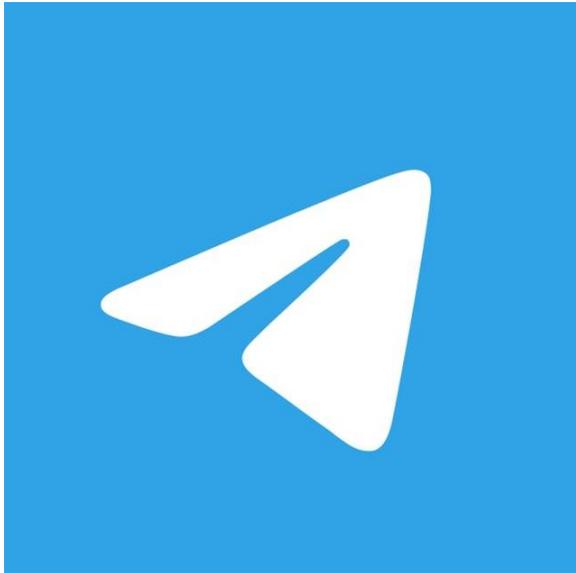
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QUESTIONS

Chap 1 Electric Charge & Field

$\Rightarrow$ Continuous charge dist.

$$\vec{F} = \frac{q_0}{4\pi\varepsilon_0} \int \frac{dq}{r^2} \cdot \hat{r}$$

$\Rightarrow$ Volume charge distribution

$$\vec{F_v} = \frac{q_0}{4\pi\varepsilon_0} \int_V \frac{\rho}{r^2} dv \, \hat{r} \qquad \boxed{\rho = \frac{dq}{dv}}$$

$$\vec{E_v} = \frac{\vec{F_v}}{q_0} = \frac{1}{4\pi\varepsilon_0} \int_V \frac{\rho}{r^2} dv \, \hat{r}$$

$\Rightarrow$ Surface charge distribution

$$\vec{F_s} = \frac{q_0}{4\pi\varepsilon_0} \int_s \frac{\sigma}{r^2} ds \, \hat{r} \qquad \boxed{\sigma = \frac{dq}{ds}}$$

$$\vec{E_s} = \frac{\vec{F_s}}{q_0} = \frac{1}{4\pi\varepsilon_0} \int_s \frac{\sigma}{r^2} ds \, \hat{r}$$

$\Rightarrow$ Line charge distribution

$$\vec{F_L} = \frac{q_0}{4\pi\varepsilon_0} \int_L \frac{\lambda}{r^2} dl \, \hat{r} \qquad \boxed{\lambda = \frac{dq}{dl}}$$

$$\vec{E_L} = \frac{\vec{F_L}}{q_0} = \frac{1}{4\pi\varepsilon_0} \int_L \frac{\lambda}{r^2} dl \, \hat{r}$$

$\Rightarrow$ Dielectric Constant (K)
(Relative permittivity)
$\searrow \varepsilon_r$

$$\varepsilon_r = K = \frac{\varepsilon}{\varepsilon_0} = \frac{F_{vac}}{F_{med}}$$

K(vacuum) = 1
K(Air) = 1.00054
K(water) = 80

$\Rightarrow$ Superposition Principle

$$\vec{F} = \frac{q}{4\pi\varepsilon_0} \sum_{\substack{all \, pt \\ charges}} q' \frac{\vec{r}-\vec{r}'}{|\vec{r}-\vec{r}'|^3}$$

$\Rightarrow$ Electric field

$$\vec{E} = \frac{\vec{F}}{q_0} \qquad \vec{E} = \lim_{q_0 \to 0} \frac{\vec{F}}{q_0}$$

$$E = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2} \quad \text{due to Point} \leftarrow \text{charge}$$

$\Rightarrow$ charge on $e = 1.6 \times 10^{-19} C$

$$\Rightarrow \boxed{m = \frac{m_0}{\sqrt{1 - v^2/c^2}}}$$

$m_0 = $ rest mass

$\Rightarrow$ Quantisation cond^n of charge

$$\boxed{Q = ne}$$

$\Rightarrow$ Coulomb's law

$$\boxed{\vec{F_{21}} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \hat{r}_{12}} \leftarrow \begin{matrix} \text{Vector} \\ \text{Form} \end{matrix}$$

$$\boxed{F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}} \leftarrow \begin{matrix} \text{Scalar} \\ \text{Form} \end{matrix}$$

$$\# \, K = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \, Nm^2 c^{-2}$$

$\Rightarrow \varepsilon_0 = $ permittivity of free space

$$\boxed{\varepsilon_0 = 8.85 \times 10^{-12} \, c^2 N^{-1} m^{-2}}$$

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Chap 1 Electric Charge & Field

QUESTIONS

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

$\hat{n}$ = unit vector normal to plane going away.

$$E = \frac{\sigma}{2\varepsilon_0} \quad \text{free from } r.$$

$\Rightarrow$ E.F. (thin spherical shell)

① outside $(r > R)$

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

② on the surface $(r = R)$

$$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{R^2}$$

③ Inside $(r < R)$

$$E = 0$$

E_{max} $E \propto \frac{1}{r^2}$
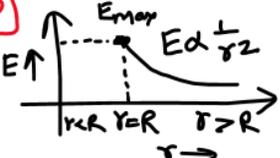
$\Rightarrow$ E.F. Equatorial Pt. (Dipole)

$$\vec{E}_{eq} = -\frac{1}{4\pi\varepsilon_0}\frac{p}{(r^2+a^2)^{3/2}}\hat{p}$$

if $r >> a$

$$\vec{E}_{eq} = -\frac{1}{4\pi\varepsilon_0}\frac{p}{r^3}\hat{p}$$

$\Rightarrow$ Torque on Dipole

$$\vec{\tau} = \vec{p} \times \vec{E} \quad \text{rector form}$$

$$\tau = pE\sin\theta \quad \text{only mag.}$$

$\Rightarrow$ Electric Flux

(It is a Scalar Q\text{ty})

$$\Delta\phi_E = \vec{E}\cdot\Delta\vec{S}$$

$$\phi_E = \oint_S \vec{E}\cdot d\vec{S}$$

$\Rightarrow$ Gauss's Theorem

$$\phi_E = \oint_S \vec{E}\cdot d\vec{S} = \frac{q_{in}}{\varepsilon}$$

$\Rightarrow$ Electric field due to long thin wire

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

λ = Uniform Linear charge density

$\Rightarrow$ Electric field due to Ring on the axis of Ring
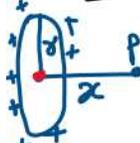
$$E = \frac{1}{4\pi\varepsilon_0}\frac{qx}{(x^2+r^2)^{3/2}}$$

$\Rightarrow$ Electric Dipole moment

$$\vec{p} = q\times 2\vec{l}$$

from (direction) $-q \to +q$

$\Rightarrow$ E.F. Axial Pt. (Dipole)

$$\vec{E}_{axial} = \frac{1}{4\pi\varepsilon_0}\frac{2pr}{(r^2-a^2)^2}\hat{p}$$

for $r >> a$

$$\vec{E}_{axial} = \frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}\hat{p}$$

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Chap 2: Electrostatic Potential & Capacitance

$$\# \boxed{V_{BA} = V_B - V_A = -\int_A^B \vec{E} \cdot d\vec{r}}$$

$$d\vec{r} = dz\,\hat{i} + dy\,\hat{j} + dz\,\hat{k}$$

⇒ **Capacitance (Spherical Cond.)**

$$\boxed{C = 4\pi\varepsilon_0 R}$$

⇒ **P.E. (Two point charges)**

$$\boxed{U = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}}$$

\# q_1 & q_2 with sign

⇒ **V at P along the axis (Ring)**

$$\boxed{V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{\sqrt{R^2 + r^2}}}$$

\# at centre O, $\boxed{V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R}}$

⇒ **P.E. (Three point charges)**
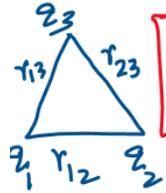
$$\boxed{U = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1 q_2}{r_{12}} + \frac{q_2 q_3}{r_{23}} + \frac{q_1 q_3}{r_{13}}\right]}$$

⇒ **P.E. of a Dipole**

$$\boxed{U = pE(\cos\theta_1 - \cos\theta_2)}$$

$$\boxed{U = -pE\cos\theta = -\vec{p}\cdot\vec{E}}$$

→ if initially $\theta_1 = 90°$
→ considered $U_{\theta=90°} = 0$

CAPACITORS

⇒ **Capacitance**

⇒ **Dipole Potential (General Pt.)**
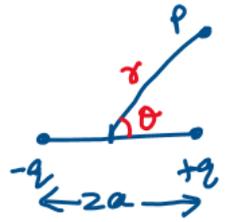
$$\boxed{V = \frac{1}{4\pi\varepsilon_0}\frac{p\cos\theta}{r^2}}$$

⇒ **Potential due to uniformly charged thin spherical Shell**

① $r > R$ (outside)

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

② $r = R$ (on the surface)

$$\boxed{V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}}$$

③ $r < R$ (Inside)

$$\boxed{V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}}$$

$V \propto \frac{1}{r}$ (for $r > R$)
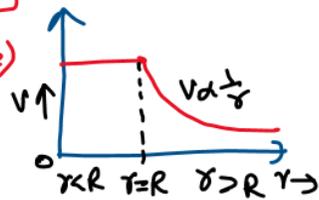
⇒ **Relation b/w E.F. & Potential**

$$\boxed{\vec{E} = -\left[\frac{\partial V}{\partial x}\hat{i} + \frac{\partial V}{\partial y}\hat{j} + \frac{\partial V}{\partial z}\hat{k}\right]}$$

$$\vec{E} = E_x\hat{i} + E_y\hat{j} + E_z\hat{k}$$

$\boxed{E = -\frac{dV}{dr}}$ —ve sign shows V decreases in the direction of

⇒ **Potential difference**

Source charge $+q$ ← Test charge $+q_0$

$$\boxed{V = V_B - V_A = \frac{W_{AB}}{q_0}}$$

⇒ **Potential due to Point charge**

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

⇒ **Dipole Potential (Axial Point)**

$$\boxed{V_{ap} = \frac{1}{4\pi\varepsilon_0}\frac{p}{(r^2 - a^2)}}$$

for short dipole $r^2 \gg a^2$

$$\boxed{V_{ap} = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}}$$

⇒ **Dipole Potential (equatorial)**

$$\boxed{V_{eq} = 0}$$

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Chap 2: Electrostatic Potential & Capacitance

QUESTIONS

⇒ Electric Susceptibility (χ)

$$\chi = \frac{\vec{P}}{\varepsilon_0 \vec{E}}$$

$\vec{P}$ = Polarisation
$\vec{E}$ = Resultant field

⇒ Relation b/w K & χ

$$K = 1 + \chi$$

K = dielectric Constant

⇒ Capacitance with partially filled dielectric

$$C = \frac{\varepsilon_0 A}{d - t + t/K}$$

⇒ Capacitance with Conducting Slab

$$C = \frac{d}{(d-t)} C_0$$

C_0 = without Slab

Conducting slab K = ∞

⇒ Redistribution of charges

C_1 C_2
(A) ᴖᴖᴖ (B)
Q_1, V_1 Q_2, V_2

↙ Common Potential

$$V = \frac{Q_1 + Q_2}{C_1 + C_2} = \frac{C_1 V_1 + C_2 V_2}{C_1 + C_2}$$

after redistribution charges Q_1' & Q_2'

$$\frac{Q_1'}{Q_2'} = \frac{C_1}{C_2}$$

⇒ Loss of energy (in Redistribution)

$$\Delta U = \frac{1}{2} \frac{C_1 C_2 (V_1 - V_2)^2}{(C_1 + C_2)}$$

⇒ In dielectric

$$K = \varepsilon_r = \frac{\vec{E_0}}{\vec{E}} = \frac{\vec{E_0}}{\vec{E_0} - \vec{E_p}}$$

⇒ Polarisation density (P)

$$P = \frac{\text{dipole moment of dielectric}}{\text{Volume}} = \sigma_p$$

Here $$\sigma_p = \frac{Q_p}{A}$$

⇒ Parallel plate Capacitor

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

⇒ Capacitors in Series

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_n}$$

⇒ Capacitors in Parallel

$$C_p = C_1 + C_2 + \cdots + C_n$$

⇒ Energy Stored in Capacitor

$$U = \frac{1}{2} C V^2 = \frac{1}{2} \frac{Q^2}{C} = \frac{1}{2} Q V$$

⇒ Energy Stored in Series & Parallel Combination is same

$$U = U_1 + U_2 + \cdots + U_n$$

⇒ Energy density of an E.F.

Total Energy = $U = \frac{1}{2} \varepsilon_0 E^2 A d$

Energy density = $u = \frac{U}{Ad} = \frac{1}{2} \varepsilon_0 E^2$

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Chap 2. Electrostatic Potential & Capacitance

QUESTIONS

$\Rightarrow$ **Effect of dielectric**

Battery disconnected	Battery kept connected
① $Q = Q_0$	$Q = KQ_0$
② $V = V_0/K$	$V = V_0$
③ $E = E_0/K$	$E = E_0$
④ $C = KC_0$	$C = KC_0$
⑤ $U = U_0/K$	$U = KU_0$

$\Rightarrow$ **Compound dielectric (series)**

$t_1 \, t_2 \, t_3$

A ——————— B
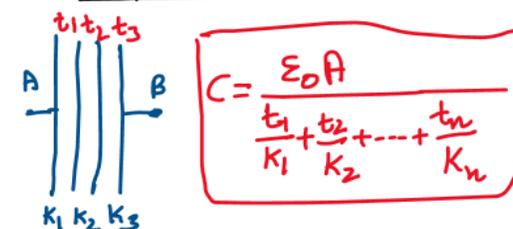
$K_1 \, K_2 \, K_3$

$$C = \dfrac{\varepsilon_0 A}{\dfrac{t_1}{K_1} + \dfrac{t_2}{K_2} + \cdots + \dfrac{t_n}{K_n}}$$

$\Rightarrow$ **Compound (Parallel)**

K_1	A_1
K_2	A_2
K_n	A_n

A — — B
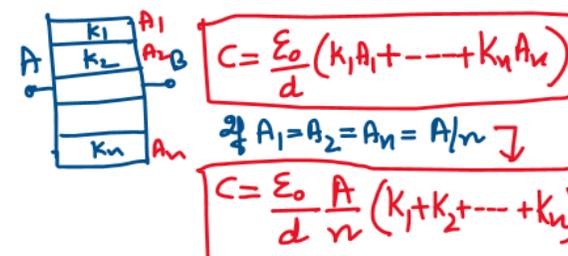
$$C = \dfrac{\varepsilon_0}{d}(K_1 A_1 + \cdots + K_n A_n)$$

if $A_1 = A_2 = A_n = A/n$

$$C = \dfrac{\varepsilon_0}{d} \dfrac{A}{n}(K_1 + K_2 + \cdots + K_n)$$

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Chap 3: Current Electricity

QUESTIONS

$\Rightarrow$ Resistivity

$$\rho = \frac{m}{ne^2\tau}$$

$\Rightarrow$ Resistance in Series

$$R = R_1 + R_2 + R_3 + \cdots + R_n$$

$\Rightarrow$ Resistance in Parallel

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$$

$\Rightarrow$ **CELL** $\Leftarrow$

$\Rightarrow$ Discharging of cell

$$V = \varepsilon - Ir$$

$$r = \frac{\varepsilon - V}{I} = \frac{\varepsilon - V}{V/R} = \left(\frac{\varepsilon - V}{V}\right)R$$

$\Rightarrow$ Relation b/w $\vec{j}, \sigma \& \vec{E}$

$$\vec{j} = \sigma\vec{E} \quad \text{OR} \quad \vec{E} = \rho\vec{j}$$

$\Rightarrow$ Mobility of charge Carriers

$$\mu = \frac{v_d}{E}$$

$\Rightarrow$ Relation b/w $I \& \mu$

$$I = neA\mu_e E$$

$\Rightarrow$ Temp. dependence of Resistivity

$$\rho = \rho_0 [1 + \alpha(T - T_0)]$$

$$\alpha = \frac{\rho - \rho_0}{\rho_0(T - T_0)} = \frac{1}{\rho_0}\frac{d\rho}{dT}$$

$$R_t = R_0(1 + \alpha \Delta t)$$

$\Rightarrow$ Conductivity

$$\sigma = \frac{1}{\rho}$$

SI unit
$ohm^{-1}m^{-1}$ or $mho\,m^{-1}$
or Sm^{-1}

$\Rightarrow$ Vector form of OHM's LAW

$$\vec{E} = \rho\vec{j} \quad \text{OR} \quad \vec{j} = \sigma\vec{E}$$

$\Rightarrow$ Drift velocity

$$\vec{v_d} = -\frac{\vec{E}}{m}q\tau$$

$\Rightarrow$ Relation b/w $I \& v_d$

$$I = neAv_d \quad \vec{j} = ne\vec{v_d}$$

$n =$ no. of e^- per unit Volume

$\Rightarrow$ Deduction of OHM's LAW

$$R = \frac{m\ell}{ne^2\tau A}$$

$\Rightarrow$ Electric Current

$$I_{av} = \frac{Q}{t} \quad I_{inst.} = \frac{dQ}{dt}$$

$\Rightarrow$ OHM's LAW

$$V = IR$$

$\Rightarrow$ Resistivity (ρ)

$$R = \rho\frac{\ell}{A}$$

$\Rightarrow$ Current density

$$\vec{j} = \frac{I}{A} \quad I = \vec{j} \cdot \vec{A}$$

$j =$ vector qty
dir $\Rightarrow$ motion of +ve charge

$\Rightarrow$ Conductance

$$G = \frac{1}{R}$$

SI unit
ohm^{-1} or mho or
Siemens (S)

QUESTIONS

Chap 3: Current Electricity

⇒ Power in Parallel Comb.

$$P = P_1 + P_2 + P_3$$

⇒ Efficiency of a Source of emf

$$\eta = \frac{\text{output Power}}{\text{Input Power}} = \frac{R}{R+r}$$

⇒ Max Power theorem

max output power of a source of emf

$$P_{max} = \frac{\varepsilon^2}{4r} \qquad \text{when } R = r$$
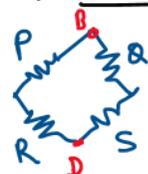
⇒ Kirchhoff's LAWS

① 1st Law/Junction Rule (KCL)

$$\Sigma I = 0$$

② 2nd Law/Loop Rule (KVL)

$$\Sigma \Delta V = 0$$

⇒ Wheatstone Bridge

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

Balanced W.B

⇒ Cond^n max I (Parallel Comb)

$$I = \frac{\varepsilon}{R + r/m} = \frac{m\varepsilon}{mR + r}$$

$$I_{max} = \frac{m\varepsilon}{r} \qquad \text{when } R << r/m$$

⇒ Mixed grouping of cells

$$I = \frac{mn\varepsilon}{mR + nr} \qquad \begin{array}{l} n \text{ cells in Series} \\ m \text{ rows} \end{array}$$

I at … when … $R = \frac{nr}{m}$

⇒ Electric Power

$$P = \frac{W}{t} = VI = I^2 R = \frac{V^2}{R}$$

⇒ Electrical Energy

$$W = P \cdot t = VIt = I^2 Rt$$

$$1 \, Kwh = 3.6 \times 10^6 \, J$$

⇒ Power in Series Comb.

$$\frac{1}{P} = \frac{1}{P_1} + \frac{1}{P_2} + \frac{1}{P_3}$$

⇒ charging of a cell

$$V = \varepsilon + Ir$$

⇒ Cells in Series

$$\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2 \qquad r_{eq} = r_1 + r_2$$

⇒ Cells in Parallel

For 2 cells ←

$$\varepsilon_{eq} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2} \qquad r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$$

⇒ n cells in Parallel

$$\frac{\varepsilon_{eq}}{r_{eq}} = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2} + \cdots + \frac{\varepsilon_n}{r_n}$$

$$\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2} + \cdots + \frac{1}{r_n}$$

⇒ Cond^n max I (Series Comb.)

$$I = \frac{n\varepsilon}{R + nr}$$

$$I_{max} = \frac{n\varepsilon}{R} \qquad \text{when } R >> nr$$

Chap 4: Moving Charges & Magnetism

QUESTIONS

→ **Force on a moving charge**

$$\vec{F} = q(\vec{v} \times \vec{B})$$

$F = qvB \sin\theta$

(i) if $v = 0$, $F = 0$

(ii) if $\theta = 0°$ or $180°$, $F = 0$

(iii) if $\theta = 90°$, $F_{max} = qvB$

→ **Force on C.C. Conductor in a mag. field.**

$$\vec{F} = I(\vec{l} \times \vec{B})$$

$$F = IlB\sin\theta$$

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{net}$$

Simplified form when $d\vec{l} \parallel d\vec{B}$ & dB constant along dl

$$BL = \mu_0 I_{net}$$

→ **B due to solenoid (Near about Axis)**

$$B = \mu_0 n I \qquad n = \frac{N}{l}$$
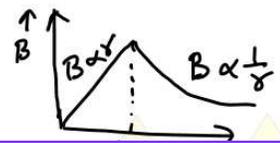
$\vec{B}$ at one end

$$B = \frac{1}{2}\mu_0 n I$$

→ **B due to C.C. thin wire Inside/outside**

long wire

① $r > R$ (outside)

$$B = \frac{\mu_0}{2\pi}\frac{I}{r}, \quad B \propto \frac{1}{r}$$

② $r = R$ (Surface)

$$B = \frac{\mu_0}{2\pi}\frac{I}{R}$$

③ $r < R$ (Inside)

$$B = \frac{\mu_0}{2\pi}\frac{I}{R^2} \times r, \quad B \propto r$$

$B \propto r$ \qquad $B \propto \frac{1}{r}$

→ **Mag. field (Infinite wire) at one end**

$$B = \frac{\mu_0}{4\pi}\frac{I}{r}$$

→ **B at centre of C.C. loop**

$$B = \frac{\mu_0}{2}\frac{I}{r}$$

→ B on $\vec{l}$ x axis of loop

$$B = \frac{\mu_0 I r^2}{2(r^2 + z^2)^{3/2}}$$

P far away $(z >> r)$

$$B = \frac{\mu_0}{2}\frac{I r^2}{z^3}$$

→ **B at Centre, circular Segment (arc l)**

$$B_0 = \frac{\mu_0}{4\pi}\frac{I}{r^2}l$$

$$B_0 = \frac{\mu_0}{4\pi}\frac{I}{r} \times \theta$$

→ **Bio-Savart's Law**

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\, d\vec{l} \times \vec{r}}{r^3}$$

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

Where $\frac{\mu_0}{4\pi} = 10^{-7}\, T\, A^{-1}\, m$

→ **Relation b/w μ_0, ε_0 & c**

$$C = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} \Rightarrow \mu_0 \varepsilon_0 = \frac{1}{c^2}$$

→ **Mag. field due to a finite C.C. wire**

$$B = \frac{\mu_0}{4\pi}\frac{I}{r}\left[\sin\phi_1 + \sin\phi_2\right]$$

→ **Mag. field due to Infinite C.C. wire (apprx in the middle)**

$$B = \frac{\mu_0}{2\pi}\frac{I}{r}$$

Chap 4: Moving Charges & Magnetism

→ Galvanometer → Voltmeter

R (High) in series

$$R = \frac{V}{I_g} - G$$

$$R_V = R + G$$

R_V = Resistance of Voltmeter

→ Current sensitivity

$$I_S = \frac{\alpha}{I} = \frac{NBA}{K}$$

→ Voltage Sensitivity

$$V_S = \frac{\alpha}{V} = \frac{\alpha}{IR} = \frac{NBA}{KR}$$

$$V_S = \frac{I_S}{R} \quad \#$$

Vol. Sens = $\dfrac{\text{current sensitivity}}{R}$

Galvanometer → Ammeter

$$S = \frac{I_g}{I - I_g} \times G$$

$$I_g = \frac{S}{G+S} \times I$$

$$R_A = \frac{GS}{G+S} < S$$

S in Parallel

R_A = Resistance of Ammeter

S = Shunt Resistance

G = Galvanom. Resistance

I_g = Full Scale deflection current

I = desired current Range.

→ force b/w two parallel C.C. Conductors

$$f = \frac{F}{l} = \frac{\mu_0}{2\pi} \frac{I_1 I_2}{\gamma}$$

Same dir. Current
ATTRACTION

$$f = \frac{F}{l} = \frac{\mu_0}{2\pi} \frac{I_1 I_2}{\gamma}$$
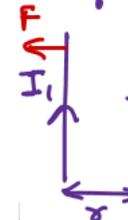
Opposite dir current REPULSION

→ Torque on C.C. loop in $\vec{B}$

$$\vec{\tau} = \vec{m} \times \vec{B}$$

$$\tau = NIABsin\theta$$

$$m = NIA$$

θ is b/w $\vec{m}$ & $\vec{B}$

GALVANOMETER

$$\alpha = \frac{NBA}{K} I \qquad \alpha \propto I$$

α = deflecting angle
K = Torsion constant of Spring
A = Area of Coil

$$G = \frac{I}{\alpha} = \frac{K}{NBA}$$

G = Galvanometer constant
G = figure of merit also

Chap 5. Magnetism & Matter

QUESTIONS

$$\vec{m} = I\vec{A} = IA\hat{n}$$

If coil has N turns

$$\vec{m} = NI\vec{A}$$

$\Rightarrow$ Gauss's law in Magnetism

$$\oint \vec{B} \cdot d\vec{s} = 0 \Rightarrow \text{Monopoles do not exist}$$

$\Rightarrow$ Magnetising field

$$B_o = \mu_0 nI \quad \text{for solenoid}$$

$\Rightarrow$ Magnetic Induction

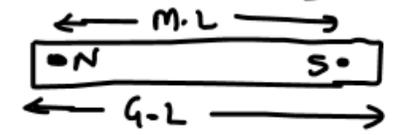$$B_M = \mu_0 n I_M \quad I_m = \text{Magnetisation Surface Current}$$

$$B_m = \mu_0 M$$

$\Rightarrow \vec{B}$ (equatorial point) Bar Magnet

$$B_{eq} = \frac{\mu_0}{4\pi} \frac{m}{(r^2 + l^2)^{3/2}}$$

For short dipole, $l \ll r$

$$\vec{B}_{eq} = -\frac{\mu_0}{4\pi} \frac{\vec{m}}{r^3} \quad \text{equatorial Point.}$$

$\Rightarrow$ Torque on mag. Dipole

$$\vec{\tau} = \vec{m} \times \vec{B}$$

$$\tau = mB\sin\theta$$

$\Rightarrow$ P.E. of magnetic Dipole

$$U = mB(\cos\theta_1 - \cos\theta_2)$$

$$U = 0 \text{ at } \vec{m} \perp \vec{B}$$

$$U = -\vec{m} \cdot \vec{B}$$

$$\frac{\text{Magnetic length}}{\text{Geometrical length}} = 0.84$$

$\Rightarrow$ Coulomb's law of mag. force

$$F = \frac{\mu_0}{4\pi} \frac{q_{M_1} q_{M_2}}{r^2}$$

$\Rightarrow$ Magnetic Dipole moment

$$\vec{m} = q_m \times 2\vec{l}$$

q_m Vector qty $S \rightarrow N$

$\Rightarrow \vec{B}$ (Axial Point) Bar Magnet

$$B_{axi} = \frac{\mu_0}{4\pi} \frac{2mr}{(r^2 - l^2)^2}$$

For short magnet $L \ll r$

$$B_{axi} = \frac{\mu_0}{4\pi} \frac{2\vec{m}}{r^3} \quad \text{Axial Point}$$

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Chap 5: Magnetism & Matter

⇒ Modified Curie's Law
(Curie-Weiss Law) (for
Ferromagnetic
Substances)

$$\chi_m = \frac{c'}{T - T_c}$$

T_c = Curie Temp or Curie Point
↳ above this temp Ferro. becomes Para.

⇒ Important Table

Diamagnetic	Paramagnetic	Ferromagnetic
$-1 \leq \chi < 0$	$0 < \chi < \varepsilon$	$\chi \gg 1$
$0 \leq \mu_r < 1$	$1 < \mu_r < 1 + \varepsilon$	$\mu_r \gg 1$
$\mu < \mu_0$	$\mu > \mu_0$	$\mu \gg \mu_0$

⇒ Relative permeability

$$\mu_r = \frac{\mu}{\mu_0}$$

⇒ Magnetic Susceptibility (χ_m)
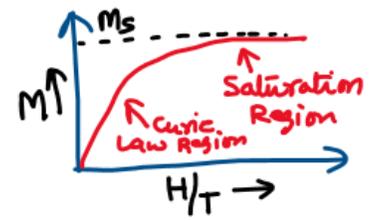
$$\chi_m = \frac{M}{H}$$

⇒ Relation b/w μ_r & χ_m

$$\mu_r = 1 + \chi_m$$

⇒ Curie's Law (for Paramagnetic)

$$\chi_m = \frac{C}{T}$$

$$\chi_m = \frac{M}{H} = \frac{C}{T}$$

M_s

M↑ Saturation Region
Curie Law Region
$H/T \rightarrow$

T = absolute Temp.
C = Curie Constant

⇒ Magnetising field Intensity

$$H = nI \quad nI = \text{no. of ampere-turns}$$

$$B_0 = \mu_0 nI = \mu_0 H \Rightarrow H = \frac{B_0}{\mu_0}$$

⇒ Intensity of magnetisation

$$\vec{M} = \frac{\vec{m}}{V} \quad \vec{m} = \text{mag. moment per unit Volume}$$

If Interior of Solenoid is filled with material with non-zero magnetisation

Net field in Solenoid $B = B_0 + B_M = \mu_0 H + \mu_0 M$

$$B = \mu_0(H + M) \Rightarrow H = \frac{B}{\mu_0} - M$$

⇒ Magnetic permeability

$$\mu = \frac{B}{H}$$

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Chap 6: Electromagnetic Induction

⇒ **emf in rotating Rod**

$$c = \frac{1}{2} B L^2 \omega$$

⇒ **Current Induced in the loop**

$$I = \frac{e}{R} = \frac{Bl v}{R}$$

⇒ **Magnetic flux**

$$\phi = \vec{B} \cdot \vec{A} \qquad \phi = \int_A \vec{B} \cdot d\vec{A}$$

Scalar qty
SI unit → weber (Wb)
CGS unit → maxwell (Mx)

$$1 Wb = 10^8 \text{ maxwell}$$

⇒ **Coil rotating in Uniform $\vec{B}$**

$$e = NBA\omega \sin \omega t$$

$$e = e_0 \sin \omega t$$

where $e_0 = NBA\omega$

⇒ **Force on movable arm PQ**

$$F = \frac{B^2 l^2 v}{R}$$

⇒ **Powered delivered by the external force**

$$P = Fv = \frac{B^2 l^2 v^2}{R}$$

⇒ **Relation b/w Induced charge & change in mag. flux**

$$\Delta q = \frac{\Delta \phi}{R}$$

⇒ **Faraday's Law**

$$e = -N \frac{d\phi}{dt} \qquad e = -\frac{N(\phi_2 - \phi_1)}{t}$$
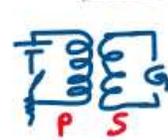
⇒ **Motional emf**

$$e = Bl v$$

QUESTIONS

Chap 6: Electromagnetic Induction

⇒ **Mutual Induction**

$$\phi = MI$$

M = Coeff. of mutual Inductance or mutual Inductance

$$e = -M \frac{dI}{dt}$$

⇒ **Mutual Inductance of two long solenoids**

$A = \pi r_1^2$
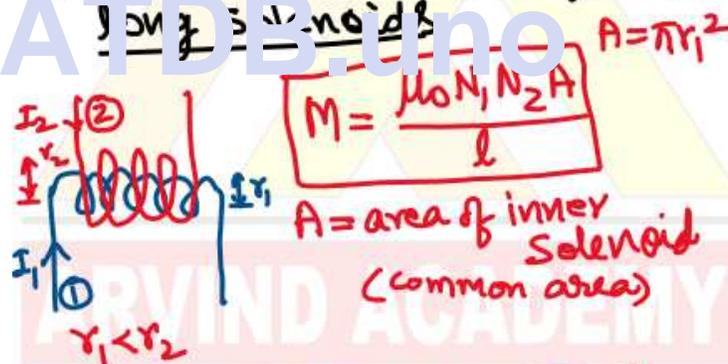
$$M = \frac{\mu_0 N_1 N_2 A}{\ell}$$

A = area of inner Solenoid (common area)

$r_1 < r_2$

$$M = \mu_0 n_1 n_2 A \ell = \mu_0 n_1 n_2 \pi r_1^2 \ell$$

⇒ **Self Induction**

Induced current
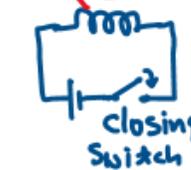
$$\phi = LI$$

L = Coeff. of Self Induction or Self-Inductance or Inductance

Closing Switch

$$e = -L \frac{dI}{dt}$$

⇒ **Self-Inductance of a Solenoid**

$$L = \mu_0 n^2 \ell A \qquad L = \frac{\mu_0 N^2 A}{\ell}$$

• If Coil is wound over a material μ_r

$$L = \mu_r \mu_0 n^2 \ell A = \frac{\mu_r \mu_0 N^2 A}{\ell}$$

Chap 7: Alternating Current

QUESTIONS

$\Rightarrow$ **Capacitive Reactance**

$$X_C = \frac{1}{\omega c} = \frac{1}{2\pi f c}$$

① For A.C. $X_C \propto \frac{1}{f}$

② For D.C., $f=0 \Rightarrow \boxed{X_C = \infty}$

$\Rightarrow$ **Series LCR circuit**

$e = e_0 \sin \omega t$

$Z = \sqrt{R^2 + (x_L - x_c)^2}$

$\tan \phi = \frac{x_L - x_c}{R}$

if $x_L > x_c$

$C = e_0 \sin \omega t$
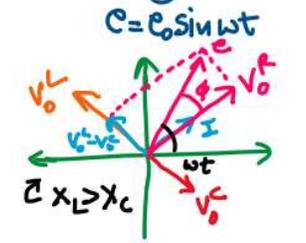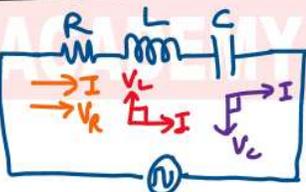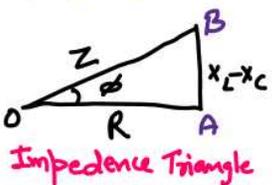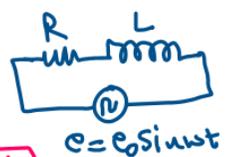
Impedance Triangle

if $x_L > x_c$
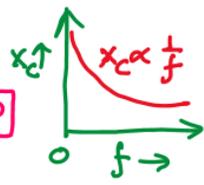
$\Rightarrow$ **LR Circuit**

$e = e_0 \sin \omega t$

$I = I_0 \sin(\omega t - \phi)$

e leads the I by ϕ
OR I lags the ε by ϕ

$$\tan \phi = \frac{x_L}{R} = \frac{\omega L}{R}$$
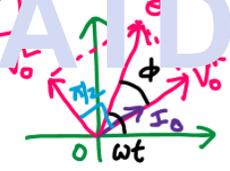
$\Rightarrow$ **CR-Circuit**

$e = e_0 \sin \omega t$

$I = I_0 \sin(\omega t + \phi)$

I leads the ε by ϕ

$$\tan \phi = \frac{x_c}{R} = \frac{y \omega c}{R}$$

$C = e_0 \sin \omega t$
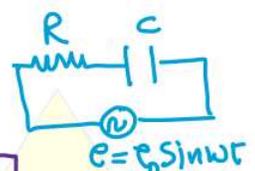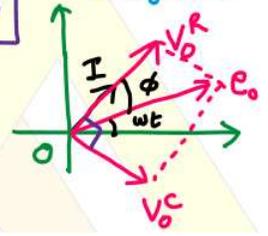
$\Rightarrow$ **Pure Inductor Circuit**

$e = e_0 \sin \omega t$

$I = I_0 \sin(\omega t - \pi/2)$

I lags behind e by $\pi/2$

Not in Phase

Graph e & I Vs ωt

Phasor diagram

$C = e_0 \sin \omega t$
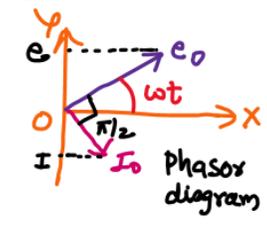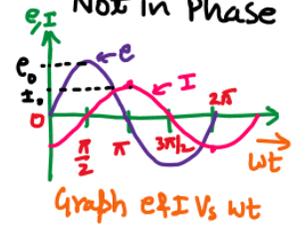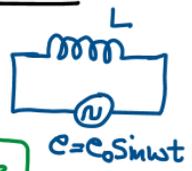
$\Rightarrow$ **Inductive Reactance**

$X_L = \omega L = 2\pi f L$

① For A.C., $X_L \propto f$

② For D.C., $f=0 \Rightarrow \boxed{X_L = 0}$
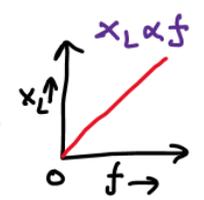
$\Rightarrow$ **only capacitor circuit**

$e = e_0 \sin \omega t$

$I = I_0 \sin(\omega t + \pi/2)$

I leads the e by $\pi/2$

$C = e_0 \sin \omega t$
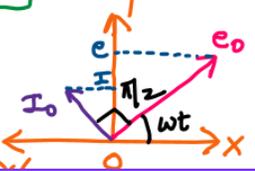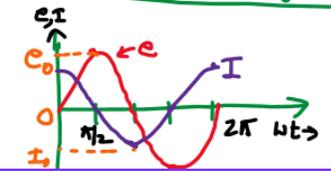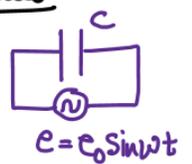
$\Rightarrow$ **AC voltage & current eqn**

$$\boxed{e = e_0 \sin \omega t} \qquad \boxed{I = I_0 \sin \omega t}$$

$\Rightarrow$ **3 Values of A.C.**

$I_{av}(\text{one cycle}) = 0 = e_{av}(\text{1 cycle})$

$I_{av}(\text{half cycle}) = \frac{2}{\pi} I_0 = 0.637 I_0$

$e_{av}(\text{half cycle}) = \frac{2}{\pi} e_0 = 0.637 e_0$

$I_{rms} = I_{eff} = I_V$

$$I_{rms} = \frac{I_0}{\sqrt{2}} = 0.707 I_0$$

$$e_{rms} = \frac{e_0}{\sqrt{2}} = 0.707 e_0$$

$\Rightarrow$ **Pure Resistor circuit**

$e = e_0 \sin \omega t$

$I = I_0 \sin \omega t$

Same Phase

$C = e_0 \sin \omega t$

Graph e & I Vs ωt

Phasor Diagram

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Chap 7: Alternating Current
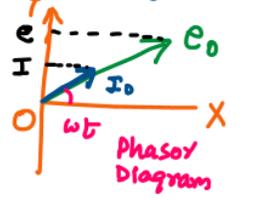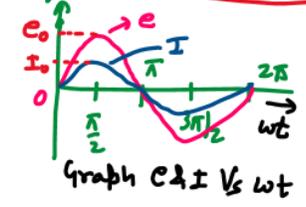
QUESTIONS

Power factor $= \cos\phi = \dfrac{R}{Z}$

→ For Pure Inductive/Capacitive
$\cos\phi = 0$

→ Purely Resistive $\boxed{\cos\phi = 1}$

→ At Resonance $\boxed{\cos\phi = 1}$

⇒ **Wattless Current**

I in a.c. circuit, if avg. power consumed in the circuit is zero.

example:-
① Purely Inductive
$\phi = \pi/2$, $P_{av} = 0$

② Purely Capacitive
$\phi = -\pi/2$, $P_{av} = 0$

$I_{rms}\cos\phi$

I_{rms}

$\xrightarrow{} X$

$I_{rms}\sin\phi$
(Wattless Current)
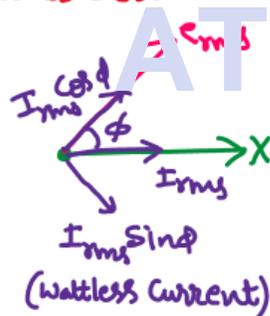
⇒ **Transformer**

$\dfrac{I_1}{I_2} = \dfrac{e_2}{e_1} = \dfrac{N_2}{N_1}$ $I_1 = I_p$
$I_2 = I_s$

$\eta = \dfrac{\text{Power output}}{\text{Power Input}} \times 100 \%$

⇒ **Resonance condition**

→ max I in Series LCR

Cond^n $\boxed{X_L = X_C}$

$\boxed{\omega_r = \dfrac{1}{\sqrt{LC}}}$ $\boxed{f_r = \dfrac{1}{2\pi\sqrt{LC}}}$

Quality factor Q

$\boxed{Q = \dfrac{1}{R}\sqrt{\dfrac{L}{C}}}$

⇒ $\boxed{\text{P W E R}}$ ⇐

$\boxed{P_{av} = e_{rms}\, I_{rms}\cos\phi}$

① Pure Resistive circuit $(\phi = 0)$
$P_{av} = e_{rms}\, I_{rms}$

② Pure Inductive $(\phi = \pi/2) \Rightarrow \boxed{P_{av} = 0}$

③ Pure Capacitive $(\phi = -\pi/2) \Rightarrow \boxed{P_{av} = 0}$

④ Series LCR
$P_{av} = e_{rms}\, I_{rms}\cos\phi$ $\cos\phi = \dfrac{R}{Z}$

⑤ At Resonance $(X_L = X_C)\,(\phi = 0)$
$\boxed{P_{av} = e_{rms} \times I_{rms}}$

⇒ **Special Cases**

① When $X_L > X_C$ or $V_L > V_C$ (Inductive Circuit)
$e = e_0\sin\omega t$ Here $\tan\phi = \dfrac{X_L - X_C}{R}$
$I = I_0\sin(\omega t - \phi)$ or $\cos\phi = \dfrac{R}{Z}$

② When $X_L < X_C$ OR $V_L < V_C$ (Capacitive circuit)
$e = e_0\sin\omega t$ Here $\tan\phi = \dfrac{X_C - X_L}{R}$
$I = I_0\sin(\omega t + \phi)$ OR $\cos\phi = \dfrac{R}{Z}$

③ When $X_L = X_C$ OR $V_L = V_C$ (Resistive circuit)
$e = e_0\sin\omega t$
$I = I_0\sin\omega t$ Here $\tan\phi = \dfrac{X_L - X_C}{R} = 0$
$\boxed{\phi = 0}$
$\boxed{\text{Same Phase}}$

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QUESTIONS
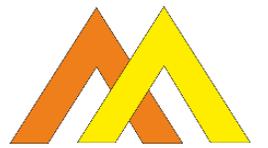
Chap 8: Electromagnetic Waves

⟹ Electromagnetic Spectrum

		freq.
>00.m	① Radio Waves	$10^4 - 10^8$ Hz
0.1m-1mm	② Microwave	$10^9 - 10^{12}$ Hz
1mm-700 nm	③ Infrared	$10^{11} - 5 \times 10^{14}$
700nm-400 nm	④ Visible light	$4 \times 10^{14} - 7 \times 10^{14}$
400nm-1mm	⑤ Ultraviolet	$10^{16} - 10^{17}$
1nm-10^{-3}mm	⑥ X-Ray	$10^{16} - 10^{19}$
<10^{-3}nm	⑦ Υ-Rays	$10^{18} - 10^{22}$

⟹ ① Radio Waves

Uses: Radio Communication
Radioastronomy

Production: Accelerated motion of charges in conducting wires or oscillating circuits.

⟹ Momentum of em wave

$$p = \frac{U}{c}$$

U = Total Energy
C = Speed of light in Vacuum / Air

⟹ Radiation Pressure

$$P_r = \frac{I}{c}$$

I = Intensity

⟹ E & B Relation

$$\frac{E}{B} = C \quad \text{or} \quad \frac{E_0}{B_0} = C$$

⟹ Relation b/w c, μ & ε

$$C = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} \qquad v = \frac{1}{\sqrt{\mu \varepsilon}} = \frac{C}{\sqrt{K \mu_r}}$$

⟹ Equation of em wave

$$\vec{E} = E_0 \sin(Kx - \omega t) \hat{j}$$
$$\vec{B} = B_0 \sin(Kx - \omega t) \hat{k}$$
$\vec{E} \perp \vec{B}$ & are in Same Phase

⟹ Electromagnetic Waves

① direction of em wave = $\vec{E} \times \vec{B}$

② Source = accelerated charge

⟹ Energy density of em wave

→ Energy per unit Volume

$$U_E = \frac{1}{2} \varepsilon_0 E_{rms}^2 \quad , \quad U_B = \frac{1}{2} \frac{B_{rms}^2}{\mu_0}$$

→ U.r.p. $\overline{U_E} = U_B$

$E_{rms} = \frac{E_0}{\sqrt{2}}$
$B_{rms} = \frac{B_0}{\sqrt{2}}$

$$U(Total) = U_E + U_B = \varepsilon_0 E_{rms}^2 = \frac{B_{rms}^2}{\mu_0}$$

⟹ Intensity of em wave

Energy crossing per unit area per unit time perpendicular to the propogation of the wave.

$$I = \varepsilon_0 E_{rms}^2 C = \frac{B_{rms}^2}{\mu_0} \times C$$

⟹ Displacement Current

$$I_d = \varepsilon_0 \frac{d\phi_E}{dt}$$

⟹ Modified Ampere's Law

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 [I_C + I_D]$$

Here $I_D = \varepsilon_0 \frac{d\phi_E}{dt}$, I_C = Conduction Current

⟹ Maxwell 4 eqⁿ Electromagnetism

① $\oint \vec{E} \cdot d\vec{s} = \frac{q}{\varepsilon_0}$ (Gauss Law)

② $\oint \vec{B} \cdot d\vec{s} = 0$ (Gauss Law for magnetism)

③ $C = -\frac{d\phi_B}{dt}$ (Faraday's Law)

④ $\oint \vec{B} \cdot d\vec{l} = \mu_0 [I_C + I_D]$ (Modified Ampere's law)

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Chap 8: Electromagnetic Waves

QUESTIONS

⇒ ⑦ Gamma Rays

Uses: In Radiotherapy for malignant tumors, initiate nuclear reactions, study of structure of atomic nuclei etc.

Production: Radioactive decay of the nucleus, Co-60 is a pure γ-Ray source.

⇒ ⑤ Ultraviolet light

Uses: In food preservation, Invisible writings, fingerprints, molecular structure.

Production:- Sun, High voltage gas discharge tubes etc.

⇒ ⑥ X-Rays

Uses: Medical diagnosis, In the study of Crystal structure, detecting cracks, In Radiotherapy to cure malignant growths.

Production: Sudden deceleration of fast moving electrons by metal target.

⇒ ② Microwaves

Uses: Radar System, Aircraft navigation, Geostationary Satellites.

Production: through Klystron Valve or Magnetron Valve.

⇒ ③ Infrared Waves (Heat waves)

Uses: Remote Control TV, VCR. In Green houses, Infrared Lamps in treatment of muscular complaints, Study of molecular structure, Secret writings.

Production: Vibration of atoms and molecules.

⇒ ④ Visible light

Uses: We Can See, initiate chemical reactions.

Production: Radiated by excited atoms in ionised gas & incandescent bodies.

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QUESTIONS

Chap 9: Ray optics & Optical Instruments

$\Rightarrow$ **Thin Lens Formula**

$\rightarrow$ $\dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{f}$

$\rightarrow$ $m = \dfrac{v}{u}$

$\rightarrow$ $m = \dfrac{f}{f+u} = \dfrac{f-v}{f}$

m = Linear magnification

$\Rightarrow$ **Power of Lens**

$\rightarrow$ $P = \dfrac{1}{f}$

$\Rightarrow$ **Refraction at spherical Surfaces**

① Rarer $\rightarrow$ Denser

$\dfrac{\mu_D}{v} - \dfrac{\mu_R}{u} = \dfrac{\mu_D - \mu_R}{R}$

② Denser $\rightarrow$ Rarer

$\dfrac{\mu_R}{v} - \dfrac{\mu_D}{u} = \dfrac{\mu_R - \mu_D}{R}$

$\dfrac{\mu_D - \mu_R}{R}$ $\rightarrow$ is called Power factor of the Spherical surface

$\Rightarrow$ **Lens Maker's Formula**

$\dfrac{1}{f} = \left(\dfrac{\mu_D - \mu_R}{\mu_R}\right)\left[\dfrac{1}{R_1} - \dfrac{1}{R_2}\right]$

$\Rightarrow$ When Lens is placed in AIR
$\mu_R = 1$

$\dfrac{1}{f} = (\mu - 1)\left[\dfrac{1}{R_1} - \dfrac{1}{R_2}\right]$

Refractive Index $= \dfrac{\text{Real depth}}{\text{Apparent depth}}$
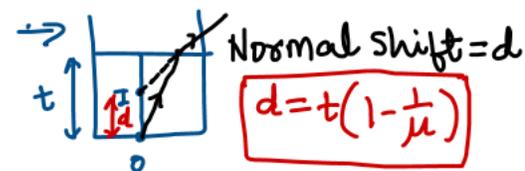
Normal Shift = d

$d = t\left(1 - \dfrac{1}{\mu}\right)$

$\rightarrow$ Total Normal shift for Compound media

$d = t_1\left(1 - \dfrac{1}{\mu_1}\right) + t_2\left(1 - \dfrac{1}{\mu_2}\right) + ---$

$\Rightarrow$ **Total Internal Reflection (TIR)**

$\rightarrow$ $^R\mu_D = \dfrac{1}{\sin i_c} = \mu$

$h = r\sqrt{\mu^2 - 1}$
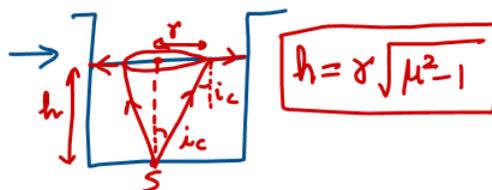
$\Rightarrow$ **Reflection**

$\rightarrow$ $R = 2f$ OR $f = R/2$

$\rightarrow$ $\dfrac{1}{v} + \dfrac{1}{u} = \dfrac{1}{f}$

$\rightarrow$ $m = -\dfrac{v}{u}$ OR $m = \dfrac{f-v}{f}$

$\rightarrow$ $|m| > 1$ Image magnified
$|m| < 1$ Image diminished
$|m| = 1$ Same size

$\rightarrow$ $m = +ve$ [Image Virtual & Erect]
$m = -ve$ [Image Real & Inverted]

$\Rightarrow$ **Refraction**

$\rightarrow$ $^1\mu_2 = n_{21} = \dfrac{\sin i}{\sin r}$

$\rightarrow$ $^1\mu_2 = n_{21} = \dfrac{\mu_2}{\mu_1} = \dfrac{v_1}{v_2} = \dfrac{\lambda_1}{\lambda_2}$

$\rightarrow$ $^1\mu_2 \times {}^2\mu_3 \times {}^3\mu_1 = 1$

$\rightarrow$ $^w\mu_g = \dfrac{a\mu_g}{a\mu_w}$ OR $^1\mu_2 = \dfrac{a\mu_2}{a\mu_1}$

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Chap 9: Ray optics & Optical Instruments

QUESTIONS

⇒ Compound Microscope

magnifying power of Compound microscope by definition

$$M = \frac{v_0}{u_0} \times \frac{D}{u_e}$$

$$M = m_0 \times m_e$$

m_0 = Linear magnification by obj

m_e = magnifying power of eyepiece (Angular magnification)

→ Case 1: Final Image at D

$$M = \frac{v_0}{u_0}\left(1 + \frac{D}{f_e}\right) \quad OR$$

$$M = -\frac{L}{f_0}\left(1 + \frac{D}{f_e}\right)$$

L = Length of Microscope Tube

$$L = |v_0| + |u_e|$$

→ Case 2: Final Image at ∞

$$M = \left(\frac{v_0}{u_0}\right)\left(\frac{D}{f_e}\right) \quad OR$$

$$M = -\frac{L}{f_0} \times \frac{D}{f_e}$$

⇒ OPTICAL INSTRUMENTS

⇒ Microscope

$$M = \frac{\text{Visual angle formed by Final Image}}{\text{Visual angle formed by object kept at D}}$$

(Angular magnification)

$$M = \frac{\beta}{\alpha}$$

⇒ Simple Microscope

magnifying power of Simple microscope by definition

$$M = \frac{D}{u_e}$$

→ Case 1: Final Image at D

$$M = 1 + \frac{D}{f} \quad \text{maximum magnification}$$

→ Case 2: Final Image at ∞

$$M = \frac{D}{f} \quad \text{min magnification}$$

• For Simple Microscope

$$\frac{D}{f} \leq M \leq 1 + \frac{D}{f}$$

⇒ Combination of lenses

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

$$P = P_1 + P_2$$

Total magnification (m)

$$m = m_1 \times m_2 \times m_3 - - -$$

⇒ PRISM

$$A = r + r'$$

$$i + i' = A + \delta$$
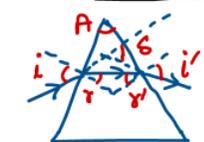
→ at δ_m (angle of min. deviation)

$$i = i' \quad \text{and} \quad r = r'$$

→ Refractive Index of Prism material

$$\mu = \frac{\sin\left(\frac{A + \delta_m}{2}\right)}{\sin(A/2)}$$

→ For small angled Prism

$$\delta = (\mu - 1)A$$

Chap 9: Ray optics & Optical Instruments

QUESTIONS

$\Rightarrow$ **ASTRONOMICAL Telescope**

$M = \dfrac{\text{Visual angle formed by final Image}}{\text{Visual angle formed by object}}$

$$\boxed{M = \dfrac{\beta}{\alpha}}$$

magnifying Power of Refracting Telescope by definition

$$\boxed{M = -\dfrac{f_o}{u_e}}$$

→ Case 1: Final Image at D

$$\boxed{M = -\dfrac{f_o}{f_e}\left(1 + \dfrac{f_e}{D}\right)}$$

$L =$ length of Telescope

$$\boxed{L = |f_o| + |u_e|}$$

→ Case 2: Final Image at ∞

$$\boxed{M = -\dfrac{f_o}{f_e}} \quad \&$$

$$\boxed{L = |f_o| + |f_e|} \text{ length of Telescope}$$

\# For larger magnification in Telescope $\Rightarrow \boxed{f_o >> f_e}$

QUESTIONS

Chap 10: Wave optics

$\Rightarrow$ **Imp. Note**

If $I_1 = I_2 = I_0$ (Intensities are same)

then

$$\boxed{I = 4I_0 \cos^2 \phi/2}$$

In another form

$$\boxed{I = I_{max} \cos^2 \phi/2} \quad \text{Here } I_{max} = 4I_0$$

$\Rightarrow$ Relation b/w Phase & Path diff.

$$\boxed{\Delta\phi = \frac{2\pi}{\lambda} \times \Delta p}$$

$\Delta\phi =$ Phase diff. (Angle)

$\Delta p =$ Path diff. (distance)

$\Rightarrow$ **Effect on λ, ν, ν during Refraction**

$\rightarrow$ freq ν unchanged

$$\boxed{^1\mu_2 = \frac{\mu_2}{\mu_1} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}}$$

$\rightarrow \lambda \& \nu$ changed in Refraction

$\rightarrow \boxed{^a\mu_1 = \frac{c}{v}}$ (Absolute Refractive Index)

$\Rightarrow$ **Intensity at any point in interference**

$$\boxed{A^2 = a_1^2 + a_2^2 + 2a_1 a_2 \cos\phi}$$

$I \propto A^2$ (In wave)

$$\boxed{I = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos\phi}$$

$2\sqrt{I_1 I_2} \cos\phi =$ Interference Term

$\phi =$ Constant Phase diff.

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QUESTIONS

Chap 10: Wave Optics

→ Angular width of a fringe

$$\theta = \frac{\beta}{D} = \frac{\lambda}{d}$$

→ If apparatus immersed in a liquid of refractive Index (μ) then λ will decrease $\lambda' = \lambda/\mu$

Consequently fringe width decreases

$$\beta' = \frac{\beta}{\mu}$$

⇒ Theory of Interference fringes

Path diff at Point P

$$\Delta p = \frac{xd}{D}$$
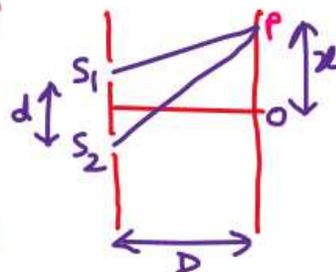
→ Position of Bright fringes

$$x_n = \frac{n D \lambda}{d}$$ n^{th} bright fringe $n = 1, 2, 3, ---$

→ Position of Dark fringe

$$x'_n = \frac{(2n-1)D\lambda}{2d}$$ n^{th} Dark fringe $n = 1, 2, 3, ---$

→ Fringe Width

$$\beta = \frac{D\lambda}{d}$$ → All fringes of equal width.

⇒ Condition for Constructive Interference (Maxima)

Phase diff. even multiple of π → $\boxed{\Delta \phi = 2n\pi}$

Path diff even multiple of $\lambda/2$ → $\boxed{\Delta p = 2n(\lambda/2)}$

Path diff. integral multiple of λ → $\boxed{\Delta p = n\lambda}$

Here $n = 0, 1, 2, 3, ---$

⇒ Condition for destructive Interference (Minima)

Phase diff odd multiple of π → $\boxed{\Delta \phi = (2n-1)\pi}$

Path diff. odd multiple of $\lambda/2$ → $\boxed{\Delta p = (2n-1)\lambda/2}$

Here $n = 1, 2, 3, ----$

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QUESTIONS

Chap 10: Wave Optics

$\Rightarrow$ **Secondary Maxima**

Angular width $\boxed{\theta = \lambda/a}$

Linear Width $\boxed{\beta = \dfrac{D\lambda}{a}}$ Half of Central maxima

$\rightarrow$ Distance of nth maxima from 'o' Centre of Screen

$$\boxed{x_n = \frac{(2n+1)D\lambda}{2a}}$$

$\rightarrow$ Direction of nth minima

$$\boxed{\theta'_n = (2n)\left(\frac{\lambda}{2a}\right) = n\frac{\lambda}{a}}\ n = 1,2,3\ldots$$

opposite of Interference, even multiple π minima ξ)

$\rightarrow$ Distance of nth minima from 'o' Centre of Screen.

$$\boxed{x'_n = \frac{nD\lambda}{a}}$$

$\Rightarrow$ **Central Maxima**

Angular width $= 2\theta = \dfrac{2\lambda}{a}$

Linear Width $= \beta_o = \dfrac{2D\lambda}{a} = 2\beta$

$\Rightarrow$ Comparison of I_{Max} & I_{min}

$$\boxed{\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{I_1}+\sqrt{I_2}}{\sqrt{I_1}-\sqrt{I_2}}\right)^2 = \left(\frac{a_1+a_2}{a_1-a_2}\right)^2 = \left(\frac{\frac{a_1}{a_2}+1}{\frac{a_1}{a_2}-1}\right)^2}$$

$\gamma = \dfrac{a_1}{a_2} = \sqrt{\dfrac{I_1}{I_2}} = $ amplitude Ratio

$$\boxed{\frac{w_1}{w_2} = \frac{I_1}{I_2} = \frac{a_1^2}{a_2^2}}$$

w_1 & w_2 width of two Slits

$\Rightarrow$ **Diffraction at a Single Slit**

$\rightarrow$ Path diff b/w A & B

$$\boxed{p = a\sin\theta}$$

$\rightarrow$ Direction of Secondary maxima

$$\boxed{\theta_n = \frac{(2n+1)\lambda}{2a}}\ n = 1,2,3\ldots$$

$\boxed{a = \text{Width of Slit}}$

opposite of Interference, odd multiple π maxima ξ)
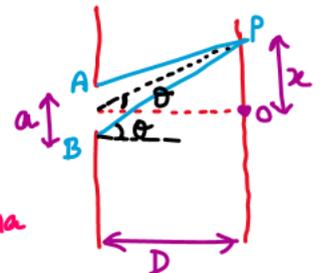
QUESTIONS

$\Rightarrow$ Determination of Planck's Constant (h) & Work function $(W_0 \text{ or } \phi_0)$

$K_{max} = h\nu - W_0$

$K_{max} = eV_0$

$eV_0 = h\nu - W_0$

$V_0 = \left(\frac{h}{e}\right)\nu - \frac{W_0}{e}$

Compared with

$y = mx + c$ | $m = h/e$ | $c = -W_0/e$ | #

Slope $= h/e \Rightarrow h = e \times \text{Slope}$

$W_0 = e \times \text{magnitude of y intercept}$

V_0 stopping Potential

Slope $= h/e$

ν_0 θ

incident freq.
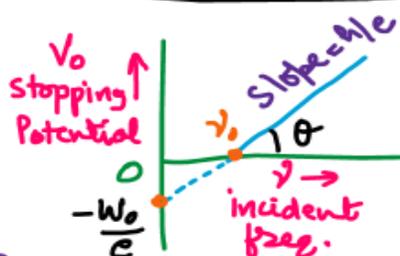
$-\frac{W_0}{e}$

$\Rightarrow$ Rest mass of Photon is zero

$m_0 = m\sqrt{1 - \frac{v^2}{c^2}} = m\sqrt{1 - \frac{c^2}{c^2}} = 0$

$\Rightarrow$ From Einstein's mass-energy relationship

the equivalent mass of Photon

$E = mc^2 = h\nu \Rightarrow m = \frac{h\nu}{c^2}$

$\Rightarrow$ Linear momentum of Photon

$p = mc = \frac{h\nu}{c} = \frac{h}{\lambda}$

$\Rightarrow$ $1\,eV = 1.602 \times 10^{-19}\,J$

$\Rightarrow$ $K_{max} = \frac{1}{2}mV_{max}^2 = eV_0$

$\Rightarrow$ Einstein's Photoelectric equation

$\rightarrow K_{max} = \frac{1}{2}mV_{max}^2 = h\nu - W_0$

$\rightarrow K_{max} = \frac{1}{2}mV_{max}^2 = h\nu - h\nu_0 = h(\nu - \nu_0)$

$\Rightarrow K_{max} = \frac{1}{2}mV_{max}^2 \propto \nu$

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QUESTIONS

Chap 11: Dual Nature

$$\Rightarrow \text{de-Broglie's Wave eq}^n$$

$$\lambda = \frac{h}{mc} = \frac{h}{p}$$

→ True for any particle of mass m moving with velocity v must be associated with matter wave of wavelength λ

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

\# $\lambda \propto \frac{1}{p}$

\# If $v = 0$ then $\lambda = \infty$

$\therefore$ No matter wave if $v = 0$

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QUESTIONS

Chap 12: Atoms

$\Rightarrow$ Speed of an e^- in Bohr's rad.

$$v = \frac{c}{137}$$ e^- speed in Bohr's radius

In General

$$v_n = \frac{1}{137} \cdot \frac{c}{n}$$

Relation b/w orbit radius & e velocity

$$\gamma = \frac{KZe^2}{mv^2}$$

- Here $K = \frac{1}{4\pi\varepsilon_0}$
- Z = atomic no. for Hydrogen it is 1.

$\Rightarrow$ orbital speed of an electron in n^{th} orbit

$$v = \frac{2\pi KZe^2}{nh}$$ $K = \frac{1}{4\pi\varepsilon_0}$

Z = atomic no.

$\Rightarrow$ Radius of n^{in} orbit

$$\gamma = \frac{n^2h^2}{4\pi^2 m KZe^2}$$ m = mass of e^-

$K = \frac{1}{4\pi\varepsilon_0}$

$\Rightarrow$ Bohr's Radius (r_0)

$\rightarrow$ In this $Z=1$ & $n=1$

$$\gamma_0 = \frac{h^2}{4\pi^2 m Ke^2} = 0.53 \text{ Å}$$

$$\gamma = n^2\gamma$$

$\Rightarrow$ α-particle

$$m_\alpha = 4m_p$$ $$q_\alpha = 2q_p = +2e$$

$\Rightarrow$ distance of closest approach (r_0)

$\rightarrow$ when α particle is shoots to nucleus of Atom

$$\gamma_0 = \frac{2KZe^2}{K_\alpha} = \frac{4KZe^2}{mv^2}$$

Here $K = \frac{1}{4\pi\varepsilon_0}$, $K_\alpha = K.E.$ of α-part.

$\Rightarrow$ Bohr's Quantisation Cond^n

$$L = mvr = \frac{nh}{2\pi}$$ $n = 1, 2, 3 \cdots$

L = Angular momentum

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QUESTIONS

Chap 12: Atoms

$\Rightarrow$ Short Formula of Total Eng. of an e^- in n^{th} orbit Hydrogen atom

$$E_n = -\frac{13.6}{n^2} \, ev$$

$\Rightarrow$ Spectral Series Hydrogen

$$\bar{v} = \frac{1}{\lambda} = R\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$$

Wave no.

Rydberg Constant

$$R = 1.0973 \times 10^7 \, m^{-1}$$

n_i = initial orbit
n_f = Final orbit

$\Rightarrow$ Bohr's model of Hydrogen Atom

① Speed of e^- $\quad v_n = \frac{1}{?}$

v_1 = Speed of e^- in 1st orbit = $\frac{C}{137}$

② Time period $\quad T_n = n^3 T_1$

③ Radius $\quad r_n = n^2 r_1$

④ Energy $\quad E_n = -\frac{13.6}{n^2} \, ev$

$\Rightarrow$ Energy of the electron

$$E_n = -\frac{2\pi^2 m k^2 z^2 e^4}{n^2 h^2}$$

-ve Energy indicates e^- is bound to nucleus by electrostatic attraction.

$\Rightarrow$ Imp. Relation b/w Total Energy(E), Kinetic Energy(K) & Potential Eng.(U) when e^- revolving in orbit

$$E = -K = \frac{U}{2} \quad \text{In hydrogen}$$

In Hydrogen

$$K = \frac{e^2}{8\pi\varepsilon_0 r} \qquad U = -\frac{e^2}{4\pi\varepsilon_0 r}$$

$$E = K + U = -\frac{e^2}{8\pi\varepsilon_0 r}$$

QUESTIONS

Chap 12: Atoms

③ H_β line $\boxed{n_i = n_f + 2}$

④ H_γ line $\boxed{n_i = n_f + 3}$

ex. H_γ for Balmer Series

$n_i = 5$, $n_f = 2$

---

④ Brackett Series ($n_f = 4, n_i = 5,6 \cdots$)

$$\boxed{\bar{\nu} = \frac{1}{\lambda} = R\left[\frac{1}{4^2} - \frac{1}{n_i^2}\right]}$$

→ in Infrared Region.

⑤ Pfund Series ($n_f = 5, n_i = 6,7 \cdots$)

$$\boxed{\bar{\nu} = \frac{1}{\lambda} = R\left[\frac{1}{5^2} - \frac{1}{n_i^2}\right]}$$

→ Infrared Region.

⇒ Some Important Points

① For shortest λ but $\boxed{n_i = \infty}$
(Highest Energy)
max ν

ex. for Balmer Series for shortest λ
$n_i = \infty$, $n_f = 2$

② For Longest λ but $\boxed{n_i = n_f + 1}$
(min ν)

→ This is called H_α line of min ν

ex. for H_α Longest λ for Balmer
$n_i = 3$, $n_f = 2$

⇒ Spectral Series Hydrogen

① Lyman Series ($n_f = 1, n_i = 2,3, \cdots$)

$$\boxed{\bar{\nu} = \frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{n_i^2}\right]}$$

→ belongs to Ultraviolet Region
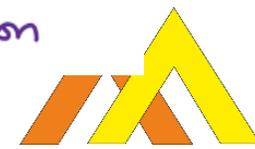
② Balmer Series ($n_f = 2, n_i = 3,4, \cdots$)

$$\boxed{\bar{\nu} = \frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{n_i^2}\right]}$$

→ lies in Visible Region.

③ Paschen Series ($n_f = 3, n_i = 4,5, \cdots$)

$$\boxed{\bar{\nu} = \frac{1}{\lambda} = R\left[\frac{1}{3^2} - \frac{1}{n_i^2}\right]}$$

→ lies in Infrared Region

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QUESTIONS

Chap 12: Atoms

$\Rightarrow$ Imp. Point

Ground Level $n = 1$

1st excited State $= n = 2$

2nd excited State $= n = 3$

- - - - -

$\Rightarrow$ Shortcut Formula

$$E = \frac{12400}{\lambda \, (\text{in } \text{Å})} \, eV$$

$\Rightarrow$ Total Energy of Hydrogen atom

$E_1 = -13.6 \, eV$

$E_2 = -3.4 \, ev$

$E_3 = -1.51 \, ev$

$E_4 = -0.85 \, ev$

$E_5 = -0.54 \, ev$

$E_6 = -0.38 \, ev$

Clearly e^- has certain definite energy levels this is called energy quantisation.

QUESTIONS

Chap 13: Nuclei

$\Rightarrow$ **Atomic mass unit** (amu ≡ u)

$1u = \frac{1}{12}$ actual mass of C-12 atom

$1u = 1.660565 \times 10^{-27}$ Kg

$1 eV = 1.602 \times 10^{-19}$ J

$1 MeV = 10^6 eV = 1.602 \times 10^{-13}$ J

million electron volt

$\boxed{1 amu = 931 MeV}$

$\Rightarrow$ **Avg. Atomic mass**

for example chlorine contains
75% of $^{35}_{17}Cl$ & 25% of $^{37}_{17}Cl$

Avg. atomic mass of chlorine
$= \frac{35 \times 75 + 37 \times 25}{75 + 25} = 35.50$

$\Rightarrow$ **Isotones Isobars etc.**

① Isotopes (A diff, Z same)

ex. $^1_1H, ^2_1H \& ^3_1H$

② Isobars (A same, Z diff)

ex $^3_1H, ^3_2He$

③ Isotones (Same no. of neutrons)

ex. $^{37}_{17}Cl, ^{39}_{19}K$

④ Isomers (Same A, Same Z)
but in diff energy states.

$\Rightarrow q_p = 1.6 \times 10^{-19}$ C

$m_p = 1.6726 \times 10^{-27}$ Kg

(1836 times of rest mass of e^-)

($m_e = 9.1093837 \times 10^{-31}$ Kg)

$\Rightarrow q_n = 0$ (charge on neutron)

$m_n = 1.6749 \times 10^{-27}$ kg

(slightly greater than proton)

$\Rightarrow$ **Important Terms**

① Nucleons (for protons & neutrons)

② Atomic no. (no. of Protons) = Z

③ Mass no. = $n_p + n_n = A$

④ No. of Neutrons = N = A − Z

⑤ Nuclear Mass = Total mass of protons & neutrons in the nucleus.

⑥ Representation

$^A_Z X$

X = element
Z = atomic no.
A = mass no.

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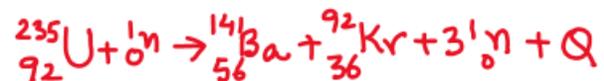ATDB.uno | Studyprayas â FOR PERSONAL STUDY USE ONLY. DO NOT SHARE OR REDISTRIBUTE.

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QUESTIONS

Chap 13: Nuclei

$\Rightarrow$ Nuclear Force

① Stongest Force

$$F_g : F_e : F_n = 1 : 10^{36} : 10^{38}$$

② Short Range force about 2-3 fm from nucleon.

③ Variation with distance P.E min at $r_0 \simeq 0.8$ fm (Strongest attraction at r_0)

④ Charge independent.

⑤ Saturation effect

⑥ Spin dependent character

⑦ Nuclear force due to exchange of mesons.

⑧ Non-Central forces.

$\Rightarrow$ Binding Energy & BEN

$$B.E. = \Delta m c^2$$

$$B.E.N. = \frac{B.E.}{A}$$

$\Rightarrow$ Nuclear Fission

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3\,^{1}_{0}n + Q$$

$\Rightarrow$ Nuclear Fusion

$$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{4}_{2}H + 21.6\ MeV$$

$\Rightarrow$ Radius of Nucleus

$$R = R_0 A^{1/3}$$ $R_0 = 1.2 \times 10^{-15} m$ $A = $ mass no.

$\Rightarrow$ Nuclear density

$$\rho_{nu} = \frac{3m}{4\pi R_0^3} = \text{Constant}$$

$m = $ Avg. mass of nucleon

\# Imp. Note ρ_{nu} is independent from size(R) & mass no. (A).

\# approp. same for all nucleus.

$\Rightarrow$ Mass defect

$$\Delta m = \left[Z m_p + (A - Z) m_n - m_N \right]$$

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QUESTIONS

⇒ Forward Biasing p-n Junction

① Barrier pot. decreases to $(V_B - V)$

② Depletion Layer width decreases

③ effective Resistance across p-n jun. decreases

④ Current (I) in mA

⇒ Intrinsic Semiconductor

$$I = I_e + I_h$$

I = Total Current
I_e = Electron Current
I_h = hole current

⇒ Extrinsic Semi.

n type
Si/Ge + Pentavalent Dopants
ex. Ar, Sb & P
$(n_e \gg n_h)$

p type
Si/Ge + Trivalent dopants
ex. Al, In, B
$(n_h \gg n_e)$

⇒ In a doped Semiconductor

Under thermal equilibrium

$$n_e \times n_h = n_i^2$$

⇒ Intrinsic Semiconductor

$$n_e = C \, e^{-E_g/2KT}$$

n_e = no. of e^- set free at absolute temp T.

K = Boltzman Constant

E_g = Ionisation Energy

T = Absolute Temp.

⇒ Intrinsic Semiconductor

$$n_e = n_h = n_i$$

n_e = no. density of free e^-

n_h = no. density of holes

n_i = Intrinsic charge Carrier Concentration.

QUESTIONS

Chap 14: Semiconductors

$\Rightarrow$ <u>Rectifier</u>

① Half wave

> output freq = Input freq.

② Full Wave

> output freq = 2 × Input freq.

$\Rightarrow$ <u>Reverse Biasing p-n jun.</u>

① Barrier potential increases to $(V_B + V)$

② depletion layer width Increases

③ Resistance of p-n jun. becomes very large

④ No currents through majority charge carriers.

⑤ very small current due to minority charge carriers (Reverse current) of order μA.

$\Rightarrow$ <u>Dynamic Resistance</u>

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

QUESTIONS

Thank You

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