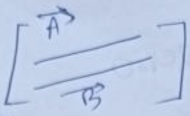
2/12/21

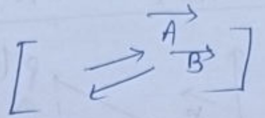
Physics (N mam)

Some kind of vectors -

① **Equal vectors** ⇒ $|\vec{A}| = |\vec{B}|$ 

or $\vec{A} = \vec{B}$

Same mag in same direction

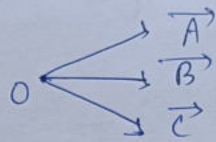
② **Negtive vectors** ⇒ ~~$|\vec{A}| = -|\vec{B}|$~~ 

or $\vec{A} = -\vec{B}$

Same mag in opposite direction

③ **Co-Planer vectors** ⇒

$\vec{A}, \vec{B}, \vec{C}$



They will lie in a same line of action, then they will called co-planer vector.

④ **Unit vectors** ⇒

magnitude is unity (that means one)

$$\hat{n} = \frac{\vec{P}}{|\vec{P}|}$$

• If $\vec{r} = 3\hat{i} + \hat{j} + 2\hat{k}$, find the unit vector along $\vec{r}$.

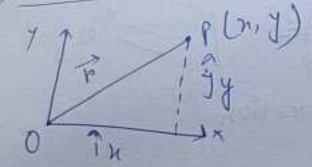
$$\hat{n} = \frac{3\hat{i} + \hat{j} + 2\hat{k}}{\sqrt{9+1+4}}$$

$$= \frac{1}{\sqrt{14}}(3\hat{i} + \hat{j} + 2\hat{k})$$

(5) Zero vectors

mag = zero

(6) Position vectors



$\vec{OP} = \vec{r}$

$\vec{r} = \hat{i}x + \hat{j}y$

$\boxed{\vec{r} = \hat{i}x + \hat{j}y + \hat{k}z}$

$|\vec{r}| = \sqrt{x^2 + y^2 + z^2}$

↓

This is position vector

• The position vectors of two points ~~a and~~ a and b are ~~(a, b)~~ $\vec{r_1} = 10\hat{i} - 12\hat{j} + 16\hat{k}$. calculate $|\vec{r_1}| + |\vec{r_2}|$

$\vec{r_2} = 4\hat{i} - 5\hat{j} + 12\hat{k}$

$|\vec{r_1}| = \sqrt{100 + 144 + 256} = \sqrt{500}$

$|\vec{r_2}| = \sqrt{16 + 25 + 144} = \sqrt{185}$

~~$|\vec{r_1}| + |\vec{r_2}| = \sqrt{500} + \sqrt{185}$~~

$= 35.96$

$|\vec{r_1} + \vec{r_2}| = |14\hat{i} - 17\hat{j} + 28\hat{k}|$

$= \sqrt{1269}$

$= 35.62$

16
16
256

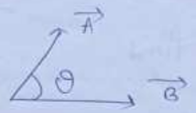
16
256
100
144
500

144
16
25
185

• Product of vector

• Scaler product

$\vec{A}, \vec{B}$



$\vec{A} \cdot \vec{B} = |A||B| \cos\theta$

• Charistaristics (Scaler)

(i) if $\theta = 90°$, that is (i.e.) = they are Perpendicular

$\therefore \vec{A} \cdot \vec{B} = |A||B| \cos\frac{\pi}{2}$

$= 0$

They are called orthogonal vectors

(ii) if they are Paralal, then $\theta = 0$

$\therefore \vec{A} \cdot \vec{B} = AB \cos 0$

$= AB$

(iii) ~~They~~ $\boxed{\begin{array}{l}\text{then } \vec{A} \cdot \vec{A} = A^2 \\ \hat{i} \cdot \hat{i} = 1, \hat{j} \cdot \hat{j} = 1, \hat{k} \cdot \hat{k} = 1\end{array}}$

$\vec{A} = \hat{i}A_x + \hat{j}A_y + A_z\hat{k}$

$\vec{B} = B_x\hat{i} + B_y\hat{j} + B_z\hat{k}$

$\vec{A} \cdot \vec{B} = (A_x\hat{i} + A_y\hat{j} + A_z) \cdot (B_x\hat{i} + B_y\hat{j} + B_z\hat{k})$

$= A_xB_x + A_yB_y + A_zB_z$

(iii) distributive property

$\vec{A} \cdot (\vec{B} + \vec{C}) = \vec{A} \cdot \vec{B} + \vec{A} \cdot \vec{C}$

$\vec{A}\cdot\vec{B}$
$\downarrow \quad \downarrow$
$m \quad n$

$(m\vec{A}\cdot n\vec{B})$ if we find
then the ans is ;- $mn(\vec{A}\cdot\vec{B})$

① if $\vec{A} = 2\hat{i} + 2\hat{j} - \hat{k}$
$\vec{B} = 6\hat{i} + 3\hat{j} - 2\hat{k}$
find the angle between the vectors

$\vec{A}\cdot\vec{B} = 12 + 6 + 2$
$= 20$

$20 = \cancel{(2\hat{i}+2\hat{j}}\ \sqrt{4+4+1}\cdot\sqrt{36+9+4}\cos\theta$
$= \cancel{\sqrt{7}\cdot\sqrt{7}}\ \ \cancel{18.7\cos\theta}$

$\Rightarrow \cancel{\cos\theta = 1.0/6}$
$\Rightarrow \theta =$

$\Rightarrow 20 = 3\cdot 7\cos\theta$
$\Rightarrow \cos\theta = \frac{20}{21}$

② show that the vectors,
$\vec{A} = \hat{i} + 4\hat{j} + 3\hat{k}$
$\vec{B} = 4\hat{i} + 2\hat{j} - 4\hat{k}$ are mutually perpendicular

$4 + 8 - 12 = \sqrt{1+16+9}\cdot\sqrt{16+4+16}\cdot\cos\theta$
$\Rightarrow 0 = \cos\theta$
$\Rightarrow \theta = 90° = \frac{\pi}{2}\ \therefore \vec{A}\perp\vec{B}$

- vector product

$\vec{A}\times\vec{B} = AB\sin\theta\ \hat{n}$ [$\hat{n}$ unit vector]

- Properties

(i) if $\vec{A}\times\vec{B} = 0$, $\theta = 0$ [$\because$ parallel]
(ii) if $\theta = \pi$, then they (vec) are anti-parallel
(iii) vector product of two equal vector = 0
$\therefore \vec{A}\times\vec{A} = 0$
(iv) distributive properties
$\vec{A}\times(\vec{B}+\vec{C})$
$= \vec{A}\times\vec{B} + \vec{A}\times\vec{C}$ (Prove)

$\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$
$\vec{B} = B_x\hat{i} + B_y\hat{j} + B_z\hat{k}$
$\vec{C} = C_x\hat{i} + C_y\hat{j} + C_z\hat{k}$

$$\vec{A}\times\vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

Q. A force $\vec{F} = (5\hat{i} + 2\hat{j} + 3\hat{k})$ N acting on a particle displaces it's form initial position $2\hat{i} + 5\hat{j} + 5\hat{k}$ to it's new position $12\hat{i} + 15\hat{j} + 18\hat{k}$. How much work is done.

$|\vec{S}| = (12\hat{i} - 2\hat{i}) + (15\hat{j} - 5\hat{j}) + (18\hat{k} - 5\hat{k})$
$= 10\hat{i} + 10\hat{j} + 13\hat{k}$

$\vec{w} = (5\hat{i} + 2\hat{j} + 3\hat{k}) \cdot (10\hat{i} + 10\hat{j} + 3\hat{k})$ $[\because \vec{w} = \vec{F}\cdot\vec{S}]$

$= 79$

② if two vectors are $6\hat{i} + 0.3\hat{j} - 5\hat{k}$ and $\hat{i} + 4.2\hat{j} - 2.5\hat{k}$. Find their vector product and by calculation prove that the new vector is perpendicular to the two.

$$\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 6 & 0.3 & -5 \\ 1 & 4.2 & -2.5 \end{vmatrix}$$

$= (-0.75 + 21)\hat{i} - (-15 + 5)\hat{j} + (25.2 - 0.3)\hat{k}$

$= 20.25\hat{i} + 10\hat{j} + 24.9\hat{k}$

$\therefore$ The vector product is $20.25\hat{i} + 10\hat{j} + 24.9\hat{k}$

Let, $\vec{A} = 6\hat{i} + 0.3\hat{j} - 5\hat{k}$, $\vec{B} = \hat{i} + 4.2\hat{j} - 2.5\hat{k}$

$\vec{C} = 20.25\hat{i} + 10\hat{j} + 24.9\hat{k}$

$\vec{A}\cdot\vec{C} = AC\cos\theta$

$\Rightarrow (121.5 + 3 - 124.5) = \sqrt{36 + 0.09 + 25} \cdot \sqrt{410 + 100 + 620} \cdot \cos\theta$

$\Rightarrow \cos\theta = 0 \quad \therefore \theta = 90° \quad \therefore \vec{A}$ and $\vec{C}$ are perpendicular.

$\vec{B}\cdot\vec{C} = BC\cos\theta$

$\Rightarrow (20.25 + 42 - 62.25) = \sqrt{1 + 17.64 + 6.25} \cdot \sqrt{410 + 100 + 620} \cdot \cos\theta$

$\Rightarrow \cos\theta = 0 \quad \therefore \vec{C} \perp \vec{B}$

$\therefore \theta = 90°$

CSE 214002

③ Find the area of the parallelogram determined by the vectors $\vec{A} = 3\hat{i} + 2\hat{j}$ and $\vec{B} = 2\hat{j} - 4\hat{k}$.

$$\vec{A}\times\vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & 2 & 0 \\ 0 & 2 & -4 \end{vmatrix}$$

$= (-8 - 0)\hat{i} - (-12 - 0)\hat{j} + (6 - 0)\hat{k}$

$= -8\hat{i} + 12\hat{j} + 6\hat{k}$

the area of parallelogram (সামান্তরিক)

$|\vec{A}\times\vec{B}| = \sqrt{64 + 144 + 36}$

$= 15.62$ unit^2

~~$= 7.81$ unit^2~~

• Torque $\vec{\tau} = \vec{r}\times\vec{F}$

(i) Prove that $-\vec{A}\times(\vec{B}\times\vec{C}) = \vec{B}(\vec{A}\cdot\vec{C}) - \vec{C}(\vec{A}\cdot\vec{B})$

(ii) $\vec{a}\times(\vec{b}\times\vec{c}) + \vec{b}\times(\vec{c}\times\vec{a}) + \vec{c}\times(\vec{a}\times\vec{b}) = 0$

$\Rightarrow \vec{b}(\vec{a}\cdot\vec{c}) - \vec{c}(\vec{a}\cdot\vec{b}) + \vec{c}(\vec{b}\cdot\vec{a}) - \vec{a}(\vec{b}\cdot\vec{c}) + \vec{a}(\vec{c}\cdot\vec{b}) - \vec{b}(\vec{c}\cdot\vec{a})$

$= 0$

• Triple Product

$$\vec{A}\cdot(\vec{B}\times\vec{C}) = \vec{B}(\vec{A}\cdot\vec{C}) - \vec{C}(\vec{A}\cdot\vec{B})$$

$$\begin{vmatrix} A_x & A_y & A_z \\ B_x & B_y & B_z \\ C_x & C_y & C_z \end{vmatrix}$$

• Show that central force is consinvative

$$\vec{F} = m f(\vec{r})$$

$$\vec{r} \times \vec{F}(r) = 0$$

$$\Rightarrow \vec{r} \times m\vec{f}(r) = 0$$

$$\Rightarrow \vec{r} \times \vec{f}(r) = 0$$

$$\Rightarrow \vec{r} \times \frac{d^2 r}{dt^2} = 0$$

$$\frac{d}{dt}\left(\vec{r} \times \frac{d\vec{r}}{dt}\right)$$

$$= \left(\frac{d\vec{r}}{dt} \times \frac{d\vec{r}}{dt}\right) + \vec{r} \times \frac{d^2\vec{r}}{dt^2}$$

$$= 0 + \vec{r} \times \frac{d^2 r}{dt^2}$$

$$\int \frac{d}{dt}\left(\vec{r} \times \frac{d\vec{r}}{dt}\right) = \int 0$$

$$\Rightarrow r \times \frac{dr}{dt} = \text{constant}$$

Prove

• Curl $\vec{F} = 0$

$$\text{curl } \vec{f}(r) = 0$$

$$\vec{\nabla} \times \vec{f}(r) = 0$$

$$\Rightarrow \vec{\nabla} \times f(r)\,\hat{r} = 0$$

$$\Rightarrow \vec{\nabla} \times \frac{f(r)\cdot\vec{r}}{r} = 0$$

$$\Rightarrow \vec{\nabla} \times \frac{f(r)}{r}(x\hat{i} + y\hat{j} + z\hat{k}) = 0$$

$$\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ \frac{f(r)x}{r} & \frac{f(r)y}{r} & \frac{f(r)z}{r} \end{vmatrix}$$

$$= \hat{i}\left(\frac{z}{r}\frac{\partial f}{\partial y} - \frac{y}{r}\frac{\partial f}{\partial z}\right) - \hat{j}\left(\frac{z}{r}\frac{\partial f}{\partial x} - \frac{x}{r}\frac{\partial f}{\partial z}\right) + \hat{k}\left(\frac{y}{r}\frac{\partial f}{\partial x} - \frac{x}{r}\frac{\partial f}{\partial y}\right) \quad \text{—(1)}$$

$$r^2 = x^2 + y^2 + z^2$$

$$\frac{\partial f}{\partial y} = \frac{\partial f}{\partial r}\cdot\frac{\partial r}{\partial y}$$

$$\frac{\partial r}{\partial y} = \frac{y}{r} \Rightarrow \frac{\partial f}{\partial r}\cdot\frac{y}{r}$$

$$\frac{\partial f}{\partial z} = \frac{z}{r}\cdot\frac{\partial f}{\partial r}$$

$$\frac{\partial f}{\partial x} = \frac{x}{r}\cdot\frac{\partial f}{\partial r}$$

from (1)

$$\hat{i}\left[\frac{z}{r}\cdot\frac{\partial f}{\partial r}\cdot\frac{y}{r} - \frac{y}{r}\cdot\frac{\partial f}{\partial r}\cdot\frac{z}{r}\right] = \hat{i}\times 0$$

একইভাবে,

$$\hat{j}\times 0, \quad \hat{k}\times 0$$

$$\therefore \hat{i}\times 0 - \hat{j}\times 0 + \hat{k}\times 0$$

$$= 0 \quad \text{(Proved)}$$

• Coefficient of viscocity − (defination)

$$F \propto \frac{dv}{dx}$$

$$\Rightarrow F = \eta\frac{dv}{dx} \quad [\eta = \text{eta}] \quad [F = \text{Per unit area}]$$

• viscocity cgs unit − Poise

• dimention of eta −

$$\cancel{MLT^{-2}} \quad \eta = \frac{F}{\frac{dv}{dx}} = \frac{F/A}{\frac{dv}{dx}}$$

$$= \frac{[ML^{-2}T^{-2}/L^2]}{[LT^{-1}/L]}$$

$$= [ML^{-1}T^{-1}]$$

- Renolds numbers

derivation imp নয় formula imp

$$\boxed{V = \frac{K\eta}{\rho r}}$$

[V = critical velocity
r = tube এর radius
K = renolds number
ρ = density of the liquid]

- Poysiziy's equation (পয়সলির সমীকরণ)

$$\boxed{V = \frac{\pi (P_1 - P_2)a^4}{8\eta l}}$$

[a = radious of the tube
l = length of the tube
P_1, P_2 = Pressures at the two ends of the tube]

- equation of continuity
- $\rho v_x \delta y \delta z$ and the mass flowing out through the opposite face

$$= \{\rho v_x + \frac{\partial}{\partial x}(\rho v_x)\delta x\} \delta y \delta z$$

~~the net mass flowing out per sec~~ parallel to the x axis $= \frac{\partial}{\partial x}($

$$\therefore \boxed{(\vec{\nabla} \cdot \rho \vec{v}) \delta x \delta y \delta z}$$

- বার্নোলির উপপাদ্য (Not Prove, only equation)

$$\boxed{\frac{P}{\rho g} + \frac{v^2}{2g} + h = H \text{ (constant)}}$$

[where, $\frac{P}{\rho g}$ = Pressure head, $\frac{v^2}{2g}$ = Kinetic energy, h = gravitation head and H = Total head]

Elasticity

- defination of Stress and Strain
- hook's Law
- Poision's ratio (defination)
- Poision's ratio

$$\boxed{\sigma = \frac{d/D}{l/L}}$$

[where,
σ = poision's ratio
d = change (পরিবর্তন) of radius
D = initial diametre (প্রারম্ভিক ব্যাস)
l = change of length
L = initial length]

- Hook's Law

$$\boxed{\frac{\text{Stress (পীড়ন)}}{\text{Strain (বিকৃতি)}} = \text{constant}}$$

that means, Stress ∝ Strain

- Defination of Stress and Strain

- **Coefficient of viscosity** – The coefficient of viscosity is defined as the force of friction that is required to maintain a difference of velocity of 1cm/s between parallel layers of fluid.

- **Poisson's ratio** – The ratio of the proportional decrease in a lateral measurement to the proportional increase in length in a sample of material that is elastically stretched.

(or) Within the elastic limit, the ratio of lateral strain to the longitudinal strain is called Poisson's ratio.

- What is central force – In classical mechanics, a central force on an object is a force that is direct towards or away from a point called center of force.

- Nuclear force: A^{14} → Atomic No. ; ↓ neutron No.

Isotope → Same proton no.

Isotone → Same neutron No.

Isobar → Same neuclear mass

(definations) (difference between them), (problems)

- Binding energy: amount of energy required to seperate a particle from a system of particles or to disperse all the particles of the system.

- Successive Disintegration: If a parent radioactive nucleus A has numbers of atoms N_0 at time t_0. After disintegration it converts a nucleus B which is further radioactive. Then such type of disintegration is known as successive disin-.

- Bernoulli's equation and conservation of energy

$$\boxed{\frac{1}{2}v^2 + \frac{P}{\rho} + U = \text{Constant}}$$

This is Bernoulli's equation, which express the principle of conservation of mechanics energy, since $\frac{1}{2}v^2$ is the K.E per unit mass, $U = gh$ is the gravitational P.E. per unit mass a height h above the datum level, and $(U + \frac{P}{\rho})$ is the P.E. function per unit mass.

For stationary flow $\frac{\partial\sigma}{\partial t} = 0$ and,

$$\frac{1}{2}\,\text{grad}\, v^2 - |\vec{v}\ \text{curl}\,\vec{v}| = \vec{F} - \frac{1}{\rho}\,\text{grad}\, P$$

not necessary

- Radious of nucleus

$$\boxed{R = R_0 A^{\frac{1}{3}}}$$ [R_0 = Radious of proton]

$R_0 = 1.2 \times 10^{-15}$ m

$$^{222}_{86}A \longrightarrow {}^{210}_{84}\beta$$

$$\begin{array}{r} 222 \\ -210 \\ \hline 12 \end{array}$$

~~86~~ ?

3টে α ও 4টে β টা বেরিয়েছে

4 − 2 কমে
α 2টা
β বেরোলে
+1 2টা

α - decay – $X^A_Z \xrightarrow{-\alpha} X^{A-4}_{Z-2} + He^4_2$

β - decay – $X^A_Z \xrightarrow{-\beta} X^A_{Z+1} + e^0_{-1}$

γ - decay – $X^A_Z \xrightarrow{-\gamma} X^A_Z + \gamma$

• Radioactive decay constant -

$\frac{dN}{dt} \propto N$

$\boxed{\Rightarrow \frac{dN}{dt} = -\lambda N}$ [∵ decay হচ্ছে তাই '-' দেওয়া হল]
[N = Number of atoms]

$\frac{dN}{dt} = -\lambda N$

$\Rightarrow \frac{dN}{N} = -\lambda \, dt$

$t = 0 \longrightarrow N = N_0$

$t = t \longrightarrow N = N$

$\int_{N_0}^{N} \frac{dN}{N} = -\lambda \int_0^t dt$

$\Rightarrow [\log N]_{N_0}^{N} = -\lambda [t]_0^t$

$\Rightarrow \log\left(\frac{N}{N_0}\right) = -\lambda t$

$\Rightarrow \frac{N}{N_0} = e^{-\lambda t}$

$\Rightarrow \boxed{N = N_0 e^{-\lambda t}}$ [λ = decay constant]

• Half life

$t = t_{1/2}$ হলে $N = \frac{N_0}{2}$

$\cancel{\frac{N_0}{2} = \frac{N_0}{2} e^{-\frac{\lambda t_{1/2}}{2}}}$

$\cancel{\Rightarrow e^{-\frac{\lambda t}{2}} = \frac{1}{2}}$

$\cancel{\Rightarrow \frac{\lambda t}{2} = \log 2}$

$\frac{N_0}{2} = N_0 e^{-\lambda t_{1/2}}$

$\Rightarrow e^{-\lambda t_{1/2}} = \frac{1}{2}$

$\Rightarrow \lambda t_{1/2} = \log 2$

$\Rightarrow \lambda t_{1/2} = \log 2$

$\Rightarrow \boxed{t_{1/2} = \frac{0.693}{\lambda}}$

• Nuclear fission (defi) [1টি ভারী ✗ 2টি হালকা]
নিউক্লিয়াস ভেঙে

$\boxed{U^{285}_{92} + {}_0n^1 \longrightarrow La^{148}_{57} + Ba^{85}_{35} + 3\,{}_0n^1}$
(Lanthanum) (Berilium)

1.86 mev energy release হয় এইভাবে (Nuclear fission).
nuclear fission, subdivision of a heavy atomic nucleus.

[এই 3টি দিয়ে U^{285}_{92} কে hit করলে 9টি neutron পাওয়া -- 9টি=27টি পাওয়া --]

• Nuclear fusion (defi) [2টি নিউক্লিয়াস জুড়ে একটি হয়]

${}_1H^2 + {}_1H^2 \longrightarrow {}_2H^3 + {}_0n^1$ [${}_1H^3$ = Tritium]

${}_1H^3 + {}_1H^2 \longrightarrow {}_2He^4 + {}_0n^1$ [${}_1H^2$ = ডয়টেরিয়াম]

3.7 mev energy release হয় এইভাবে।

Nuclear fusion is a reaction in which two or more atomic nuclei are combined to form one or more different atomic nuclei and sub atomic particles.

- uses of radioactive isotopes. Carbon dating

medical diagonosis, research involving - biology and genetics.

i) $_{92}X^{A} \rightarrow {}_{Z}Y^{228} + {}_{2}\alpha^{4}$, Find A, Z

A = 232
Z = 90

$A = 228 + 4 = 232$
$92 = Z + 2$
$\Rightarrow Z = 90$

4 + 228 = 232
92 − 2 = 90

half life

ii) $P_0^{210} \longrightarrow$ 140 days

find the decay constant

~~210~~ =

$t_{1/2} = \frac{0.693}{\lambda}$

$\Rightarrow \lambda = \frac{0.693}{140 \times 60 \times 60 \times 24}\ sec^{-1}$

$= 5.73 \times 10^{-8}\ sec^{-1}$

(iii) $_{92}U^{238} \Rightarrow 8\alpha, 6\beta$ বেরিয়েছে। নতুন element টি কী? $8 \times 4 = 32$

α বেরোলে, $= {}_{90}O^{206}$

β বেরোলে, $_{82}O^{206} \leftarrow$ new element

$_{92}U^{238} \xrightarrow{-8\alpha} {}_{76}U^{206} \xrightarrow{-6\beta} {}_{82}U^{206}$

- Photoelectric effect [definition] → not so imp for all

$$\boxed{E_{max} = \frac{1}{2}mv_{max}^2}$$
$$\boxed{= h\nu - W} \quad -①\ [W = \text{work function}]$$

definition of work function — min amount of energy to release an electron.

- Threshold frequency

$\boxed{h\nu_0 = W}$ [ν_0 = Threshold frequency]

from ①,

$$\boxed{\begin{array}{l} E_{max} = h\nu - h\nu_0 \\ E_{max} = h(\nu - \nu_0) \end{array}}$$

- Stopping Potential / cutoff potential

$eV_0 = E_{max}$

$\Rightarrow eV_0 = h(\nu - \nu_0)$ [V_0 = Stopping potential]

$\Rightarrow V_0 = \frac{h}{e}(\nu - \nu_0)$

(i) the work function of a metal is 3.45 ev. what is the maximum wavelength of a foton that can eject an electron from the metal?

$w = 3.45$ ev

$$\boxed{\begin{aligned} &h(\nu - \nu_0) \\ &= h\left(\frac{c}{\lambda} - \frac{c_0}{\lambda}\right) \\ &E_{max} = h\nu - W \\ &= \frac{hc}{\lambda} - \end{aligned}}$$

$h\nu_0 = W$

$\Rightarrow \frac{hc}{\lambda_0} = 3.45$

$\Rightarrow \lambda_0 = \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{3.45 \times 1.6 \times 10^{-19}}$

$= 3.6 \times 10^{-7} m$

(ii) A metal of work function 3ev is illumin by light of wave lenght 3000 Å. calculate the threshold frequancy and the E_{max}.

$$\boxed{\begin{aligned} &h\nu_0 = W \\ &\Rightarrow \frac{hc}{\lambda} = W \\ &\Rightarrow 6.626 \times 10^{-34} \times 3000 \times 10^{-10} \end{aligned}}$$

3000 Å $= 3000 \times 10^{-8}$ cm

$= 3000 \times 10^{-10}$ m

$c = 3 \times 10^{8}$ m

$\Rightarrow \nu_0 = \frac{W}{h}$

$= \frac{3 \times 1.6 \times 10^{-19}}{6.626 \times 10^{-34}}$

$= 7.2 \times 10^{14}$ HZ

$E_{max} = \cancel{6.626 \times 10^{-34}\left(\frac{3 \times 10^{10}}{3000 \times 10^{-10}} - 7.2 \times 10^{14}\right)}$

$= \frac{hc}{\lambda} - W \quad [\because \nu = \frac{c}{\lambda}]$

$= \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{3000 \times 10^{-10}}$ $\quad w = 6.626 \times 10^{-19} - eV$

$= 1.826 \times 10^{-19}$ $\quad - 3 \times 1.6 \times 10^{-19}$

(ii) Find the frequency of the light which ejects from a metal surface electrons fully stopped by a retarding potention 3 volt. The photoelectric effect begins in this metal atom frequency of 6×10^{14} sec^{-1}. Find the work function for this metal.

V_0 (stopping potential) $= 3V$

ν_0 (threshold frequency) $= 6 \times 10^{14}$

$W = h\nu_0$

$= 6.626 \times 10^{-34} \times 6 \times 10^{14}$

$= 3.97 \times 10^{-19}$ J

$$\boxed{\begin{aligned} &n = \frac{c}{\lambda} \\ &n = \text{frequency} \\ &c = n\lambda \end{aligned}}$$

we know,

$eV_0 = h\nu - W$ [ν = frequency of the light
W = work function
V_0 = Stopping Potential
e = electronic charge]

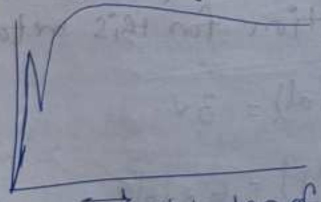
$\Rightarrow \dfrac{eV_0 + W}{h} = \nu$

$\Rightarrow \nu = \dfrac{1.6\times10^{-19}\times3 + 4\times10^{-19}}{6.626\times10^{-34}}$

$= 1.328\times10^{15}$ Hz

• Photoelectric effect – It is a phenomenon in which electrically charged particles are released from or within a material when it absorbs electromagnetic radiation.

• Binding energy curve–



• De-brogly •

• De-brogly hypothisis – De brogly proposed that $P = \dfrac{h}{\lambda}$ relation applies to the meterial particals as well as the photons.

[$E = h\nu$
$P = \dfrac{E}{c} = \dfrac{h\nu}{c}$]

$P = \dfrac{h\nu}{c}$

$\boxed{P = \dfrac{h}{\lambda}}$

• $\boxed{\lambda = \dfrac{h}{mv}}$ → [For a particle of mass m, moving with speed v]

• $\boxed{\lambda = \dfrac{h}{P}}$ [λ = de brogly wavelength]

• $\boxed{P = h^{cut} K}$ → [K = Propagation vector]
(not imp)
[$h^{cut} = \hbar$ (single)]

• $\boxed{K = \dfrac{2\pi}{\lambda}}$

Basic relations of quantum theory { [$\therefore P = \hbar K$] [$E = \hbar\omega$]

• $E = \dfrac{P^2}{2m}$ → [E = kinetic energy]

$\Rightarrow P = \sqrt{2mE}$

$\Rightarrow \dfrac{h}{\lambda} = \sqrt{2mE}$

$\Rightarrow \boxed{\lambda = \dfrac{h}{\sqrt{2mE}}} = \boxed{\dfrac{h}{\sqrt{2meV}}}$

[m = mass
λ = wavelength
e = e⁻ charge
V = Potential difference]

• Hizen burg theorey (Statement) –

$\boxed{\cancel{\Delta x \Delta p \gg h^{cut}}}$ → hizenburg realation for Position and momentum

$\boxed{\Delta x \Delta P \geq \hbar}$

- $\boxed{E = \frac{p^2}{2m}}$

$\Delta E = \frac{2p\Delta p}{2m} = \frac{p\Delta p}{m}$

$= v \cdot \Delta p \quad [p = mv]$

$v = \frac{\Delta x}{\Delta t}$

$\Rightarrow \Delta t = \frac{\Delta x}{\Delta v}$

$\Delta E \times \Delta t = \frac{v \cdot \Delta p \cdot \Delta x}{v}$

$\boxed{\Delta E \Delta t = \Delta p \Delta x \geq h^{cut}}$

hizenburg relation for position and time.

- statement - The position and the velocity of an object cannot both be measured exactly, at the same time.

14/12/21

- Electrostatics

↳ Deals with Static change

$\cdot q$

- Culomb's law

$q_1 \xrightarrow{r_{21}} q_2$ (1 → 2)

Force 1 → 2 হলে F_{21}

$\vec{r_{21}} = |r_{21}| \hat{r}_{21}$

$\vec{F_{21}} \propto q_1 q_2$ —(i)

$\vec{F_{21}} \propto \frac{1}{r_{21}^2}$ —(ii)

By Combining (i) and (ii)

$\vec{F_{21}} \propto \frac{q_1 q_2}{r_{21}^2}$

$\Rightarrow \boxed{\vec{F_{21}} = \hat{r}_{21} \frac{q_1 q_2}{r_{21}^2} \cdot K}$ [Proportional Constant]

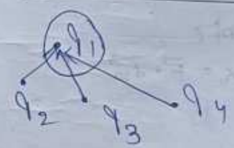
$K = \frac{1}{4\pi\epsilon_0}$ [ϵ_0 = Permittivity Constant]

as, $\vec{r_{21}} = -\vec{r_{12}}$

$\hat{r}_{21} = -\hat{r}_{12}$

$\boxed{\vec{F_{12}} = -K \cdot \frac{q_1 q_2}{r_{21}^2} \cdot \hat{r}_{21}}$

- Principle of superposition



$\boxed{F_i = \sum_{j=2}^{n} \frac{q_i q_j}{r_{ij}} \hat{r}_{ij}}$

[∵ q_1 নিজের উপর কোনো force করে না তাই $\sum_{j=2}^{n}$]

- Electrostatic Potential

workdone by an external agency in bringing a unit positive charge from infinity to that point.

$$\boxed{\phi(b) = -\int_{\infty}^{b} \vec{E} \cdot d\vec{r}}$$

[agency টা যে field এর বিরুদ্ধে জোর করে তাকে কাজ করতে হচ্ছে তাই '-' sing]

- Electrostatic field

$$\boxed{\vec{E} = \lim_{q \to 0} \frac{\vec{F}}{q}}$$

- relation between E.f and Potential

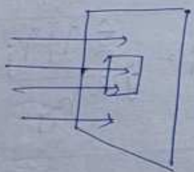
$$\boxed{\vec{E} = -\vec{\nabla} \varphi}$$

$$\vec{\nabla} = \frac{\partial}{\partial x}\hat{i} + \frac{\partial}{\partial y}\hat{j} + \frac{\partial}{\partial z}\hat{k}$$

$$\vec{\nabla} = \frac{\partial}{\partial r}\hat{r}$$

$\boxed{\nabla = \text{gradient}}$

- Flux



electric flux $= \vec{E} \cdot \vec{dr}$

$$\boxed{\text{Flux} = \iint_S \vec{E} \cdot \vec{dr}}$$

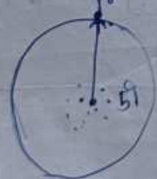
For অনেক ছোট ছোট surface এর সমষ্টি.

if the surface is close,

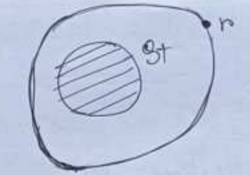
$$\boxed{\text{Flux} = \oiint_S \vec{E} \cdot \vec{dr}}$$

- Guss theorem

$$\boxed{\oiint_S \vec{E} \cdot \vec{ds} = \frac{Q}{\epsilon_0}}$$



(i)



$$\oiint \vec{E} \cdot \vec{ds} = E \cdot 4\pi r^2$$

$$E 4\pi r^2 = \frac{Q}{\epsilon_0}$$

$$\therefore E = \frac{Q}{4\pi\epsilon_0 r^2}$$

$$\Rightarrow \varphi = \int \frac{q}{4\pi r^2 \epsilon_0} dr$$

$$= -\frac{q}{4\pi r\epsilon_0} + C_1$$

at $r = 0, \varphi = 0$

$\therefore C_1 = 0$

$$q = -\frac{\varphi}{4\pi\epsilon_0}$$

$$E = -\nabla\varphi = -\frac{\partial}{\partial r}\varphi$$

$$\int E \cdot dr = -\int \partial\varphi$$

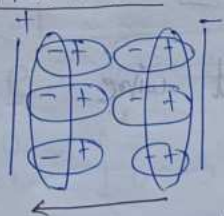
$$\Rightarrow \varphi = \int E \cdot dr$$

- Dipole $\rightarrow \cdot q_1 \overset{l}{- - -} \cdot q-$

Ex —

$\boxed{\text{dielectric meterial - water}}$

- Polarisation



Field of Polarisation

$$\vec{P} \propto \vec{E}$$

$$\boxed{\vec{P} = \epsilon_0 \chi \vec{E}}$$

$\chi \rightarrow$ susceptibility

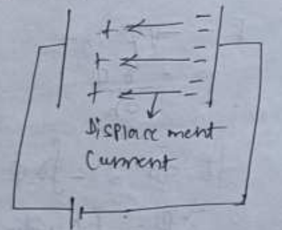
Imp $\boxed{\vec{D} = \epsilon_0 \vec{E} + \vec{P}}$ [$\vec{D} \Rightarrow$ Displacement Current]

$$\vec{D} = \epsilon_0 \vec{E} + \epsilon_0 \chi \vec{E}$$
$$= (\epsilon_0 + \epsilon_0 \chi)\vec{E}$$

$$\boxed{\vec{D} = \epsilon_0 \vec{E}(1+\chi)}$$ (vector quantity)

$[\epsilon_0 (1+\chi) = \epsilon]$

- capacitor



→ capacitor

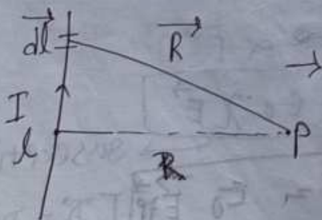
$$\boxed{C = \frac{\epsilon A}{d}}$$ → □ → Rectangular capacitor

$$\boxed{C = \frac{2\pi\epsilon}{\ln \frac{b}{a}}}$$ → cylindrical capacitor

- magnetic effect
- Biot Savart law

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

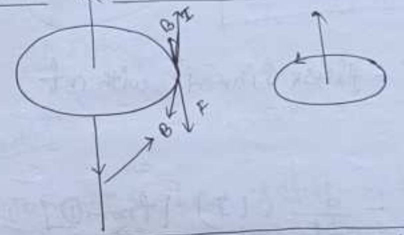
[where
μ_0 = permeability of free space
$d\vec{B}$ = magnetic field at a point]



→ long straight wire

$$\boxed{\oint \vec{B} \cdot \vec{dl} = \mu_0 I}$$

- Ampere's circuital law



- $\boxed{\text{magnetic moment} = \text{current} \times \text{area}}$

$$\boxed{M = IA}$$

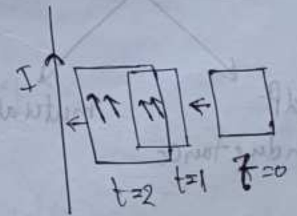
- Faraday's law

- Induced emf in a ckt is $\propto$ to the rate of change of magnetic flux linked with the ckt
- The direction of induced emf is such that it means to oppose the cause of its generation.

$$\boxed{e = -\frac{d\phi}{dt}}$$

$$e = \oint_l E \cdot dl \quad \text{—(i)}$$

$$\phi = \int_S B \cdot ds \quad \text{—(ii)}$$



So,

$$\boxed{\oint_l E \cdot dl = -\frac{d}{dt}\int_S \vec{B} \cdot ds}$$

-  φ = flusk linked with ckt

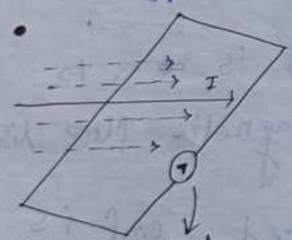
$\varphi = LI$ —(1)

$e = -\frac{d\varphi}{dt} = -\frac{d}{dt}(LI)$ [from (1)]

[L = self inductance]
स्वावेश गुणांक

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

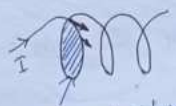
or, ~~$e = \frac{-d\varphi}{dt}$~~
~~$= -\frac{d\varphi}{dt}$.~~

- 

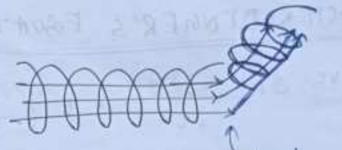
Induced Current

- Inductance

self Inductance — mutual Inductance



Self Inductance



mutual Inductance

suggesation

1) coulumbo's law → statement, mathamatical form
2) electric field, electrostatic Potential (V) → defination, ($\vec{E}$)
Relation between E and V, math related it.
Ex $\vec{E} = -\nabla\varphi$ φ = given (x^2+y^2) → Find E
3) Gauss's law → statement, mathematical form, math related it. $\odot$ —r— E, V
Imp
(The Previous math by A mam (Phy))
4) Defination of dipole and dipole moment
5) paralal Plate capacitor, cylyndrical Capacitor → formula, math related it.
6) Bios savart law → statement, mathemetical form
7) Farady's law → statement
8) self Inductance → about it
9) mutual Inductance
10) maths of this madam's calss

• SCHRODINGER'S EQUATION (N mam)

Wave eqn $\frac{\partial^2 y}{\partial t^2} = c^2\left(\frac{\partial^2 y}{\partial x^2}\right)$

where c is a constant with the dimensions of velocity. This is a differential equation.
In wave mechanics, we introduce a new wave function (ψ), which at every point in space and time can be written as $\psi(x, y, z, t)$

• Properties

(i) ψ, is general is not real but a complex function, i.e it has a real part and an imaginary part.
the square of ψ is interpreted as the probability (per unit volume) that the particle will be found at that point

$$\boxed{\int \psi^2 dv = 1}$$

(ii) ψ is not a measure of any simple physical quantity such as displacement.

(iii) ψ is continuous in space.

• The Schrodinger eq

Consider a particle of momentum P and energy E.

Its wavelength is $\lambda = \frac{h}{p}$ and frequency $\nu = \frac{E}{h}$

wave number $k = \frac{2\pi}{\lambda} = \frac{p}{\hbar}$ $\left[\frac{h}{2\pi} = \hbar\right]$

angular frequency $\omega = 2\pi\nu = \frac{E}{\hbar}$

For a free particle $E = \frac{p^2}{2m} = \frac{k^2\hbar^2}{2m}$

$$\Rightarrow k^2 = \frac{2mE}{\hbar^2}$$

$$\Rightarrow k = \frac{\sqrt{2mE}}{\hbar}$$

[$\hbar$ = Hizenburg const : $\frac{h}{2\pi}$ (or $\hbar$)]

Now if the particle travels in x- dirn then the wave will also travel in the same dirn
The harmonic wave meeting this condn is –

$$\psi(x,t) = e^{-i(\omega t - kx)} \quad \text{in the } x\text{-dirn} \quad \text{— (1)}$$

and $\psi(x,t) = e^{-i(\omega t + kx)}$ in -ve x-dirn

$$\psi = e^{-i(\omega t - kx)} = e^{-i\left(\frac{Et}{\hbar} - \frac{x}{\hbar}\sqrt{2mE}\right)} \quad \text{— (2)}$$

differentiate eqn (2) once with respect to time.

$$\frac{\partial \psi}{\partial t} = -i\frac{E}{\hbar}\psi \quad \text{— (3)}$$

differentiate eq^n ③ twice w.r.t. x

$$\frac{\partial \psi}{\partial x} = i\frac{\sqrt{2mE}}{\hbar}\psi$$

$$\frac{\partial^2 \psi}{\partial x^2} = -\frac{2mE}{\hbar^2}\psi \quad \text{— (4)}$$

Comparing eq^n ③ and ④

$$\boxed{-\frac{\hbar^2}{2m}\cdot\frac{\partial^2}{\partial x^2}\psi(x,t) = i\hbar\frac{\partial}{\partial t}\psi(x,t)}$$

↓

The time dependent Schrodingers eq^n in one dimension.

If the particle is (আৱদ্ধ) restricted the presence of a force represented by some given potential energy function $v(x,t)$ then –

$$\frac{\hbar}{i}\frac{\partial \psi}{\partial t} = \frac{\hbar^2}{2m}\cdot\frac{\partial^2 \psi}{\partial t^2} - v(x,t)\psi$$

• Energy and momentum operator

Consider a particle of mass m moving in the +ve X direction. The potential energy of the particle is v. momentum is p and total energy is E. For the free particle wave eq^n is

$$\psi = Ae^{-i(\omega t - kx)} = Ae^{-\frac{i}{\hbar}(Et - px)} \quad \text{— ①}$$

• differentiate partially w.r.t. t

$$\frac{\partial \psi}{\partial t} = -\frac{iE}{\hbar}\psi$$

$$\Rightarrow E\psi = -\frac{\hbar}{i}\frac{\partial \psi}{\partial t} \; ; \Rightarrow E\psi = \frac{i^2 \hbar}{i}\cdot\frac{\partial \psi}{\partial t}$$

$$\Rightarrow E\psi = i\hbar\frac{\partial \psi}{\partial t} \quad \text{— ② [Eq^n ② energy operator]}$$

Similarly partially differentiating ① w.r.t. x

$$\frac{\partial \psi}{\partial t} = +\frac{ip}{\hbar}\psi$$

$$\Rightarrow p\psi = \frac{\hbar}{i}\frac{\partial \psi}{\partial x} \; ; \Rightarrow p\psi = \frac{-1\cdot\hbar}{-i}\frac{\partial \psi}{\partial x} \; ; \Rightarrow p\psi = \frac{i^2\hbar}{-i}\frac{\partial \psi}{\partial x}$$

$$\Rightarrow p\psi = -i\hbar\frac{\partial \psi}{\partial x} \quad \text{— ③}$$

• Time independent Schrodinger's eq^n

According to classical mechanics, the total energy of the particle is

$$E = K.E + P.E$$
$$= \frac{1}{2}mv^2 + v$$
$$= \frac{p^2}{2m} + v$$

multiplying both sides by ψ

$$E\psi = \left(\frac{p^2}{2m} + V\right)\psi$$

$$E\psi = -\frac{\hbar^2}{2m} \cdot \frac{\partial^2 \psi}{\partial x^2} + V\psi$$

$$\frac{\hbar^2}{2m} \cdot \frac{\partial^2 \psi}{\partial x^2} = V\psi - E\psi$$

$$\frac{\hbar^2}{2m} \frac{\partial^2 \psi}{\partial x^2} + (E-V)\psi = 0$$

$$p\psi = -i\hbar \frac{\partial \psi}{\partial x}$$

$$\frac{\partial^2 \psi}{\partial x^2} = \frac{i^2 p^2}{\hbar^2}\psi = \frac{-p^2}{\hbar^2}\psi$$

$$-\hbar^2 \frac{\partial^2 \psi}{\partial x^2} = p^2 \psi$$

$$\boxed{\frac{\partial^2 \psi}{\partial x^2} + \frac{2m}{\hbar^2}(E-V)\psi = 0}$$

time independent Schrodinger's eqn for 1D particle.

$$\boxed{\left(\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} + \frac{\partial^2 \psi}{\partial z^2}\right) + \frac{2m}{\hbar^2}(E-V)\psi = 0}$$

This is for 3D particle

- **Particle in a box**

The walls of the box are assumed to be perfectly elastic, and rigid and the particle moves freely between these walls

If the particle has energy E and momentum $p = \sqrt{2mE}$ then the harmonic waves travelling to the right and left along the x-axis are respectively $= e^{-i\left(\frac{Et}{\hbar} - \frac{x}{\hbar}\sqrt{2mE}\right)}$ and $e^{-i\left(\frac{Et}{\hbar} + \frac{x}{\hbar}\sqrt{2mE}\right)}$

From superposition principle

$$\psi(x,t) = Ae^{-i\left(\frac{Et}{\hbar} - \frac{x}{\hbar}\sqrt{2mE}\right)} + Be^{-i\left(\frac{Et}{\hbar} + \frac{x}{\hbar}\sqrt{2mE}\right)} \quad \text{— (1)}$$

A, B are constants,

At $x=0$ and $x=L$, ψ must be zero at all times

Thus $\psi(0,t) = 0$ at $x=0$ — (2)
$\psi(L,t) = 0$ at $x=L$ — (3) } Boundary condn

These two are the boundary condn.

From eqn (2) and (3), we obtain from eqn (1)

$$Ae^{-iEt/\hbar} + Be^{-iEt/\hbar} = 0 \text{ at } x=0 \quad \text{— (4)}$$

and

$$Ae^{-i\left(\frac{Et}{\hbar} - \frac{L}{\hbar}\sqrt{2mE}\right)} + Be^{-i\left(\frac{Et}{\hbar} + \frac{L}{\hbar}\sqrt{2mE}\right)} = 0$$

at, $x=L$ — (5)

From eqn (4) we obtain $B = -A$

and then eqn (5) reduces to

$$Ae^{-\frac{iEt}{\hbar}}\left(e^{\frac{iL}{\hbar}\sqrt{2mE}} - e^{-\frac{iL}{\hbar}\sqrt{2mE}}\right)=0$$

this equation is equal to

$$2iA\sin\left(\frac{L}{\hbar}\sqrt{2mE}\right)=0$$

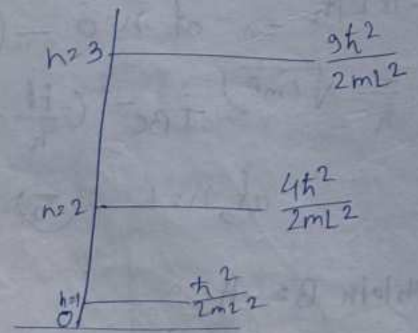
$$\sin\theta = \frac{e^{i\theta}-e^{-i\theta}}{2i}$$

this demands that ($\sin\theta=0$, if $\theta=0,\pi,2\pi$ sin function be an integer multiple of π.)

$$\frac{L}{\hbar}\sqrt{2mE}=n\pi$$

$$E_n = \frac{n^2\pi^2\hbar^2}{2mL^2} \quad -⑥ \quad n=1,2,3$$

eq^n ⑥ shows that the energies of the particle in a box are quantized. The lowest energy is obtained by ~~Sett~~ putting $n=1$ called the energy of the ground state. $E_1=\frac{\pi^2\hbar^2}{2mL^2}$



∵ Since we have $B=-A$ eq^n ⑤ can be rewritten as—

$$\psi(x,t) = Ae^{-i\left(\frac{Et}{\hbar}-\frac{x}{\hbar}\sqrt{2mE}\right)} - Ae^{-i\left(\frac{Et}{\hbar}+\frac{x}{\hbar}\sqrt{2mE}\right)}$$

$$= Ae^{-\frac{iEt}{\hbar}}e^{\frac{ix}{\hbar}\sqrt{2mE}} - Ae^{-\frac{iEt}{\hbar}}e^{-\frac{ix}{\hbar}\sqrt{2mE}}$$

$$= Ae^{-\frac{iEt}{\hbar}}\left[e^{\frac{ix}{\hbar}\sqrt{2mE}} - e^{-\frac{ix}{\hbar}\sqrt{2mE}}\right]$$

$$= Ae^{-i\frac{n^2\pi^2\hbar^2 t}{2mL^2}}\left[e^{ix\sqrt{\frac{n^2\pi^2}{L^2}}} - e^{-ix\sqrt{\frac{n^2\pi^2}{L^2}}}\right]$$

$$= Ae^{-\frac{in^2\pi^2\hbar t}{2mL^2}}\left[e^{ix\cdot\frac{n\pi}{L}} - e^{-ix\cdot\frac{n\pi}{L}}\right]$$

$$= Ae^{-\frac{in^2\pi^2\hbar t}{2mL^2}}\sin\left(\frac{n\pi x}{L}\right)\cdot 2i$$

$$\boxed{\psi(x,t) = 2iAe^{-\frac{in^2\pi^2\hbar t}{2mL^2}}\sin\left(\frac{n\pi x}{L}\right)}$$

contains a time-dependent part and space dependent part.

If we consider only the spatial part

$$\psi(x) = A\sin\frac{n\pi x}{L}$$

From normalization condition

$$\int_0^L \psi^2(x)\,dx = 1$$

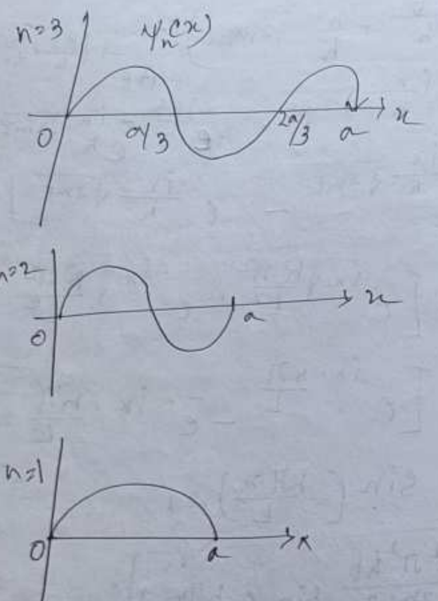
$$|A^2|\int_0^L \sin^2\frac{n\pi x}{L}\,dx = 1$$

$$|A^2|\cdot\frac{L}{2}=1$$

$$A=\sqrt{\frac{2}{L}}$$

$$\therefore \boxed{\psi_n(x) = \sqrt{\frac{2}{L}}\sin\frac{n\pi x}{L}}$$

→ expression in box is final wave function for a particle in box imp $\psi(x) = \sqrt{\frac{2}{L}} \sin\left(\frac{n\pi x}{L}\right)$



① A Proton is confined in an infinite square well of width 10 fm. Calculate the energy of the Photon emitted when the Photon undergoes a transition from the first excited state (n=2) to the ground state (n=1)

$$E_n = \frac{n^2 \hbar^2}{2mL^2}$$

$$E = E_2 - E_1 = \frac{4\hbar^2}{2mL^2} - \frac{\hbar^2}{2mL^2} = \frac{3\hbar^2}{2mL^2}$$

H/W

② A Particle with mass m is in an infinite square well Potential with the walls at $x = -L/2$ and $x = L/2$ write down the wave functions for the states $n=1$, $n=2$ and $n=3$

at $x = -\frac{L}{2}$

the wave functions are,

for $n=1$

$$\psi\left(-\frac{L}{2}\right) = \sqrt{\frac{2}{L}} \sin\left(\frac{-1\cdot\pi\cdot L}{2\cdot L}\right)$$

$$= -\sqrt{\frac{2}{L}} \sin\left(\frac{\pi}{2}\right)$$

$$= -\cancel{8.126\times10^{3}} \sqrt{\frac{2}{L}}$$

for $n=2$

$$\psi\left(-\frac{L}{2}\right) = \sqrt{\frac{2}{L}} \sin\left(-\frac{2\cdot\pi\cdot L}{2\cdot L}\right) = 0$$

for $n=3$

$$\psi\left(-\frac{L}{2}\right) = \sqrt{\frac{2}{L}} \sin\left(-\frac{3\cdot\pi\cdot L}{2\cdot L}\right) = +\sqrt{\frac{2}{L}}$$

at $x = \frac{L}{2}$

the wave functions are,

for $n=1$

$$\psi\left(\frac{L}{2}\right) = \sqrt{\frac{2}{L}} \sin\left(\frac{1\cdot\pi\cdot L}{2\cdot L}\right) = \sqrt{\frac{2}{L}}$$

for $n=2$

$$\psi\left(\frac{L}{2}\right) = \sqrt{\frac{2}{L}} \sin\left(\frac{2\pi\cdot L}{2\cdot L}\right) = 0$$

for $n=3$

$$\psi\left(\frac{L}{2}\right) = \sqrt{\frac{2}{L}} \sin\left(\frac{3\cdot\pi\cdot L}{2\cdot L}\right) = -\sqrt{\frac{2}{L}}$$

2

• Kinetic energy (A man)

Imp • Assumptions (অনুমান) of the kinetic theory

1) A gas consists of a large number of identical molecules which are like minute hard elastic spheres constantly moving about in all possible directions with different velocities in a random fashion.

2) During the motion, the molecules collide with one another and also with the walls of the container, the collisions being perfectly elastic, in other words, there is no loss of K.E when the collisions occur. As the chance of collision in all directions is the same, the collisions do not affect the molecular density.

3) The collisions are essentially instantaneous, that is, the duration of a collision is insignificant compared to the time between collisions.

4) The ~~collisions~~ are es molecules exert no forces (attraction or repulsion) on one another except when they actually collide; that is, between two successive collisions they move in straight lines with uniform.

5) Since the molecules are like geometrical mass-points, the actual volume occupied by them is negligible compared to the total volume of the gas (that is, of the container)

• Basic eqn for kinetic energy

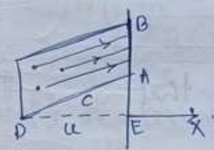
Imp • Perfect gas eqn

any velocity 'c' of a particle in space can be resolved into components u, v, ω along the three axes such that

$$\boxed{c^2 = u^2 + v^2 + \omega^2}$$

the limit of u, v and ω are from $-\infty$ to $+\infty$ those of c are from 0 to ∞.

Now, u suffers a change in direction on reflection from the wall BAE, the other two components v and ω remain uncharged by this type of reflection. The change in momentum per reflection of a molecule is $mu - (-mu) = 2mu$.



If n_u be the number of molecules per unit volume moving with velocity u, the number striking unit area of the wall in time dt would be contained in a cylinder of cross-sectional area unity and a vertical hight udt.

∴ volume of the cylinder $= udt$

∴ No. of molecules in the cylinder $= n_u dt$

∴ change in momentum/area suffered by the above molecules in time dt is $- 2mu \times n_u u dt$

∴ The above quantity for all the molecules moving in the positive x-direction, that is, total change in momentum per unit area is

$$2m\sum_0^\infty n_u u^2 dt$$

If the above change is momentum results in average force $\delta\vec{F}$, then $\delta\vec{F} dt = 2m\sum_0^\infty n_u u^2 dt \Rightarrow \delta\vec{F} = 2m\sum_0^\infty n_u u^2$

Since the area involved is unity, $\delta\vec{F}$ is the pressure P. Therefore, $P = 2m\sum_0^\infty n_u u^2$

where n_u is function of u.
Let $\overline{u^2}$ be the mean square velocity along x, so that we may write,

$$\overline{u^2} = \frac{n_1u_1^2 + n_2u_2^2 + \cdots + n_mu_m^2 + \cdots}{n_1 + n_2 + \cdots + n_m + \cdots} = \frac{\sum n_iu_i^2}{\sum n_i} = \frac{\sum n_iu_i^2}{n/2}$$

The factor $\frac{1}{2}$ arises due to the fact that only the molecules in the positive x direction are being considered

$\therefore \sum_0^\infty n_u u^2 = \frac{1}{2} n\overline{u^2}$, where n = total no of molecules per unit volume

$\therefore P_x = 2m \times \frac{1}{2} n\overline{u^2} = mn\overline{u^2}$, Similarly, $P_y = mn\overline{v^2}$ and $P_z = mn\overline{w^2}$

$\therefore$ The expression for the pressure is

$$P = P_x = P_y = P_z = mn\overline{u^2} = mn\overline{v^2} = mn\overline{w^2}$$

But $\overline{u^2} = \overline{v^2} = \overline{w^2} = \frac{1}{3}\overline{c^2}$ where $\overline{c^2}$ is the mean square velocity of the molecules. $\therefore \boxed{P = \frac{1}{3}mn\overline{c^2} = \frac{1}{3}mnc^2}$

where $c = (\sqrt{\overline{c^2}})$ is r.m.s velocity of the molecules. The above expression may also be written as $\boxed{P = \frac{1}{3}\rho c^2}$ where $\rho = mn$ = density of gas.

- **Boyle's law – From the Pressure equation**

we have $P = \frac{1}{3}\rho c^2$

If m' be the mass of a gas that occupies a volume V, $\rho = m'/V$

$$P = \frac{1}{3}\frac{m'}{V}c^2$$

$$\Rightarrow PV = \frac{1}{3}m'c^2$$

At constant temperature T, c^2 is a constant

$\therefore PV$ = constant

which is Boyle's law. This formula is called the eqn of an isotherm. So graphs of P v/s V for different T called isotherms, are rectangular hyperbolas.

Pg-31 this have to learn
Assumptions, deduction of perfect gas eqn, " "
Pressure eqn,
Boyle's law,
Charle's law/Gay Lussac law
Clapeyron's eqn

- **Clapeyron's equation**

we have Pressure

$$P = \frac{1}{3}mnc^2 = \frac{1}{3}\frac{n}{N_A} \cdot mN_A c^2$$

$(N_A$ = Avogadro no$)$

$$= \frac{1}{3}\frac{n}{N_A}Mc^2 = \frac{n}{N_A}PV = \frac{n}{N_A}RT$$

$(\because M = mN_A$ = mol. weight and $PV = \frac{1}{3}Mc^2 = RT)$

Avogadro No, R, Boltzman's constant – values pg-(34)

$(\because R/N_A = K$ = Boltzmann constant$)$

which is Clapeyron's eqn, an useful expression.

- Gay-Lussac law (Charles' law) –

$$PV \propto c^2; \text{ but } c^2 \propto T$$

$\therefore PV \propto T \Rightarrow V/T$ = Constant, at constant P.

This equation, called an eqn of an isobar, expresses the well-known Gay-Lussac law (or Charle's law). The graph of the isobar is plainly a straight line emerging from the origin.

2.9.2

- $$\boxed{\rho = N\left(\frac{m}{2\pi KT}\right)^{3/2}} \boxed{e^{-mc^2/2KT}}$$

(Concept of Probability)

[N = Total no of molecules
m = mass of single molecules
K = Boltzmann Constant
T = Temperature in kelvin]

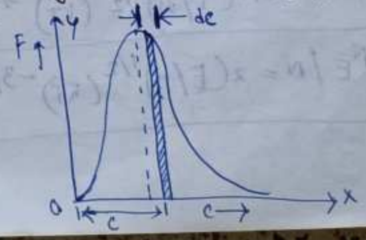
- $$dN_c = \rho \cdot 4\pi c^2 \cdot dc$$

$$dN_c = 4\pi N\left(\frac{m}{2\pi KT}\right)^{3/2} e^{-mc^2/2KT} c^2 dc$$

Gausion distribution / maxwell's distribution law velocity or speed

[where dN_c = no of molecules]

- Plot of the function F against C: Distribution curve of molecular speed –



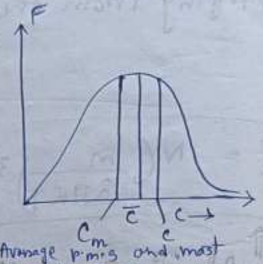
Pg-42
2.11, 2.6

- Ratio of the three speeds.

$$\bar{c} : C : C_m = \sqrt{\frac{8KT}{\pi m}} : \sqrt{\frac{3KT}{m}} : \sqrt{\frac{2KT}{m}}$$

$$= \sqrt{8/\pi} : \sqrt{3} : \sqrt{2}$$

[$\bar{C}$ = average velocity
C = r.m.s velocity
C_m = most probable velocities]



Average r.m.s and most probable speeds

So, $\frac{\bar{c}}{c} = \sqrt{\frac{8}{3\pi}} = 0.921$

$\frac{C_m}{C} = \sqrt{\frac{2}{3}} = 0.817$

Thus, the ratio of the speeds in the ascending order is

$C_m : \bar{C} : C = 1 : 1.128 : 1.224$

- The distribution of Kinetic energy

Plot graph
2.11.4 expression

$$\cancel{dN_c = 4\pi N \left(\frac{m}{2\pi KT}\right)^{3/2} e^{-mc^2/2KT} c^2 dc}$$

$$dN_E = 4\pi N \left(\frac{m}{2\pi KT}\right)^{3/2} e^{-E/KT} \cdot \frac{2E}{m} \frac{dE}{\sqrt{2mE}}$$

$$= 2N (E/\pi)^{1/2} (KT)^{-3/2} e^{-E/KT} dE$$

$$\therefore \boxed{dN_E / N = 2(E/\pi)^{1/2} (KT)^{-3/2} e^{-E/KT} dE}$$

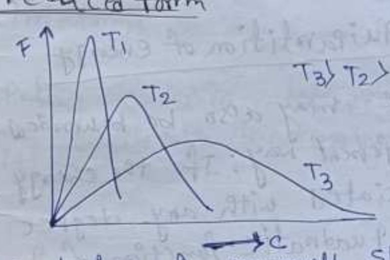
2.11.3

- Momentum distribution

$$\boxed{dN_p = 4\pi N (2\pi m KT)^{-3/2} e^{-mp^2/2KTm^2} p^2 dp}$$

2.12.1

- ~~Tem~~ Velocity distribution: temperature dependence and reduced form



Broadening of maxwell speed distribution curve with temperature

Temperature dependence – If we integrate the expression for the fraction of molecules having a specified velocity between c and $c+dc$, i.e.

$\frac{dN_c}{N} = 4\pi (m/2\pi KT)^{3/2} e^{-mc^2/2KT} c^2 dc$ for all the possible values of it, we w.r.t. 'c' should get 1.

$\therefore \int_0^\infty 4\pi (m/2\pi KT)^{3/2} e^{-mc^2/2KT} c^2 dc = 1$

This implies that the integral $\int_0^\infty F dc = 1$

This means that the area under the distribution curve of molecular velocity i.e F vs C plot is unity.

[PS-417]

• Degrees of freedom of a dynamical system

The no. of independent coordinates necessary for specifying the position and configuration in space of a dynamical system.

• Principle of equipartition of energy (classical)

~~Each~~ The principle may also be reworded in a slightly different way: If the energy of a system associated with any degree of freedom is a quadratic function of the variable specifying the degree of freedom (that is proportional to the square of coordinate or component of a velocity), then in a state of thermal equilibrium of the system at a temperature T, the mean value of the corresponding energy equals $\frac{1}{2}kT$

• EX – Monoatomic gas – For a gas whose molecules are monoatomic and for which the energy is wholly kinetic energy of translation, the degrees of freedom $f = 3$

$C_V = \frac{1}{2} f R = \frac{3}{2} R$

$\gamma = 1 + \frac{2}{f} = 1 + \frac{2}{3} = \frac{5}{3} = 1.67$

Diatomic gas – Number of degrees of freedom $f = 3N - m = 3 \times 2 - 1 = 5$

the molecule has two rotational degrees of freedom.

$\therefore C_V = \frac{1}{2} f R = \frac{5}{2} R = 2.5R$

$\gamma = 1 + \frac{2}{5} = \frac{7}{5} = 1.40$

• For a diatomic atom degrees of freedom is 5.

" " triatomic " " " " " 6.

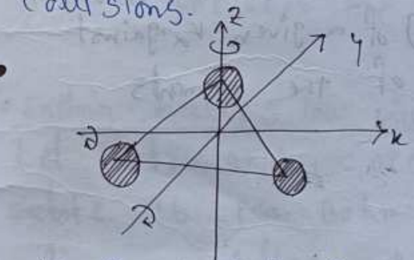
Imp

• Free Path – distance between the two successive collision. the path traversed by the molecule

Imp

• Mean free path – ~~A of~~ a mean free path λ of a molecule is the average distance traversed by it between two successive collisions.

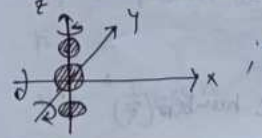
•



$m = 3,\ N = 3 \times 3 = 9$

$\therefore f = 3N - m = 9 - 3 = 6$

If, this balls [●] are in the same line such that,



, then $m = 2,\ N = 3 \times 3 = 9$

$f = 3 \times 3 - 2 = 9 - 2 = 7$

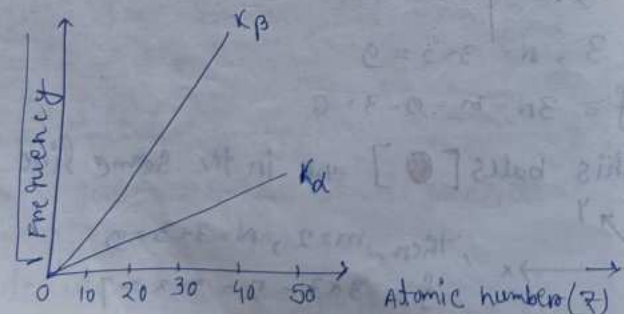
Imp

(1) Assumptions of K.T.
(2) Reduce the eqn of perfect gas - maths related this
(3) Boly's law, charl's law, clepyron's law from the gas eqn - prove that. - maths releated this.
(4) values of ...
(5) three distribution's and corresponding plat.
(6) the ratio of three
(7) Tem. dependance on velocity distribution
(8) Degrees of freedom - defination
(9) Equipartision of energy - derive bout
(10) mono di, tri atomic's degres of freedom - বাদ দেওয়া
(11) Free path, mean free path - defination.

- solide state physics (N mam)

- mosley's Law

In 1913 mosley plotted the square root of the frequencies ($\sqrt{\nu}$) of a given K_α against the atomic number(Z) of the elements emitting that line.



The same linear relation was found to hold good for any line in any series. Therefore he concluded that atomic number in the fundamental property of elements.

Imp mosley's law - The frequency of a spectral (statement) line in X-ray spectrum varies as the square of the atomic no. of the element emmitting it

$\nu \propto Z^2$

mosley's law can be written as

Imp $\boxed{\sqrt{\nu} = a(Z-b)}$

Here 'Z' is the atomic no. of the element and 'a' and 'b' are constants depending upon the particular line.

Imp • Explain mosley's law with bohr's theory

Let a transition occur from n_1 to n_2 state as per Bohr's theory. the energy of an emitted photon is -

$$h\nu = RCh Z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

n_1 = quantum no. of final energy level

n_2 = " " initial "

ν = freqn for the K_α lines

Z = atomic no

R = Rydberg cons

$$\nu = RCZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\Rightarrow RC\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = \frac{\nu}{Z^2}$$

$$\Rightarrow \nu = a^2 Z^2 \quad \left[\because RC\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = a^2\right]$$

$$\Rightarrow \sqrt{\nu} = aZ$$

[For K_α emission, one of the two K electrons is first emitted leaving a single electron in the K-shell. The negative charge of thin residual electrons partially screens the nuclears charge ($Z \cdot e$) of the atom)

Now due to the effective coulomb force, it becomes $(Z-1)e$

Now $Z^2 \longrightarrow (Z-1)^2$

so, $\nu = a^2(Z-1)^2$

For K_α emission, $n_1 = 1$, $n_2 = 2$

$$\nu = Rc\left(\frac{1}{1^2} - \frac{1}{2^2}\right)(Z-1)^2$$

$$\Rightarrow \nu = \frac{3}{4}Rc(Z-1)^2$$

$$\Rightarrow \sqrt{\nu} = \sqrt{\frac{3Rc}{4}}\,(Z-1) \quad \text{—(1)}$$ (approximately corresponding to mosely's law)

We know, $\sqrt{\nu} = a(Z-1)$ —(2)

comparing (1) and (2) $a = \sqrt{\frac{3RC}{4}}$

$b = 1$

(1) If λ_{cu} is the wavelength of K_α x-ray line of copper ($Z=29$) and λ_{mo} is the wavelength of the K_α x-ray line of molybdenum ($Z=42$). Find the ratio of $\lambda_{cu}/\lambda_{mo}$

$\Rightarrow$ we know for K_α line

$$\nu = \frac{3}{4}RC(Z-1)^2$$

$$\frac{1}{\lambda} = \frac{3}{4}R(Z-1)^2$$

$$\frac{\lambda_{cu}}{\lambda_{mo}} = \frac{(Z_{mo}-1)^2}{(Z_{cu}-1)^2} = \frac{(42-1)^2}{(29-1)^2}$$

$$= \frac{\cancel{28^2}}{\cancel{41^2}} = \frac{41^2}{28^2}$$

$$= 2.14$$

Imp • Importance of mosley's law

mosley's law is imp. as it proved that the atomic no. is a more fundamental property of elements and not atomic mass.

Imp (2) Characteristic x-rays of frequency 4.2×10^{18} Hz are produced when transitions from L to K-shell take place in a certain target material

$$\frac{1}{\lambda} = R(Z-1)^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$\boxed{\begin{matrix} K \rightarrow L \rightarrow M \rightarrow N \\ 1 \quad 2 \quad 3 \quad 4 \end{matrix}}$

$$\Rightarrow \frac{\nu}{c} = 1.1\times10^7 \times (Z-1)^2\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$$

$$\Rightarrow Z = 42$$

$[c = 3\times10^8]$

$[\nu = 4.2\times10^{18}\ Hz]$

Imp → (short Qn)
• Contribution from mosley's Law

Mosley's work helped to perfect the periodic table by –
(i) The discovery of new elements hafnium(72), illinium (61), rhenium (75) etc.
(ii) the determination of the atomic no. of rare earths and fixing their positions in the periodic table.

• Crystal

A solid of definite shape with its atomes, ions or molecules arranged in some regular repetitious three dimentional pattern is termed as a Crystal

• Crystalline Solid

The crystalline state of a solid is characterised by regular and periodic arrangement of atoms or molecules.

• Amorfos Solid – without any regular form

• Latice – Periodic arrangements of crystals in atom.

• why are most solids crystaline?
The energy released during formation of an ordered structure is more than that released during the formation of disordered structure thereby making the crystaline state and low energy state.

• Difference between crystalline and amorphous Solid –
(i) Crystalline solid has long range order whereas an amorphous solid has only a short range order.
(ii) crystalline solid is anisotropic in character wherease amorphous solid is isotropic in character.
(iii) crystalline solids have sharp melting points whereas in amorphous solids there is a gradual softening of the meterial.

• why x-rays are used for crystal structure analysis?
x-rays are used for producing diffraction effect in crystals due to the fact that wavelength of x-rays is comparable to the interatomic distences in actual crystals.

Example -

$eV = h\nu = \frac{hc}{\lambda}$

$\lambda = \frac{hc}{eV}$

For $V = 10 KV$, $\lambda = \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{1.6 \times 10^{-19} \times 10 \times 10^{3}}$

$= 1.24 \times 10^{-10} m$

$= 1.24 Å$

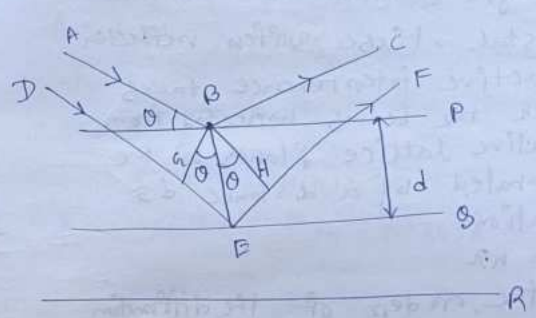
This wavelength is comparable to the inter atomic spacing of an actual crystal.

For (as short an)

- visible or ultra violet light has a larger wavelength. Those waves gives rise to familiar effects of optical reflection and refraction. Therefore, cannot be used for exploring the crystal.

- The wavelength of gamma rays is much smaller than that of x-rays, therefore γ-rays are diffracted through very small angles which cannot be conveniently measured.

- Bragg's law



Consider parallel lattice planes equidistance from one another in a crystal structure, separated by a distance d.

Path difference between the two wave fronts $= GE + EH$

Now in $\triangle BGE$

$GE = BE \sin\theta = d\sin\theta$

and in $\triangle BEH$, $EH = BE \sin\theta = d\sin\theta$

$\therefore$ Path difference $= GE + EH = 2d\sin\theta$

If this path difference is an integral multiple of wavelength λ, constructive interference ~~of waveleng~~ will take place between the reflected beams. Thus the intensity will be maximum if -

$2d\sin\theta = n\lambda \qquad n = 1, 2, 3$

↓

Bragg's eqn and ~~rep~~ represents Bragg's law.

Bragg's equation : When x-rays of wavelength λ are incident on a crystal surface making an angle θ with the surface of the crystal, these suffer reflection and constructive interference takes place between the beams reflected from two consecutive lattice planes of the crystal separated by a distance d, Then the relation–

$$2d\sin\theta = n\lambda$$

Where n is the order of the diffraction spectrum maxima, is known as Bragg's equation.

The law represented by Bragg's equation

$$2d\sin\theta = n\lambda$$

is known as Bragg's law.

(1st text is the statement of Bragg's law)

Ex–
Im

(1) The spacing between successive (100) Planes in NaCl is 2.82 Å. x-rays incident on the surface of the crystal is found to give rise to first order Bragg reflection at glancing angle 8.8°. Calculate the wavelength of x-rays.

According to Bragg's law $2d\sin\theta = n\lambda$

$d = 2.82\,Å = 2.82 \times 10^{-10}\,m$

$\theta = 8.8°$ $\therefore \sin\theta = 0.153$

$n = 1$

$2d\sin\theta = n\lambda$

$\Rightarrow 2 \times 2.82 \times 10^{-10} \times 0.153 = \lambda$

$\Rightarrow \lambda = 0.863 \times 10^{-10}\,m = 0.863\,Å$

(2) X-rays of wavelength 1.5 Å make a glancing angle of 16° in the first order when diffracted from NaCl crystal. Find the lattice constant of NaCl.

$2d\sin\theta = n\lambda$ $\lambda = 1.5 \times 10^{-10}\,m$

$n = 1$

$\theta = 16° \Rightarrow \sin\theta = 0.2756$

$$d = \frac{n\lambda}{2d\sin\theta} = \frac{1 \times 1.5 \times 10^{-10}}{2 \times 0.2756}$$

$= 2.72 \times 10^{-10}\,m$

$= 2.72\,Å$

1st form 2 Below
& 2nd form the next time

- magnetic Properties(RSir)

- magnetism

1) magnetism is a phenomenon by which a material exerts either attracti-ve repulsive force on another.

2) Basic source of magnetic force is movement of electrically charged Particles. thus magnetic behaviour of a material can be traced to the structure of atoms.

3) Electrons in atoms have a Planetary motion in that they go around the nucleus. this orbital motion and its own spin ~~stin~~ cause separate magnetic moments, which contribute to the magnetic behaviour of materials. thus every material can respond to a magnetic field.

4) However, the manner is which a material responds depend much on its atomic structure, and determines whether a material will be strongly or weakly magnetic

- Bohr magneton

- magnetic moment due to spin of an electron is known as Bhor magneton m_B.

$$m_B = \frac{qh}{4\pi m_e} = 9.274 \times 10^{-24}\ A \cdot m^2$$

- where q is the charge on the electron, h – planck's constant, m_e – mass of e^-
- Bohr magnetons is the most fundamental magnetic moment.

- why not all materials are magnets?
- As every material consists spinning electrons each of them could be a magnet. Fortunately not so!
- There are two reasons for it.
- First: according to Pauli exclusion rules two electrons with same energy level must have opposite spins – thus so are their magnetic moments, which cancle out each other.
- Second: orbital moments of electrons also cancle out each other – thus no net magnetic moments if there is no unpaired electrons.

- Some e^- ~~ab~~ such as transition ~~electron~~ elements, lanthanids and actinides have a net magnetic moment since some ~~moment~~ s of their energy levels have an unpaired electron.

- <u>magnetic dipols</u>
- magnetic dipoles are found to exist in magnetic materials, analogous to electric dipoles.
- A magnetic dipole is a small magnet composed of north and south poles instead of positive and negative charges.
- within a magnetic field, the force of field exerts ~~a~~ a torque that tends to orient the dipoles with the field.
- ~~magnetic field, the force of field exerts~~

magnetic forces are generated by moving electrically charged particles. These forces are in addition to any electrostatic forces that may already exist.

- It is convenient to think magnetic forces in terms of distributed field which is represented by imaginary lines. these lines also indicate the direction of the force.

- <u>magnetic field</u>
- If a magnetic field is generated by passing current I through a coil of length l and number of turns n, then the magnetic field strength, H (units A/m) is given by
  (চৌম্বক প্রাবল্য)

$$H = \frac{nI}{l}$$

magnetic flux density (induction) is the measure of lines within a medium. It has units as weber (Wb)/m^2 or tesla and it is defined as

$$B = \mu H$$

(চৌম্বক-ভেদ্যতা)

- where μ - permeability. It is a specific property of the medium, and has units Wb/A·m or henry (H)/m
- Relative magnetic permeability, is defined as $\mu_r = \frac{\mu}{\mu_0}$
  (আপেক্ষিক চৌম্বক ভেদ্যতা)
- μ_r is a measure of the degree to which the material can be magnetized.
- where μ_0 - magnetic permeability of vacuum.

If M = magnetization defined as
M . is defined as $M = \chi H$ then
$B = \mu_0 H + \mu_0 M$
$= \mu_0 \mu_0 H$

mechanics of Particle (N mass) (for exam)

~~vector con cross product, dot product~~

- ① Center of mass (defi.)
② Conservation of linear momentum
③ Conservation of angular momentum — derivation
④ Total energy (2.9.8 expression)

① Coulomb's law - The magnitude of the electrostatic force of attraction or repulsion between two point charge is directly proportional to the product of the magnitudes of charges and inversely proportional to the square of the distance between them.

② Electrostatic potential - The amount of work energy needed to move a unit of electric charge from a reference point to the specific point in an electric field. (time)

[Another definition]

Electric field - An electric property associated with each point in space when charge is present in any form.

③ Gauss law statement - It states that the net flux of an electric field in a closed surface is directly proportional to the enclosed electric charge. yet another statement of Gauss's law states that the net flux of a given electric field through a given surface, divided by the enclosed charge should be equal to a constant.

④ Dipole moment - The product of internuclear distance between bonded atoms and charge present in bonded atoms

$P = 2ql$

Dipole - Two equal and opposite charges separated by a very small distance are said to constitute an electric dipole.

⑥ Biot savart law - The magnetic intensity at any point due to a steady current in an infinitely long straight wire is directly proportional to the current and inversely proportional to the distance from point to wire.

⑧ Self-inductance - It is the tendency of a coil to resist changes in current in itself.

⑨ mutual inductance - If two coils of wire are brought into close proximity with each other so the magnetic field from one links with the other, a voltage will be generated in the second coil as a result. This is called mutual inductance.

1. Centre of mass — The centre of mass of the system is defined as a point in whose position vector $\vec{R}$ is given by

$$m\vec{R} = \sum m_i \vec{r_i}$$

$$\Rightarrow \vec{R} = \frac{\sum m_i \vec{r_i}}{m} = \frac{\sum m_i \vec{r_i}}{\sum m_i}$$

2, 3 — done in mechanics

3 — $\frac{d\vec{P}}{dt} = 0, \Rightarrow \vec{P} = \text{constant}$

4. Total energy —

$$T + V + \frac{1}{2}\sum_{ij}{}' V_{ij} = \text{Constant}$$

where T = total energy of the system

V = Potential energy

The total ~~E~~ mechanical energy of the system is constant in time, that is it is conserved.

5. Show that the gravitational force is conservative.

$$\vec{F} = \frac{-Gm_1m_2\vec{r}}{r^3} = -\frac{K}{r^3}\vec{r}$$

we have to prove —

$$\vec{\nabla}\times\vec{F} = 0$$

$$\Rightarrow \vec{\nabla}\times\vec{E}\left(-\frac{K}{r^3}\vec{r}\right) = 0 \qquad \vec{r} = x\hat{i}+y\hat{j}+z\hat{k}$$

Now $\vec{\nabla}\times\left(-\frac{K}{r^3}\vec{r}\right) = \nabla\left(-\frac{K}{r^3}\right)\times\vec{r} - \frac{K}{r^3}(\vec{\nabla}\times\vec{r})$

$$\therefore \vec{\nabla}\times\vec{r} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ x & y & z \end{vmatrix} = 0$$

$$\cancel{= \hat{i}\left(\frac{\partial z}{\partial y} - \frac{\partial y}{\partial z}\right) - \hat{j}\left(\frac{\partial z}{\partial x} - \frac{\partial x}{\partial z}\right) + \hat{k}\left(\frac{\partial y}{\partial x} - \frac{\partial x}{\partial y}\right)}$$

$$\therefore \vec{\nabla}\times\left(-\frac{K}{r^3}\vec{r}\right) = \vec{\nabla}\left(-\frac{K}{r^3}\right)\times\vec{r}$$

$$= \frac{3K}{r^4}\vec{r}\times\vec{r}$$

$$= 0 \quad [\because \vec{r}\times\vec{r} = 0]$$

$\therefore \vec{\nabla}\times\vec{F} = 0$. Thus the gravitational force is conservative.

(ii) $\vec{F} = \frac{-\hat{r}}{r^n}$

$$= -\frac{\vec{r}}{r^1 r^n}$$

$$= \frac{-\vec{r}}{r^{n+1}}$$

R.T.P

$$\vec{\nabla}\times\vec{F} = 0$$

$$\Rightarrow \vec{\nabla}\times\left(\frac{-\vec{r}}{r^{n+1}}\right) = 0$$

Now $\vec{\nabla}\times\left(\frac{-\vec{r}}{r^{n+1}}\right) = \vec{\nabla}\left(\frac{-1}{r^{n+1}}\right)\times\vec{r} - \frac{1}{r^{n+1}}(\vec{\nabla}\times\vec{r})$

$$\vec{\nabla}\times\vec{r} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ x & y & z \end{vmatrix} = 0$$

$$\therefore \vec{\nabla} \times \left(\frac{-\vec{r}}{r^{n+1}}\right) = \vec{\nabla}\left(-\frac{1}{r^{n+1}}\right) \times \vec{r}$$

$$= \frac{n+1}{r^{n+2}} \; \hat{r} \times \vec{r}$$

$$= 0$$

$$\therefore \vec{\nabla} \times \left(\frac{-\vec{r}}{r^{n+1}}\right) = 0$$

• Dia-magnetism –

(i) very weak, Only exists in Presence of an electric field, non-Permanent.

(ii) The induced magnetic moment is small and the magnetization (m) direction is opposite to the direction of applied field (H).

(iii) Thus the relative permeability is less than unity.

(iv) magnetic susceptibility is negative and it's value is small (-10^{-3}).

(v) E.g. – Cu, Ag, Si etc.

• Para-magnetism –

(i) slightly stronger, exists only in Presence of an external magnetic field, not Permanent.

(ii) The dipoles do not interact.

(iii) materials which exhibit a small positive magnetic susceptibility in the presence of a magnetic field are called para magnetic, and the effect is termed as Para-magnetism.

(iv) The magnetization is positive.

(v) However, because the dipoles don't interact extremely large magnetic fields are required to allign all of the dipoles.

(vi) The increases of temperature decreases Para-magnetic effect.

(vii) Eg – Ca, Al, ti, alloy etc.

(viii) Relative permeability is greater than unity.

• Ferro-magnetism –

(i) This is permanent and exists even in the absence of an external field.

(ii) Magnetic susceptibility is very large.

(iii) Relative permeability is very greater than unity.

(iv) Above the curie temperature ferro-magnetic materials behave like Para-magnetic materials, magnetic susceptibility is given by the curie-weiss law, defined as,

$$\chi = \frac{C}{T - T_C}$$

C = material constant, T = temperature, T_C = Curie temperature.

(i), Eg - Co, Ni, Fe etc,