Handwritten Notes
On
Modern Physics

'MODERN PHYSICS'

- [1] → Atomic Str.
- [2] → Photoelectric effect. [P.E.E]
- [3] → Matter Waves
- [4] → Nuclear Physics
- [5] → Radioactivity
- [6] → X - Ray.
- [7] → Positive Ray
- [8] → Electronics
- [9] → COMMUNICATON System.

** (कोई पारमाणी नहीं bounded e^- होगा P.E.E)

Photoelectric Effect

2016 AIIMS → Emmision of e^- take place from metal surface When sufficient high freq light fall upon It called P.E.E.

* Discovered by → Heartz (NCERT)
* Law of P.E.E → Linard & Milliken
* Final Explanation → Eienstein.

[1] → A/c to plank quantum theory Radiation transfer its energy in form of small pockets. Min energy pockets called photon.

* photon transfer 100% energy to single electron (e^-). If it is sufficient to Remove the e^- come out from metal surface otherwise photon is absorbed.

properties of photon.

|1| → photon move in straight line with velocity of light.

$c_0 = 3\times10^8$ m/sec

$$\boxed{C_M = \frac{c_0}{\mu_M}} \quad (C_M \le c_0) \quad (\mu_m \ge 1)$$

$$\boxed{V \propto \lambda}$$

* Frequency of photon remain unchange with medium.

*|2| → It is a neutral particle ($q_{ph} = 0$).

**|3| → Mass of photon →
- * Rest Mass = 0 $(m_0)_{ph}$.
- Relative Mass = $m_R = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{0}{0} \Rightarrow$ NOT define
- Effective Mass = $\boxed{m_{eff} = \frac{h}{c\lambda}} \propto 1/\lambda$

|a| → Eg → max → V I B G Y O R →min (W)

→ $\lambda\uparrow$, $m_{eff}\downarrow$

|b| → $\lambda_{U.V} < \lambda_{visible}$

$m_{eff} \Rightarrow$ U.V > visible.

|4| → Energy of photon →

$$E = h\nu = \frac{hc}{\lambda} = \frac{12400}{\lambda(A^\circ)} eV$$

$$\lambda_{ph} = \frac{12400}{E_{ph}(eV)} A^\circ$$

NOTE → * In a Reflection freq, velo, wavelength & energy of one photon Remain same but total energy may change.

* Penetration power (P.P)

$\lambda \uparrow, \nu \downarrow, E_{ph} \downarrow, P.P \downarrow$

JIPMER 2016

	γ-ray	X-ray	U.V Rays	VISIBLE	I.R	M.W	R.W
→ Wavelength	< 0.01 Å	0.01 Å – 100 Å	100 Å – 3800 Å	3800 Å – 7800 Å	7800 Å – 10^6 Å	> 10^6 Å	
Energy Range →	> 1.2 MeV	1.24 eV – 124 keV	3.1 eV – 124 keV	1.3 eV – 3.1 eV	0.012 eV – 1.3 eV	< 0.124 eV	
	⇓ Mega e-volt order	⇓ Kelo e-volt order	eV order	eV order	eV order	eV order	

NOTE → * Left to Right mass of photon ↓.
* P.E.E not possible from Infra, Radio wave, Microwave.

|5| → Momentum of photon → Momentum = mass × velocity

$$p = \frac{h}{\lambda} = \frac{E_{ph}}{c}$$

|6| → Intensity [I] → Energy transfered per unit time, per unit area.

$$I = \frac{E}{At} = \frac{P}{A}$$

E → Energy of Radiation $= N_{ph}(h\nu)$; t → time; P → power of Radiation source; A → Area in which radiation distributed

NOTE → Intensity of Radiation only depend on power of Radiation source & distance from Radiation source. It is independ from color of Radiation, Freq & Wavelenth of Radiation.

|a| → point source / spherical source → $I = \frac{P}{A} = \frac{P}{4\pi r^2} \propto \frac{1}{r^2}$

$r \uparrow, I \downarrow$; $a = \frac{1}{r}$

|b| → Linear / cyllindrical source → $I = \frac{P}{A} = \frac{P}{2\pi r L} \propto \frac{1}{r}$

$r \uparrow, I \downarrow$; $a = \frac{1}{\sqrt{r}}$

NOTE → If Nature of source is not define consider point source.

|7| → No. of photon incident or, Imident per unit time →

$$I = \frac{E}{At}, \quad \frac{N_{ph}}{t} = n_{ph}$$

$$n_{ph} = \frac{IA}{h\nu} = \frac{IA\lambda}{hc} = \frac{P\lambda}{hc}$$

$*\ n_{ph} \propto P\lambda$

- |a| → P = same ⇒ $n_{ph} \propto \lambda$ Eg → VIBGYOR ($\lambda \uparrow, n_{ph} \uparrow$)
- |b| → λ = same ⇒ $n_{ph} \propto P$ Eg → $(n_{ph})_{100} < (n_{ph})_{220W}$.

$$n_{ph} = 5\times10^{24}\, I A \lambda = 5\times10^{24} \lambda h$$

(I in $\frac{W}{m^2}$, A in m^2, λ in m)

$$\frac{1}{hc} = 5\times10^{24}\ (S.I)$$

|8| → Quantum Efficiency (Q_e) → $\dfrac{\text{no of emmited per unit time}}{\text{No. of photon Incident per unit time}}$

$$n_e = \frac{\text{output}}{\text{Input}}$$

$$\eta = \frac{n_{e^-}}{n_{ph}}$$

$$*\ n_e = \eta\, n_{ph} = \eta\left(\frac{P\lambda}{hc}\right)$$

|9| → Photoelectric current (i) →

$$i = \frac{dq}{dt}$$

$$*\ i = n_{e^-}(e) = \eta\, n_{ph}(e) = \eta\left(\frac{P\lambda}{hc}\right)(e) = \eta\left(\frac{IA\lambda}{hc}\right)(e)$$

$$\frac{1}{hc} = 5\times10^{24}\ S.I = 5\times10^{24}\, I A \lambda\ /\text{sec}$$

(I in $\frac{W}{m^2}$, A in m^2, λ in m)

[10] → Force / pressure excerted on surface →

If surface is perfectelly Reflected →

|e| → change in Momentum:

- $\vec{\Delta p}_{\parallel} = \vec{p_f} - \vec{p_i} = \frac{h}{\lambda}\sin\theta - \frac{h}{\lambda}\sin\theta = 0$
- $\vec{\Delta p}_{\perp} = \vec{p_f} - \vec{p_i} = -\frac{h}{\lambda}\cos\theta - \frac{h}{\lambda}\cos\theta = -\frac{2h}{\lambda}\cos\theta \neq 0$

|a| → Momentum transfered to the surface →

$$|\vec{\Delta p}_{\parallel}| = 0$$

$$|\vec{\Delta p}_{\perp}| = \frac{2\lambda}{\lambda}\cos\theta$$

|b| → Force →

$$\vec{F}_{\parallel} = \frac{\Delta p_{\parallel}}{dt} = 0$$

$$\vec{F}_{\perp} = \frac{\vec{dp}}{dt} = \frac{\frac{2h}{\lambda}\cos\theta}{t}$$

|c| → Total force → $F_{\perp} = \frac{2P}{c}\cos\theta = \frac{2IA}{c}\cos\theta = 2u\cos\theta$

|d| → Pressure →

$$\frac{F_{\perp}}{A} = \frac{2P}{Ac}\cos\theta = 2\left(\frac{I}{c}\right)\cos\theta \quad \left(\frac{I}{c}\right)$$

(b) → If surface is perfectly absorbing →

(i) → Change in momentum →

$$\vec{\Delta p}_{\parallel} = \vec{p_f} - \vec{p_i} = 0 , -\frac{h}{\lambda}\sin\theta = -\frac{h}{\lambda}\sin\theta$$

$$\vec{\Delta p}_{\perp} = \vec{p_f} - \vec{p_i} = 0 , -\frac{h}{\lambda}\cos\theta = -\frac{h}{\lambda}\cos\theta \neq 0$$

(ii) → Momentum transfer to the surface →

$$\vec{\Delta p}_{\parallel} = \boxed{\frac{h}{\lambda}\sin\theta} , \quad \vec{\Delta p}_{\perp} = \boxed{\frac{h}{\lambda}\cos\theta}$$

(iii) → Force →

$$\vec{F}_{\parallel} = \frac{d\vec{p}_{\parallel}}{dt} = \boxed{\frac{h/\lambda \sin\theta}{t}}$$

$$\vec{F}_{\perp} = \frac{d\vec{p}_{\perp}}{dt} = \boxed{\frac{\frac{h}{\lambda}\cos\theta}{t}}$$

(iv) → Total force →

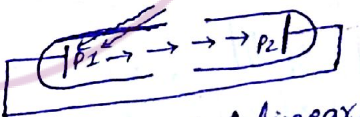
$$F_{\parallel} = \frac{P}{c}\sin\theta = \frac{IA}{c}\sin\theta$$

$$F_{\perp} = \frac{P}{c}\cos\theta = \frac{IA}{c}\cos\theta$$

(v) → Pressure →

$$P_r = \frac{F_{\perp}}{A} = \frac{P}{Ac}\cos\theta = \left(\frac{I}{c}\right)\cos\theta = u\cos\theta$$

NOTE → BECE 2015
* Pressure exerted by perfectly absorbing surface is half of perfectly reflecting surface.
  $P_r = 2\left(\frac{I}{c}\right)\cos\theta$ | $P_a = \left(\frac{I}{c}\right)\cos\theta$
* If nature of surface is not define consider perfectly reflecting surface.
* If angle of incident is not define consider radiation incident normally.
* If surface is perfectly reflecting, partially absorbing net press. on surface is scalar addition of ~~add~~ reflecting & absorbing part.



2. Practical Explanation of P.E.E. → or, Linard & Milliken

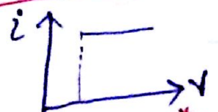
(i) → Effect of Intensity :→ Photoelectric current ↑ linearly with intensity of incident radiation.

* $I(\uparrow) \Rightarrow n_{ph}(\uparrow) = n_{electron}(\uparrow) = i(\uparrow)$

$$\boxed{i \propto I = \frac{P}{4\pi r^2}} \propto \frac{1}{r}$$

(ii) → Effect of freq →
* $\nu < \nu_0 \Rightarrow i = 0$
* $\nu \geq \nu_0 \Rightarrow i \neq 0$

$\boxed{i \propto \nu^{\circ}}$



$\nu_0 \rightarrow$ Threshold freq

** Pitch of voltage ∝ space charge
Intensity ∝ no. of photon.

NOTE → A/R*** P.E.E depend on freq but P.E.C independent from freq.

on changing freq. no of photon incident per unit time Remain unchange but its energy is change that's why the quantity of e^- Remain same.

Threshold freq. → Minimum Required freq. for photoelectron emmision called threshold freq.

* $\nu \geq \nu_0 \Rightarrow$ P.E.E is possible.
* $\nu < \nu_0 \Rightarrow$ P.E.E is not possible.
* $\lambda \leq \lambda_0 \Rightarrow$ P.E.E is possible
* $\lambda > \lambda_0 \Rightarrow$ P.E.E not possible
* $\frac{c}{\lambda} < \frac{c}{\lambda_0} \Rightarrow \lambda > \lambda_0$ No possible
* $\frac{c}{\lambda} \geq \frac{c}{\lambda_0} \Rightarrow \lambda \leq \lambda_0 \Rightarrow$ possible

condition of P.E.C

$\nu \geq \nu_0$
$\lambda \leq \lambda_0$

$\lambda_0 \Rightarrow$ Threshold Wavelength
↳ Max Wavelength above which P.E.E is not possible.

*** |iii| → Effect of potential →

|a| → on applying zero pot different b/w plates P_1 & P_2 amount of P.E.C is not equal to zero. It explain self K.E of e^- which is provided by photon.

|b| → on ↑ ⊕ve pot. on plate P_2 w.r.t P_1 P.E.C ↑ with pot. & become saturated after certain pot.

|c| → P.E.C ↑ with potential. It means electron crossponding to same metal for same freq. has diff K.E.

|d| → When no. of e^- Reached on plate P_2 per unit time is equal to no. of e^- emmited per unit time from plate P_1, P.E.C become saturated.

|e| → on ↑ ⊖ve pot. on plate P_2 w.r.t P_1 PEC ↓ & become zero at certain pot is stoping potential.

Stopping potential (ν_0) ⇒ Required ⊖ve potential to stop max K.E e^-.

$W = -K.E_{max} = eV_0$

$V_0 = -\frac{K.E_{max}}{e}$

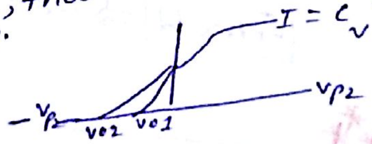
* Required pot. for zero P.E.C $V_0 = -\frac{K.E_{max}}{e}$

* stopping pot. $\Rightarrow |V_0| = \frac{K.E_{max}}{e}$

A/R * At stopping pot. P.E.C becomes zero but emmision of photoelectron takes place.

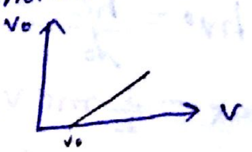
* Stopping pot. depend on nature of emmited plate & Freq. of incident Radiation. It is independent from Intencity & nature of callector plate.

Reason → on changing Intensity quantity of Incident photon is change but energy Remain same, that's why stopping pot. Remain unchange with Intensity.



$|V_{02}| > |V_{01}|$
$\nu_2 > \nu_1$
$\lambda_2 < \lambda_1$

* on changing Frequency, Energy of Incident photon chang that's why Required ⊖ve pot. to stop photo e^- is change.



|3| → Eienstien explanation →

|i| → It exclain P.E.E on the basis of particle nature of Radiation. Crompton Effect, Raman effect.

* Dual nature of light → particle → P.E.E, Crompton Effect, Raman effect
  → Wave → Reflection, Refraction, Interference, Diffraction, polarisation.

|ii| → Photon transfer its 100% energy to single e^- or, vice-versa (one to one Interaction).

AIEEE |iii| → There is no time lack b/w incident of photon & emmision of e^- (10^{-9} sec).

|iv| → Eienstien fallow Energy conservation (Heat loss = 0) & provide energy equation of P.E.E.

$$\boxed{E_{ph} = E_R + K.E_e}$$

E_R → Require Energy to Remove the e^-; $K.E_e$ → kinetic energy of e^-

$$\boxed{K.E_e = E_{ph} - E_R}$$

$K.E_{min} = 0$, $K.E_{max}$

max ($E_R = E_{ph}$), min ($E_R = W/\phi$)

Range → $\boxed{0 \text{ to } K.E_{max}}$, $\boxed{0 \text{ to } V_{min}}$

* Required energy to Remove the all e^- from metal surface crossponding to same freq. is diff that's why K.E of emmited e^- possible b/w 0 to max value.

* same metal → $\boxed{K.E_{e^-} = E_{ph} - E_R}$

$K.E_{e^-}$ → max; E_R → min ⇓ $(E_R)_{min} = W$ or, ϕ (work function).

Work function (W/ϕ) → Required min energy to Remove the e^- from metal surface.

$E_{ph} = h\nu$ (min, min)

$$W = h\nu_0 = \frac{hc}{\lambda_0} = \frac{12400}{\lambda_0(A^\circ)} \text{ eV}$$

$\nu \geq \nu_0$

$h\nu \geq h\nu_0$

$\boxed{E_{ph} \geq W}$ ⇒ P.E.E possible

$\boxed{E_{ph} < W}$ ⇒ Not possible

condn of P.E.E

$\nu \geq \nu_0$

$\lambda \leq \lambda_0$

$E_{ph} \geq W$

$K.E_{max} = E_{ph} - W$

$K.E_{min} = 0$

**

$$K.E_{max} = E_{ph} - W$$

$$E_{ph} = h\nu = \frac{hc}{\lambda} = \frac{12400}{\lambda(A^\circ)} \text{ eV}$$

$$W = h\nu_0 = \frac{hc}{\lambda_0} = \frac{12400}{\lambda_0(A^\circ)} \text{ eV}$$

$$K.E_{max} = \frac{1}{2} m_e v_{max}^2 = eV_0$$

$$m_e = 9.1 \times 10^{-31} \text{ kg}$$

NOTE → ***Work function depend on nature of surface & It will change with temp. & impurity.

(a) → IA & IIA element ⇒ 2eV to 4eV

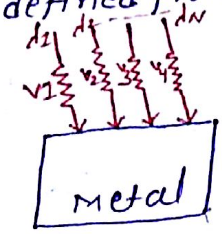
*$W_{min} = Cs$ (2.14 eV) $W_{max} = Pt$ (5.65)

(b) → d-block, f-block → 4eV to 10 eV

(c) → Temp ↑ ⇒ Work function ↓.

* Freq. same in All Medium but Wavelength & velocity are changable Medium to Medium.

* If polychromatic light incident on same metal then stopping pot. is defined from max freq & min wavelength.



$v_1 > v_2 > v_3$

$\lambda_1 < \lambda_2 < \lambda_3$

*$$V_0 = \frac{hc}{e\lambda_{min}} - \frac{W}{e}$$

$$V_0 = \frac{h}{e}\nu_{max} - \frac{W}{e}$$

Points of Exp. Material study of P.E.E

NOTE →

(i) → Intensity (I) = const, Frequency (ν) ↑.
no. of photon = const.
i_{in} ↑ & V_P ↓ & i_s remain same.

(ii) → Intensity (I) = ↑, Frequency (ν) = const.
no. of photon ↑
i_{in} ⇒ ↑, i_s = ↑, V_P = ↑

'MATTER WAVE'

Wave Associated with Moving particle.

Wave or, De-brogali Wave or, *probable wave.

De-brogali Hypothesis → Every particle present in nature represent dual nature. (wave & particle)

⇒ Wavelength of light $\lambda = \frac{h}{p} = \frac{h}{m_{eff}(c)}$

⇒ Wavelength of moving particle

$$\lambda = \frac{h}{p} = \frac{h}{m_e v}$$

* $m_R = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$ (m_0 → Rest mass; v → velocity of particle; c → velo of light)

$$\lambda = \frac{h}{m_0 v}\sqrt{1-\frac{c^2}{v^2}}$$

$v \neq 0$
$v \neq 0$

* $v = 0$ (Rest) ⇒ $\lambda = \infty$ (not define) * $v = c \Rightarrow \lambda = 0$
* $v <<< c \Rightarrow \left(\frac{v}{c}\right) <<< 1 \Rightarrow \lambda = \frac{h}{m_0 v}$ (neglect →)
* 'v' in range of 'c' → $\lambda = \frac{h}{m_R v}$

$K \cdot E_{Transfer} = \frac{1}{2}m_0 v^2 = \frac{p}{2m_0} \Rightarrow p = \sqrt{2m_0 K \cdot E_{Transfer}}$

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2m_0 K \cdot E_{Transfer}}}$$

Work done by pot. on charge particle → * $K \cdot E = q\Delta V$ *

$$\lambda = \frac{h}{p} = \frac{h}{m_R v} = \frac{h}{\sqrt{2m_0 K \cdot E}} = \frac{h}{\sqrt{2m_0 q\Delta V}}$$

*** # * If wavelength of wave (λ) = size of obstracle ⇒ Differaction take place.
* If wavelength of wave (λ) > size of obstracle ⇒ Reflection [In case of light shadow formed]
* If wavelength of wave (λ) < size of obstracle ⇒ Rectilinear propagation.

NOTE → * De-brogali principle is applicable on micro as well as macro particle but practically it is proved only for micro particle.

2016 AMU * Wave nature of particle practically proved by diffrection** principle in a devission Germer & G.B Thomson Exp.

*** # Standard Result: → $\lambda = \frac{h}{p} = \frac{h}{m_R v} = \frac{h}{\sqrt{2m_0 K \cdot E}} = \frac{h}{\sqrt{2m_0 q\Delta V}}$

|I| → Electron →

$$\lambda_e = \frac{12.27}{\sqrt{\Delta V(\text{volt})}} A^\circ = \frac{12.27}{\sqrt{K \cdot E(ev)}}$$

$$\Delta V = \frac{(12.27)^2}{\lambda_e^2} = \frac{150}{\lambda_e^2}$$

$$\Delta V = \frac{150}{\lambda_e^2} \text{ volt} \quad (A^\circ \to \lambda_e)$$

, $K \cdot E_e = \frac{150}{\lambda_e^2} ev$ ($\uparrow A^\circ$)

|II| → Proton →

$$\lambda_p = \frac{0.286}{\sqrt{\Delta V(\text{volt})}} A^\circ = \frac{0.286}{\sqrt{K \cdot E(ev)}} A^\circ$$

|III| → Deutron →

$$\lambda_D = \frac{0.202}{\sqrt{\Delta V(\text{volt})}} A^\circ = \frac{0.202}{\sqrt{K \cdot E(ev)}} A^\circ$$

|IV| → α-particle → $\lambda_\alpha = \dfrac{0.101}{\sqrt{\Delta V(\text{volt})}} A^\circ = \dfrac{0.101}{\sqrt{\frac{K.E}{2}(ev)}}$

#

particle	charge	Mass
e^-	$-e$	$m_e = \frac{m_p}{1836}$
p	+e	m_p
d	+e	$2m_p$
α	+2e	$4m_p$

** *** # Ratio of de-brogali wavelength associated with e^-, H^+, deutron & α-partide when it is move with.
|i| → same Momentum |ii| → same velocity |iii| → same K.E |iv| → same pot.

|i| → $\lambda = \frac{h}{p}$ = same ⇒ $\lambda_e : \lambda_p : \lambda_d : \lambda_\alpha$ = $1:1:1:1$

|ii| → $\lambda = \frac{h}{mv} \propto \frac{1}{m}$ ⇒ $\lambda_e : \lambda_p : \lambda_d : \lambda_\alpha = \frac{1}{m_e} : \frac{1}{m_p} : \frac{1}{m_d} : \frac{1}{m_\alpha}$

$= 1840 : 1 : \frac{1}{2} : \frac{1}{4}$

$= 1800 \times 4 : 4 : 2 : 1$

$\lambda_e > \lambda_p > \lambda_d > \lambda_\alpha$

|iii| → K.E ⇒ same ⇒ $\lambda = \frac{h}{\sqrt{2mK.E}} \propto \frac{1}{\sqrt{m}}$

$\lambda_e : \lambda_p : \lambda_d : \lambda_\alpha = \sqrt{1840 \times 4} : \sqrt{4} : \sqrt{2} : \sqrt{2}$

|iv| → ΔV ⇒ same ⇒ $\lambda = \frac{h}{\sqrt{2m_0 q \Delta V}} \propto \frac{1}{m}$

de-brogali wavelength of moving e^- is max.

NOTE → In same condition de-brogali wavelength max for photon. & in a neutral particle max for photon.

** Standard Result for Neutral particle

|I| → Neutron: → $\lambda_n = \frac{h}{p} = \frac{h}{m_R V} = \frac{h}{\sqrt{2m_0 K.E}} = \frac{0.286}{\sqrt{K.E(ev)}} A^\circ$

|II| → ** Thermal Neutron: → In a fussion Rxn energy of the neutron is very high that's why Moderator is required for fission, Moderated neutron.
* It behave as a gas molecule. → $K.E = \frac{f}{2}KT$

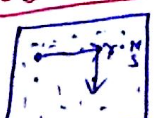
f=3 $K.E = \frac{3}{2}KT$ ⇒ $\lambda = \frac{h}{\sqrt{2m(\frac{3}{2}KT)}}$

* $K = \frac{R}{N_A} = 1.38 \times 10^{-23} J/K$ (Boltzman const.)

$\lambda = \frac{h}{\sqrt{3mKT}} = \frac{28.2}{\sqrt{T(K)}} A^\circ$

|III| → Photon → * $\lambda = \frac{h}{p} = \frac{h}{2mcv(c)} = \frac{hc}{E_{ph}} = \frac{12400}{E_{ph}(ev)} A^\circ$

|IV| → Gas Molecule →



$\propto \frac{1}{\sqrt{MOT}}$

$\lambda = \frac{h}{m\sqrt{\frac{3KT}{m}}}$

$\lambda = \frac{h}{\sqrt{3mKT}}$

$V_{R.M.S} = \sqrt{\frac{3KT}{m}}$

$\lambda = \frac{h}{\sqrt{3(\frac{M_W}{N_A})K.T}}$

Comparison of Electron & photon →

	Electron	Photon
[I] → Rest mass →	$m_0 = 9.1\times10^{-31} kg = \frac{m_p}{1840}$	$(m_0)_{ph} = 0$
[II] → R.M.S →	$E_0 = m_0c^2 = 0.51 MeV$	$(E_0)_{ph} = 0$
[III] → K.E →	$K.E = \frac{1}{2}mv^2$ $(v<<c)$, $K.E = \frac{hv}{2\lambda_e}$	
[IV] → T.E →	$T.E = \frac{hc^2}{\lambda_e v}$	$T.E_{ph} = K.E_{ph} = \frac{hc}{\lambda}$

[I] → condition 1st → Electron & photon move with same de-brogli wavelength.

$\lambda_e = \lambda_{ph} = \lambda$ $\quad K.E_{ph} = \frac{hc}{\lambda_{ph}}$ $\quad K.E_{e^-} = \frac{hc}{2\lambda_{e^-}}$ $\quad \frac{K.E_{e^-}}{K.E_{ph}} = \frac{hv/2\lambda}{hc/\lambda} = \frac{v}{2c}$

$v << c \Rightarrow K.E_{e^-} << K.E_{ph}$

[II] → condition 2nd →

$\lambda_{e^-} = \lambda_{ph} \Rightarrow$ compair its total energy.

$T.E_{ph} = \frac{hc}{\lambda_{ph}}$, $\quad T.E_e = \frac{hc^2}{\lambda_e v}$ $\quad \frac{T.E_{e^-}}{T.E_{ph}} = \frac{hc^2/hv}{hc/\lambda} = \frac{c}{v} > 1$

$T.E_{e^-} > T.E_{ph}$

III → condition 3rd ⇒ Electron & photon move with same K.E compair its de-brogali wavelength.

AIPMT 2016 * $K.E_{ph} = \frac{hc}{\lambda_{ph}}$ $= \frac{h^2}{2m\lambda^2}$

* $\lambda_e = \frac{h}{\sqrt{2mK.E_{e^-}}}$

* $\frac{\lambda_{e^-}}{\lambda_{ph}} = \frac{h/\sqrt{2K.E}}{hc/E}$

* $\frac{\lambda_e}{\lambda_{ph}} = \frac{1}{c}\sqrt{\frac{E}{2m_0}}$

* $\sqrt{E} = c\sqrt{2m_0} \Rightarrow \lambda_{e^-} = \lambda_{ph}$
* $\sqrt{E} = c\sqrt{2m_0} \Rightarrow \lambda_{e^-} > \lambda_{ph}$
* $\sqrt{E} = c\sqrt{2m_0} \Rightarrow \lambda_{e^-} < \lambda_{ph}$

$\sqrt{E} = c\sqrt{2m_0}$

$E = 2(m_0c^2) = 2\times0.51$

$E = 1.02 MeV$

* $E = 1.02 MeV \Rightarrow \lambda_{e^-} = \lambda_{ph}$
* $E > 1.02 MeV \Rightarrow \lambda_{e^-} > \lambda_{ph}$
* $E < 1.02 MeV \Rightarrow \lambda_{e^-} < \lambda_{ph}$

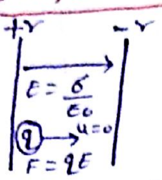
NOTE → * If e^- & photon move $\bar{c}$ same de-brogali wavelength then $K.E_{ph} > K.E_{e^-}$. but Total energy of photon is less than from e^-

* If e^- & photon move $\bar{c}$ same K.E then de-brogali wavelength depend on magnitude of energy.

*** # Special case →

Case [I] → Motion of charged particle in presence of electric field.

[A] → Uniform Electric field →

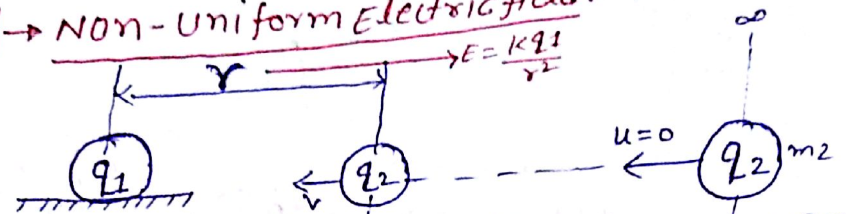


$$V = \frac{qEt}{m}$$

* $$P = mV = qEt$$

* $$\lambda = \frac{h}{P} = \frac{h}{qET}$$

[B] → Non-Uniform Electric field: →



$K.E_r = \frac{1}{2}mv^2$

$P.E_r = \frac{K(q_1)(q_2)}{r}$

$K.E_\infty = 0$

$P.E_\infty = 0$

* $$K.E_r = \frac{Kq_1q_2}{r}$$

** $$\lambda = \frac{h}{\sqrt{2m\left(\frac{Kq_1q_2}{r}\right)}}$$

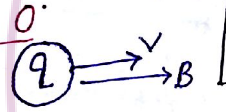
NOTE → In presence of electric field, de-Broglie wavelength of charged particle is change at every instant.

Case [II] → Motion of charge particle in presence of Mag. field →

Lorentz force → $F = qVB\sin\theta$

* $V = 0 \Rightarrow F = 0 \Rightarrow$ Rest $\Rightarrow \lambda = \infty$

[A] → $\theta = 0°$

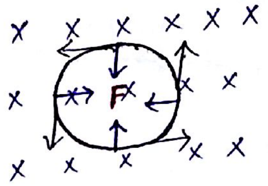


$F = 0 \Rightarrow a = 0 \Rightarrow V = const \Rightarrow \lambda = \frac{h}{mv} = const.$

[B] → $\theta = 180°$

$F = 0,\ a = 0,\ V = const,\ \lambda = \frac{h}{mv} = const$

[C] $\theta = 90°$



$\vec{F} \perp \vec{V} \Rightarrow W = 0 = \Delta K.E$

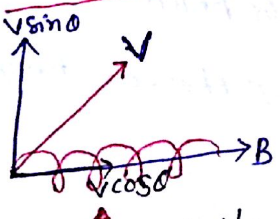
*K.E = const, *Speed = const.

$F = qVB\sin 90° = \frac{mv^2}{r}$

$P = mv = qBr$

* $\lambda = \frac{h}{P} = \frac{h}{qBr} = const.$

[D] → $\theta \neq 90°, 0°, 180°$



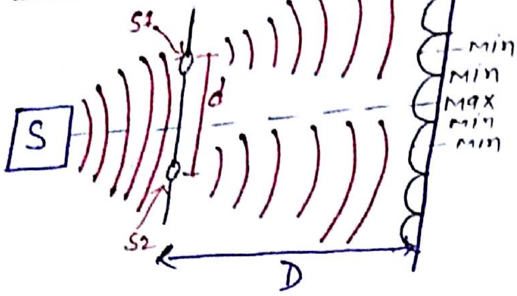
Helical path.

* $$\lambda_{||} = \frac{h}{mv\cos\theta} = const.$$

$$\lambda_{\perp} = \frac{h}{mv\sin\theta} = const.$$

$$\lambda = \frac{h}{mv} = const.$$

Case|III| → Y·D·S·C Exp perform with Matter Wave



* $\beta = \frac{\lambda D}{d} = \frac{h}{\sqrt{2m_0 q\Delta V}}\frac{D}{d} \propto \frac{1}{\sqrt{\Delta V}}$

* $\Delta V \uparrow \Rightarrow \beta \downarrow$
$\Delta V \downarrow \Rightarrow \beta \uparrow$

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Explanation of Rutherford Drawback & Bohr quantisation condn →

*|i| → Electron Rotate around the nucleus in a stable path that's why its Matter Waves is also move in a same circular orbit. When Wave are bounded it produce standing wave that's why energy of Rotating e^- remain same & e^- Rotate in stable circular orbit.
A|R

|ii| → Length of its path is complete multiple of Wavelength. $2\pi r = n\lambda$

* $n=1 \Rightarrow$ (1 Wave) $2\pi r_1 = 1(\lambda)$
* $n=2 \Rightarrow$ $2\pi r_2 = 2(\lambda)$
* $n=3 \Rightarrow$ $2\pi r_3 = 3(\lambda)$.

$2\pi r = n\lambda$
$2\pi r = n\left(\frac{h}{mv}\right)$
* $J = mvr = \frac{nh}{2\pi}$

Devison – Germer Exp → practically prove Wave nature of particle.

*Construction & Working → Electron gun based on thermeonic emmison principle Electron beam incident on Ni crystal & scatered it is collected by ionising chamber & practically calculate Max. Intensity condition.

* Thermionic emission → Emission of e^- takes place by the thermal energy.
* Photoelectric emmision → Electron emission takes place with energy of photon.
* Field emission → Electron emission take place with external electrifield. $(10^8 Vm^{-1})$

Exp. Result → Max intensity is formed at 50° deviation & at 54 volt electron gun pot.

|i| → $\Delta V = 54\,Volt$ *
$\theta = 50° \Rightarrow \phi = 90° - \frac{50}{2} = 65$ *

AIEEE/AIPMT
*|ii| → $D\sin\theta = n\lambda$
$2d\sin\theta = n\lambda$

λ = Wavelength, n = order of differaction = 1, 2, 3 - - -
$D\sin\theta = n\lambda$
$D_{Ni} = 2.15 A°$
$\lambda_{max} = \frac{D\sin\theta}{n_{min}}$ = 1
$\lambda_{max} = D\sin\theta$ *
$= 2.15\sin 50$

* $\lambda_{max} = 1.66 A°$
* $\lambda_{DB} = \frac{12.27}{\sqrt{\Delta V(volt)}} A°$
$= \frac{12.27}{\sqrt{54}}$
* $\lambda_{DB} = 1.65 A°$

λ practical value $\simeq$ λ_{DB} value

'NUCLAR PHYSICS'

|1| → Nucleus

[A] → Nucleon = Proton + Neutron

* Mass = M_p = 1.67×10^{-27} kgm ≈ [1.007 amu]
* M_n = 1.68×10^{-27} kgm = [1.008 amu]
* $q_p = +e = 1.6 \times 10^{-19}$ cb $= 4.8 \times 10^{-10}$ esu
* [$q_n = 0$]

* Largest unit of charge → Faraday.
* S.I → cb
* C.G.S → s/cb/esu/franklin
* practical unit → abcb, Farady

* Spin quantum no = [$\pm \frac{1}{2}$]
* Spin angular Momentum = [$\pm \frac{1}{2} \left(\frac{h}{2\pi}\right)$]
* Formation of proton & neutron in nucleus is explain by quark particle.
* Quark particle → up quark = $q_{up} = \pm \frac{2e}{3}$; Down quark = $q_{down} = \pm \frac{e}{3}$ → [$m_{down} > m_{up}$]

* Proton = 2 (upquark) + 1 (downquark) $= 2\left(+\frac{2e}{3}\right) + 1\left(-\frac{e}{3}\right) =$ [+e]
* Neutron = 1 (upquark) + 2 (downquark) $= 1\left(+\frac{2e}{3}\right) + 2\left(-e/3\right) =$ [0]

NOTE → Quark particle does not exist in free state that's why quanta of charge still [e].

Imp ***

NOTE → * In a stable nucleus ~~protons~~ ~~and~~ neutron both are stable particle but in a unstable nucleus both are unstable particle. & outside nucleus proton is stable particle & neutron is unstable.

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* outside nucleus neutron convert in H^+ & emit β-particle & Antineutrino & behave like radioactive substance of half life 12.5 mint.

$${}_0n^1 \longrightarrow {}_1H^1 + {}_{-1}e^e(\bar{\beta}) + \bar{\nu}\ (\text{Antinutrino})$$

this Rkn. does not obey spin angular momentum conservation that's why pauli assume another particle is also emmited with β-particle whose spin quantum no. ± 1/2, charge & mass no = 0, than particle is called Neutrino & Antineutrino.

* Most unstable particle is → Neutron

|2| → Rebresentation of nucleus →

${}_ZX^A$ →
- Z = no. of proton
- A ⇒ No. of nucleon = $N_p + N_n$
- N_n ⇒ A − Z.

|3| → Types of Nucleus →

|a| → Isotropic nucleus → Z = N_p = same, A = different. Ex → ${}_1H^1, {}_1H^2, {}_1H^3$

|b| → Isobaric Nucleus → No. of neucleon same = A, No. of proton different
Ex → ${}_6C^{14}, {}_7N^{14}$

|c| → Isotonic/Isoneutronic → Same no. of Neutron = same = A − Z
Ex → ${}_6C^{13}$ ${}_7N^{14}$ N = 13 − 6 = 7, N = 14 − 7 = 7] same (N)

** |d| → Mirror Neuclus → If no. of proton & neutron is opposite.
${}_{Z_1}^{A_1}$ ∦ ${}_{Z_2}^{Y_2}$

NOTE → Those isobar which has opposite & neuron. called mirror nucleus.

|e| → Isodiapher nucleus → difference of Neutron & proton is same.
[Nn − Np = same]

Eg → $_{92}U^{235}$ ⟶ Th^{231}

p = 92, N = 143, N−p = 51 | p = 90, N = 141, N−p = 51

** |f| → Isoster nucleus → Having same no. of atom & same no. of electron.
Eg → N_2 (14) & CO (14) & CO_2 & N_2O (22) (22)

AIEEE 2005
|g| → Isoelectronic → same no. of e^-.
Eg → O^{-2}, F^-, Ne, Na^+, Mg^{+2}, Al^{+3} ($10e^-$)

|4| → Size of nucleus →

|a| → Radius → Radius of Nucleus ∝ to cube root of Mass no.

* $r_{Nu} \propto (A)^{1/3}$ * $r_{Nu} = r_0 (A)^{1/3}$

r_0 = Rutherford Nuclear const
$= 1.2 \times 10^{-15}$ m
$= 1.2$ fermi

|b| → Volume (or size) → Nucleus behave as non-conducting solid sphere.

$V_{Nu} = \frac{4}{3}\pi r_{Nu}^3$
$= \frac{4}{3}\pi (r_0 A^{1/3})^3$
$V_{Nu} = \frac{4}{3}\pi r_0^3 A \propto A$

* A ↑, r_{Nu} ↑, V_{Nu} ↑ (size ↑)
* Exp. it has been observed that volume of nucleus ∝ mass no.
$\frac{4}{3}\pi R^3 \propto A$

|c| → Mass →

$M_{nucleus} = M_{neucleon}$
$= \Sigma M_p + \Sigma M_n$

$M_{Nu} = Zm_p + (A-Z)m_n$
* $m_p = m_n = 1$ amu
$M_{Nu} = Am_p$ = 'A' amu

* $_Z X^A$ → mass of 1 atom or, mass of Nucleus → 'A' amu
$_Z X^A$ → At weight or, mass of 1 mole → 'A' gm

* |d| → Density →

density (d) = $\frac{\text{Mass of Nucleus}}{\text{Volume of Nucleus}} = \frac{(1.67 \times 10^{-27})A}{\frac{4}{3}\pi R_0^3 A}$

* $d = 2.3 \times 10^{17}$ kg/m³

***
NOTE → * Density of nucleus is same for all nucli. (Independent from mass no.)
* As nucli do not have sharp boundry, the volume of R_0 or r_0 may also have slight deviation from the given volume.
* Density of nucleus is very high while that of atom is very small, as most of the part of atom is empty.

AIR
Nuclear spin → similar to e⁻s nucleon also rotate about their own axis & hence they posses a permanent angular momentum & hence the comple Nucleus has some Angular momentum.

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Mass Energy Relation

* $E = mc^2$

- Energy crsponding to Mass
- c → velo. of light
- m → part of Mass which is convert into Energy.

NOTE → A/c to Eiensteim system release energy its mass decrese & system absorb Energy its mass increase.

Energy crsponding to Mass —

* 1 kg → $E = 9 \times 10^{16}$ J
* → 1 a.m.u → E = 931 MeV

** $E = mc^2 = m_{amu}(931)\,MeV = m_{kgm}(9 \times 10^{16})\,J$

(a) → Rest Mass Energy [R.M.E] (E_0) →

R.M.E →
- proton, $m_{op} = 1$ a.m.u ⇒ E_{op} ⇒ 931 MeV *
- Neutron, $M_{on} = M_{op} = 1$ amu ⇒ E_{on} ⇒ 931 MeV *
- Electron, $M_{oe} = 9.1 \times 10^{-31} = \frac{m_p}{1836} = \frac{1}{1836}$ amu ⇒ E_{oe} ⇒ 0.51 MeV *
- positron, $q_{po} = e$, $m_{po} = m_e$ = R.M.E_{po} = R.M.E ⇒ 0.51 MeV *
- photon, m_{oph} ⇒ R.M.E_{ph} = 0 *

(b) → Relative Energy (ER) → Total energy.

* $E_R = m_0c^2\left(1-\frac{v^2}{c^2}\right)^{1/2}$
* $E_R = m_0c^2 + \frac{1}{2}m_0v^2$
* E_R = R.M.E + K.E
* E_R > R.M.E

$E_R = m_Rc^2$
$m_R > m_0$
$E_R > E_0$

K.E के Formula में जितना Rest mass लेता है Aur KVi नहीं लगाते, वो Relativity theory से A

Basic process/Defination

(i) → Pair production → High energy photon is absorb by nucleus & configuration* of nucleus remain unchange & nucleus emit pair of electron & positron.

* only done by photon not by neutron, proton etc.

* $E_{ph} = E_{e^-} + E_{po}$
$= R.M.E_{e^-} + KE_{e} + RME_{po} + KE_{po}$

* $E_{ph} = 1.02\,MeV + K.E_{e^-} + K.E_{po}$

NOTE*** →
* pair production energy convert in mass but mass energy equivalent is conserved.
* Minimum required energy photon for pair production is 1.02 MeV
* In a nuclear Rxn or, nuclear event charge, mass no, linear momentum, angular momentum, spin quantum no, spin angular momentum & mass energy Remain conserved means, Phy all conservation law is followed.
* $K.E_e = K.E_{po} = 0$ ⇒ $(E_{ph})_{min} = 1.02$ MeV (γ/X photon)
* $E_{ph} < 1.02$ MeV ⇒ * pair production not posible.
  * P.E.E, * Crompton Effect → possible
* $E_{ph} > 1.02$ MeV ⇒ * P.P, * P.E.E, * C.E → possible.
* P.E.E & C.E atomic event but pair production is nuclear event.

|ii| → **Pair Anhaliation** → Electron & positron come come closer & anhaliate each other release energy in form of Radiation.

AIIMS * In pair anhaliation two γ-photon are emitted & move in a opposite direction (follow linear momentum conservation.

* In pair anhaliation mass convert into Energy.

* It is Reverce process of pair production.

$E_{e^-} + E_{po} = 2E_{ph} \Rightarrow 0.51 + KE_{e^-} + 0.51 + KE_{po} = 2E_{ph}$

* $$E_{ph} = 0.51\,MeV + \left(\frac{K.E_{e^-} + K.E_{po}}{2}\right)$$

$K.E_{e^-} = KE_{ph} \Rightarrow$ * $(E_{ph})_{min} = 0.51\,MeV$

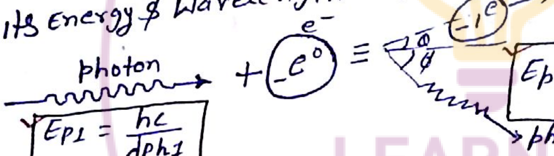
↑ For single For two ⇒ 1.02 MeV

* $$(\lambda_{ph})_{max} = \frac{12400}{0.51 \times 10^6}\,A^\circ$$

* Min release of single photon in pair anhaliation is 0.51 MeV & Min release energy 1.02 MeV.

|iii| → **P.E.E** → Photon transfer its 100% energy to single e^- (perfectally Inelastic collision) If it is sufficient to remove the electron than e^- come from metal surface effect is called PEE.

|iv| → **Compton Effect** : → Photon collide elastically with e^- & transfered sum part of its energy & wavelength shift takes place.



$E_{P1} = \frac{hc}{\lambda_{ph1}}$ $E_{ph} = \frac{hc}{\lambda_{ph2}}$

$E_{ph2} < E_{ph1}$
$\lambda_{ph2} > \lambda_{ph1}$
* compton shift or, λ-shift.

* $$\Delta\lambda = \lambda_{ph2} - \lambda_{ph1} = \frac{h}{m_0 c}(1 - \cos\phi)$$

|v| → **Mass defect (Δm)** → Mass of nucleus is slightly les than from mass of nucleon.

$\Delta m = M_{nucleon} - M_{nucleus}$

* $$\Delta m = Zm_p + (A-Z)m_n - M_{Nu}$$

|vi| → **Binding Energy (B.E)** → Required energy to bound the nucleon in nucleus or, Remove the nucleon from nucleus. (Energy crosponding to mass defect.)

* $$B.E = \Delta mc^2 \simeq \Delta m(931)\,MeV$$
(Δm in a.m.u)

* $$B.E = [Zm_p + (A-Z)m_n - M_{Nu}]c^2$$

NOTE → B.E of free nucleon & Hydron nucleus is zero.

|vii| → **Binding Energy per nucleon (B.E/A)** → Averge energy required to remove the single nucleon from nucleus.

** $$\frac{B.E}{A} = \frac{\Delta mc^2}{A} = \frac{[Zm_p + (A-Z)m_n - M_{nu}]c^2}{A}$$

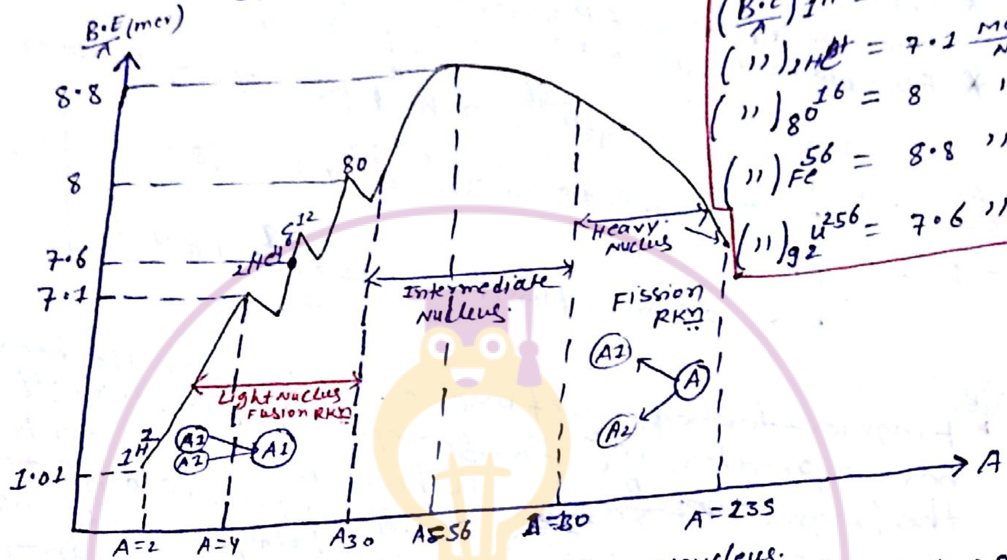
NOTE → * Stability of Nucleus ∝ $\left(\frac{B\cdot E}{A}\right)$

* $\left(\frac{B\cdot E}{A}\right)_{Max} = Fe^{56} = 8\cdot 8 \frac{MeV}{Nucleus}$

* Most stable nucleus in P.T ⇒ Fe^{56}
* " " Element " " ⇒ He
* " " " Radioactive series ⇒ Pb/Bi
 or, Last e^- of Radioactive series
* Stability of Nucleus → $Fe^{56} > O^{16} > U^{235} > He^4 > {}_1H^1$

Binding Energy Curve

curve b/w B.E per nuclon & crosponding no. of nucleon.



$\left(\frac{B\cdot E}{A}\right)_{1}H^2 = 0\cdot 01 \frac{MeV}{Nucleon}$
$(\ '' \ )_2He^4 = 7\cdot 1 \frac{MeV}{Nucleon}$
$(\ '' \ )_8O^{16} = 8$ "
$(\ '' \ )_{Fe}^{56} = 8\cdot 8$ "
$(\ '' \ )_{92}U^{256} = 7\cdot 6$ "

* $\left(\frac{B\cdot E}{A}\right)$ of Intermediate nucleus is more than & heavy nucleus.

Imp * Heavy nucleus split in two or more than two comparable mass nucleus & release Energy reaction is called fission RKn.

* In present of High temp (10^7K) & High pressure (more than 10^6 atm) light nucleus come closer & form a comparable mass nucleus & Release energy rkn is fusion RKn.

Imp * In both rkn $\left(\frac{B\cdot E}{A}\right)$ of product nucleus is more than Reactant & energy Relase in both RKn.

* Fusion RKn is possible in light nucleus & product of fusion RKn is intermediate & light nucleus.

* Fission RKn is possible in light nucleus & product of nucleus is Intermediate & Heavy.

Imp * For any stable Nucleus → Rest Mass of all its constituents > Rest mass of nucleus.

Release Energy in a Nuclear Reaction

Case-I → If Mass of product & Reactant are given →

Reactant ⟶ Product + Energy

* Change in mass $\Delta m = M_{Rea} - M_{prod}$

* $E\Delta mc^2 = \Delta m(931)\ MeV$ (↑ a.m.u)

Case-II → If Rest mass Energy is given →

Reactant ⟶ Product + Energy

$R\cdot M\cdot E_R = R\cdot M\cdot E + E$

$E = RME_R - R\cdot M\cdot E_P$

* $R\cdot M\cdot E_R > R\cdot M\cdot E_P \Rightarrow E = \oplus ve$ (Release)

* $R\cdot M\cdot E_R < R\cdot M\cdot E_P \Rightarrow E = \ominus ve$ (absorb)

Case-III → If B·E is given → B·E = −R·M·E

$E = B \cdot E_P - B \cdot E_R$

* $B \cdot E_P > B \cdot E_R \Rightarrow E = \oplus ve$ (Release)
* $B \cdot E_P < B \cdot E_R \Rightarrow E = \ominus ve$ (absorb)
* $B \cdot E_P = B \cdot E_R \Rightarrow E = 0$

1 day = 86400 sec
1 yr = $\pi \times 10^7$ sec

Nuclear Reaction

|1| → Fission Reaction → * Release energy per fission 200 MeV.

* Release Energy per nucleon per fission $= \frac{200}{235} = 0.8 \frac{MeV}{Neucleon}$
* Approx 1% of Mass convert in Energy remaning 99.9% part convert in Mass of Ba, Kr & nucleon & its K.E.
* Fisiable Material → $U^{235}, U^{238}, Pu^{239}, Th^{222}$

$$_0n^1 + {}_{92}U^{235} \longrightarrow {}_{92}U^{236} \longrightarrow Ba^* + Kr + 3({}_0n^1) + \text{Energy}.$$

Per fission → 200 MeV (Release energy)

P = 1 KW → Fission Rate ⇒ 3.1×10^{13} fission/sec
→ Mass consumption Rate $= 12 \times 10^{-12}$ kgm/sec

2016 AIIMS A/R

NOTE → Fragment formed are of unequal masses bcoz the heavy nuclei have a greater $\frac{n}{p}$ ratio as compaired to light nucli., thus the fragment formed will have more neutron to maintain this ratio generally fragment form one belongs to family with heigher $\frac{n}{p}$ value & another belong to moderate $\frac{n}{p}$ value, few extra neutron are emitted as soon as fragment are formed.

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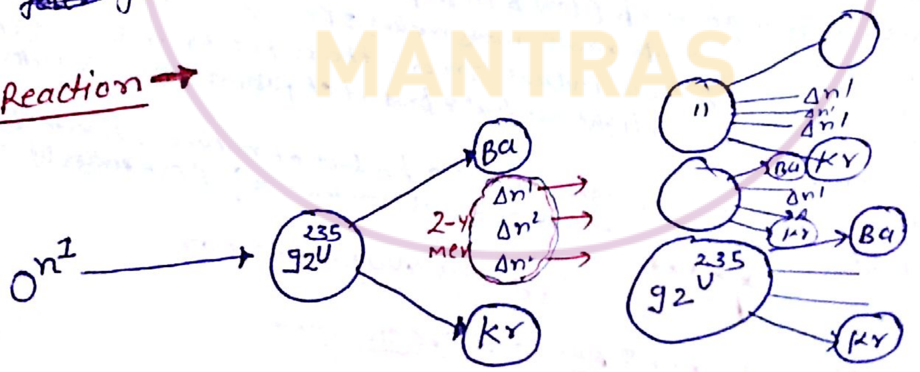
Chain Reaction →



Difficulty in chain Reaction

|1| → In a natural urenium ratio of urenium isotopes $U^{233} : U^{235} : U^{238}$ is 0.3 : 0.7 : 99 & Required energy for fission of U^{238} & U^{235} Resp. 7 − 8 MeV & less than 1 eV but energy of secondry neutron is 2 − 4 MeV.

Probability of neutron absorbtion is 99% & due to hight K·E of neutron move with very high velocity (10^6 m/sec)* & leakout from fissable material.

Removal Action →

|a| → To increase probability of collision with U^{235} ~~condition~~ concentration of U^{235} nucleus is increrease (Inrich process). (concentration of U^{235} in inrich uranium is 3% (max)).

** AIIMS 2015

|b| → To decrease energy of neutron, substance moderator are used.

* D_2O (Best Moderator), H_2O, BaO, Parafin Wax (Hydrocarbon).

↳ Why? → When comparable masses body collide elastically max energy transfer takes place. Mass of deutron is in order of mass of neutron thats why it absorb max energy of neutron.

!! *** But, H_2O is not best Moderator?? !!

Neutron (m)	Moderator (m_2)	$\frac{\Delta K.E}{K.E}$	Remain Energy
1 a.m.u	$_1H^1$ = 1 amu	→ 100%	0
1 a.m.u	$_1H^2$ = 2 a.m.u	→ $\frac{4(1)(2)}{(1+2)^2} = 8/9$ * (2003 AIIMS)	$\frac{1}{9}$

that's why H_2O is not a best Moderator!!

|c| → To maintain minimum 1 neutron in a fissable material size of fissable fule is degien as a critical size & critical Mass (10 kg).

AIR * → U^{238} does not participate in nuclear chain reaction bcoz compound nucleus forms convert it self in plutonium.

$$_{92}U^{235} + {}_0n^1 \longrightarrow {}_{92}U^{236} \longrightarrow {}_{56}Ba^{146} + {}_{36}Kr^{92} + 3\,{}_0n^1$$

or

$$\longrightarrow {}_{54}Xe^{140} + {}_{38}Sr^{94} + 2\,{}_0n^1$$

Slow moving neutron K.E = 0.04 eV {also called thermal neutron}

${}_{92}U^{236}$: compound nucleus in higher quantum state.

Neutron production factor (K) / Reproduction factor (r)

Ratio of secondry active neutron to pri. active neutron.

- Nuclear bom or, atom bom Eg ← * If K > 1 ⇒ uncondroled chain Reaction ⇒ m > critical mass.
- Nuclear Reactor ← Eg ← * If K = 1 ⇒ controled chain Rxn ⇒ m = critical mass.
- * If K < 1 ⇒ Rate of chain Reaction decrease ⇒ m < critical mass.

Imp NOTE →
* If all neutron are active than chain Reaction is G.P.
* Number of nutron produce after 'n' heat $= N^{th} = 3^N$
* Nutron production Rate & absorbtion Rate ∝ volume of fissable material.
* Nudtron leakout Rate ∝ surface.

Controled chain Reaction

Eg → Nuclear Reactor.

* control Rod → cadmium, graphite.
* Moderator → D_2O, H_2O, Ba, Parafin.
* Fusable Material → U^{235}, U^{238}, Pu^{239}, Th^{222}
* Pb → Best Radiation absorber.

uncondrolled chain Reaction

Eg → Nuclear bomb

* Fusable material → H, He, Be, B, C, N.

Breader Reactor → Fast nutron generate fuel aswell as energy.

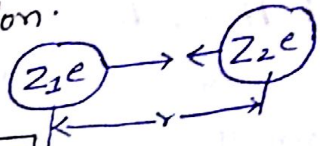
Fusion Reaction → Prescence of High temp. & High pressure light nucleus come closer & form comparable mass nucleus.

(Fusion Reaction → constructive use → sun & star; Distructive use → Nuclear bomb)

|i| → Release Energy per fusion ⇒ 28 MeV

*|ii| → Per Nucleon → Fission ⇒ 0.8 Mev/Nucleon; Fusion ⇒ 7 MeV/Nucleon.

|iii| → condition of fusion Reaction.



* $T.E \geq E.P.E$

** $T \geq \frac{1}{3K}\left[\frac{Z_1 Z_2 e^2}{4\pi\epsilon_0 r}\right]$

unstability of nucleus : (or, stability of nucleus) → A/c to nuclear force In a nucleus electrostatic Repulsion force b/w proton & proton is 10^{34} times more than gravitational attractive force but all nucleus are not unstable it means another attractive force is also present b/w nucleon called nuclear force. (Which are 50-60 times stronger than electrostatic forces.

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*** Properties of Nuclear force →

|i| → Generally it is attractive nature force & act b/w nucleon inside a nucleus.

A/R |ii| → They *donot depend on charge, hence nuclear force b/w any pair of neutron & proton is same i.e n-n or, n-p or, p-p but net force b/w them $F_{n-n} = F_{n-p} > F_{p-p}$ A/R → due to Electrostatic Repulsion.

* F_{p-p} → F_c → ⊕ve; F_g, F_N → ⊖ve < $F_{p-n} \simeq F_{n-n}$ → F_g, F_n → ⊖ve.

* donot obey law of superposition

** AIIMS 2016 |iii| → It is non central force.

A |iv| → It is non-conservative force.

R |v| → Nuclear force depend on distance b/w neucleon but it does not obey Invese square law or, Exponential law.

2016 JIPMER * |vi| → It is strongest force in a natural forces but its Range is very short. (Range = 10^{-14} m)*

** |vii| → unlike gravitational or, electrostatic force force they donot have any formula for calculation.

** |viii| → When the distance b/w nucleons is less than 0.5 fermi, they become strongally Repulsive.

* |ix| → Net force b/w proton-proton in stable nucleus (Inside) is attractive & outside nucleus is Repulsive.

A/c to Neutron proton Ratio

$N \geq Z \Rightarrow$ Nucleus stable
$N < Z \Rightarrow$ Nucleus unstable.

A/c to [illegible]

Even - Even > even-odd > odd - odd

IIT
Nuclear Reaction (No role of e^- in this Reaction)

$$(I) + (T) \longrightarrow (C) \longrightarrow (P) + (O)$$

- I → Incident particle
- T → Target nucleus.
- C → compound nucleus
- P → product nucleus
- O → outgoing Radiation (particle).

Q - Value of a Nuclear Reaction -

$$\underset{K \cdot E_i}{I} + \underset{(Rest)}{T} \longrightarrow \underset{(K \cdot E_p)}{P} + \underset{(KE_o)}{O}$$

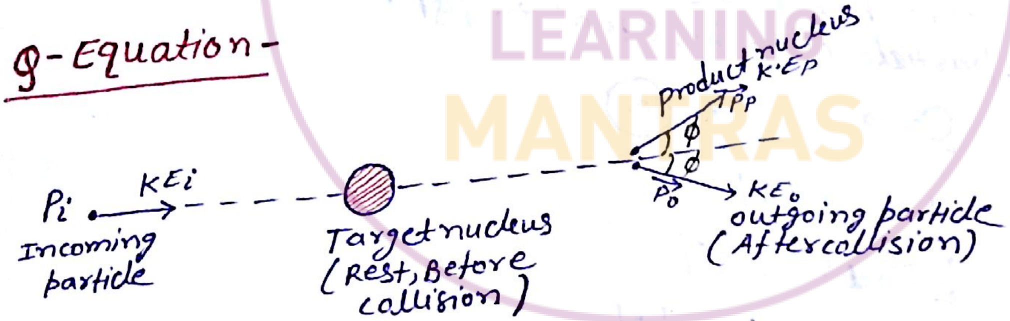
$$Q = K \cdot E_p + KE_o - KE_i$$

If mass of I, T, P, & O are m_i, m_t, m_p & m_o, then from conservation of Energy.

$$Q = (\Delta m) c^2$$

Imp
* If $m_i + m_t > m_p + m_o \Rightarrow Q > 0 \Rightarrow$ Exergonic Reaction
* If $m_i + m_t < m_p + m_o \Rightarrow Q < 0 \Rightarrow$ Endergonic Reaction.

Q - Equation -



From Momentum conservation

$$\vec{P_i} = \vec{P_p} + \vec{P_o}$$
$$\vec{P_p} = \vec{P_i} - \vec{P_o}$$
$$P_p^2 = P_i^2 + P_o^2 - 2\vec{P_i} \cdot \vec{P_o}$$
$$P_p^2 = P_i^2 + P_o^2 - 2P_i P_o \cos\theta$$
$$\because K \cdot E = P^2/2m$$

$$P_i^2 = 2m_i (K \cdot E_i)$$
$$P_p^2 = 2m_p (K \cdot E_p)$$
$$P_o^2 = 2m_o (KE_o)$$

$$Q = K \cdot E_p + K \cdot E_o - KE_i$$

$$Q = \left(1 + \frac{m_o}{m_p}\right) K \cdot E_o - \left(1 - \frac{m_i}{m_p}\right) K \cdot E_i - \frac{2}{m_p}\sqrt{m_i m_o KE_i KE_o} \cos\theta$$

If outgoing particle is scattered at angle $\pi/2$.

$$Q = \left(1 - \frac{m_o}{m_p}\right) KE_o - \left(1 - \frac{m_i}{m_p}\right) K \cdot E_i$$

A body of mass 'M' at Rest, it explodes in two particle m1 & m2, calculate energy of fragments of the body in terms of 'Q'.

$$Q = \frac{P_1^2}{2}\left[\frac{m_1+m_2}{m_1 m_2}\right]$$

$$K.E_1 = \frac{P_1^2}{2m_1} = \frac{Q m_2}{m_1 m_2}$$

$$K.E_2 = \frac{P_2^2}{2m_2} = \frac{Q m_1}{m_1+m_2}$$

NOTE → * K.E of fragments are Inversally propersnal to their masses.

* This analysis applicable in nuclear fission in two fragments.
* If nucleus is converted in three parts then we will have 2 equation & three unknowns. This was the reason of birth of nutrino & antinutrino particle during such experiment missing Energy & momentum where assigned to particles nutrino & anti-nutrino.

Threshald Energy of an Endoergic Reaction –

To initiate an endoergonic Reaction the K.E of Incoming particle must be greater than a threshald value. The K.E should overcome the ⊖ve Q value as as – Some part of it also used to provide K.E to the product nucli & outgoing particle.

In centre of mass from total momentum of particle is zero, hence K.E with respect to centre of mass of incoming particle must be equal to |Q|.

$$K.E' \geq |Q|$$

$$\frac{1}{2} M_{red} v^2 \geq |Q|$$

$$\frac{1}{2}\left(\frac{mM}{m+M}\right) v^2 \geq |Q|$$

$$\frac{1}{2} m v^2 \geq \left(\frac{m+M}{M}\right)|Q|$$

$$K.E_{particle} \geq \left(1+\frac{m}{M}\right)|Q|$$

'RADIOACTIVITY'

* Exergonic Reaction (Energy Release).

Property or, process by which disintegration or, decay of unstable nucleus takes place with emission of α, β or γ or, γ rays.

!! * It is nuclear event not atomic & remain unchange with pressure, temp. or, any other physical or, chemical change.

** * Ist order Reaction but Ist order का कोई concept apply याद करो (Mind याद रखना After study chemical kinetics).

* Random process.

** * Nuclear configuration in Radioactive emission change but atomic configuration Remain same.

AIIMS * Proton never emitted by Radioactive substance during decay.

Decay to maintain $\frac{n}{p}$ ratio –

|1| → If $\frac{n}{p}$ ratio is greater than the required value for stability, β^- emission takes place.

|2| → If n/p ratio is less than the required value for stability α-decay, β^- decay or, e^- capture takes place.

|3| → During Radioactive reaction or, nuclear reaction a nucleus in higher quantum state emit γ-ray & comes in lower quantum state.

*** [A] → α-emission → In a unstable nucleus 2 proton & 2 neutron make one particle. K.E of α-particle is 7-8 MeV but required to cross the barrier of nucleus is 28 MeV. It means α-particle not come out from nucleus.

Its emission explain with 'Tunnel Effect'. ***

In a nucleus α-particle collide with nucleus wall & another particle, collision is perfectly elastic. When it arrange energy more than 28 MeV it come out from nucleus. (In a nucleus α-particle perform 10^{21} collision/sec)

$$ {}_{Z}X^{A} \longrightarrow {}_{2}He^{4} + {}_{A-2}Y^{A-4} + \text{Energy} $$

Parent nucleus → Daughter nucleus / Remain nucleus / Product nucleus.

Parent nucleus: $N_p = Z$, $N_n = A-Z$, $N_n - N_p = A-2Z$

Daughter: $N_p = Z-2$, $N_n = (A-4)-(Z-2) = A-Z-2$, $N_n - N_p = A-2Z$

Isodiapher (no. of neutron & proton same)

* Linear Momentum conservation.

$$ V_D \leftarrow {}_{Z-2}Y^{A-4} = {}_{Z}X^{A} \rightarrow {}_{2}He^{4} \rightarrow V_\alpha $$

$$ \vec{P_D} = -\vec{P_\alpha} \Rightarrow |\vec{P_D}| = |\vec{P_\alpha}| $$

AIIMS $$ V_D = (-)\left(\frac{4}{A-4}\right)V_\alpha $$ *

(−) → Direction.

* Requile K·E of Daughter nucleus / Energy α-particle & D-nucleus

$_{Z}X^{A} \longrightarrow {}_{2}He^{4} + {}_{Z-2}Y^{A-4} + E\ (Q\text{-value})$

$Q = K{\cdot}E_\alpha + \left(\frac{m_\alpha}{m_D}\right) K{\cdot}E_\alpha \Rightarrow K{\cdot}E_\alpha = \left(\frac{m_D}{m_D + m_\alpha}\right) Q = \left(\frac{A-4}{A}\right) Q$

$K{\cdot}E_D = \left(\frac{m_\alpha}{m_\alpha + m_D}\right) Q = \left(\frac{4}{A}\right) Q$

* $\frac{4}{A} <<< \Rightarrow K{\cdot}E_D << Q$

* $K{\cdot}E_D = \left(\frac{4}{A}\right) E <<< E$

$K{\cdot}E_\alpha = \left(\frac{A-4}{A}\right) E \simeq E$

*** Grieger-Mular formula

$\log \lambda = A + B \log R$

decay const of R·A (λ); Range (R).

* $R \propto (E_\alpha)^{3/2} \propto V_\alpha^3$

NOTE → * Release energy distribute in form of K·E & Approx. 99% part transfer to α-particle & Remaning to daughter nucleus.

!! * K·E & velocity of α-particle is charasteristic of nucleus i.e vary nucleus to nucleus.

***

In α-Decay- ($_2He^4$)

- Atomic no. decrease by 2.
- Mass no. decrease by 4.
- No. of proton & neutron change by same amount.
- $\frac{n}{p}$ ratio increase.

[B] → β-emission → β^+ ($_{+1}e^0$) (positron); β^- ($_{-1}e^-$) (electron)

NOTE → * β-particle is also called e^- wich is comes out from nucleus. that's why type of β-particle is not define consider β⊖ve.

* β-emission is explain from weak nuclear interaction b/w proton & neutron. & proton convert into neutron or, vice-versa & emit β-particle.

2016 III

(i) → β^+ Emission ($_{+1}\beta^0$ or, $_{+1}e^0$ positron)

$_1H^1 \longrightarrow {}_0n^1 + {}_{+1}e^0(\beta^+) + \nu$ (nutrino)

proton → neutron

$_{Z}X^{A} \longrightarrow \beta^+ ({}_{+1}e^0) + {}_{Z-1}Y^{A} + \nu$

parent nucleus (X); Daughter nucleus (Y)

***

NOTE → Imp * It is particle whose all the properties are similar to electron, but it has a charge of $q = +1.6 \times 10^{-19}$ C. **

**

- * Atomic no. ↓se.
- * Mass no. does not change.
- * $\frac{n}{p}$ ratio ↑se. [p ↓ by one & n ↑ by one]
- * A proton inside the nucleus convert it self into a neutron & positron.

* Neutron remain inside the nucleus & positron is emitted.
* Neutrino is a particle whose properties are similar to antineutrino but it has opposite spin, It is always emitted with a positron.

$$_{Z}X^{A} \longrightarrow _{Z-1}Y^{A} + _{+1}\beta^{0} + \nu$$

$$Q = (m_x - m_y - m_e) c^2$$

(mass of nuclei)

$$Q = (M_x - M_y - 2m_e) c^2$$

M_x = Mass of $_{Z}X^{A}$ atom
M_y = Mass of $_{Z-1}Y^{A}$ atom
m_e = Mass of e^-

(iii) → β^- Emission $(_{-1}\beta^0)$ or, $(_{-1}e^0)$

$$_{0}n^{1} \longrightarrow _{1}H^{1} + _{-1}e^{0} + \bar{\nu} \text{ (Antineutrino)}$$

$$_{Z}X^{A} \longrightarrow \beta^-(_{-1}e^0) + _{Z+1}Y^{A} + \bar{\nu}$$

	$\nu/\bar{\nu}$	photon
* q →	0	0
* A →	0	0
* m →	Negligible	
* spin →	$\pm\frac{1}{2}$	+1

NOTE → * In this equation spin quantum conservation is not applicable that's why pauli assume another particle is also emitted with β-particle whose charge & mass no. is zero. but spin quantum no. ±1/2 & particle is called neutrino & Antineutrino.

** properties of Antineutrino –
* It is a chargeless, massless particle like photon.
* It is not deflected by electric or magnetic field.
* Due to very less interaction with matter it is not possible to detect it.

NOTE → * parent nucleus & daughter nucleus is isobar of each other.
* In β-emission total no of nucleon remain same but neutron & proton ratio change.

** $\left(\frac{N}{P}\right)$ → $\beta^+ (\frac{N}{P}\uparrow)$ (stability ↑); $\beta^- (\frac{N}{P}\downarrow)$ (stability ↑)

* In α-emission neutron & proton ratio must ↑ but in β-emission It may be ↑/↓.

$$_{Z}X^{A} \longrightarrow _{Z+1}Y^{A} + _{-1}\beta^{0} + \bar{\nu}$$

M_x = Mass of $_{Z}X^{A}$ atom
M_y = mass of $_{Z+1}Y^{A}$ atom.
m_e = mass of e^-

$$Q = (m_x - m_y - m_e) c^2$$

(mass of nuclei)

$$Q = [M_x - M_y] c^2$$

** Atomic no. increase by 1.
** Mass no. doesn't change.
** $\frac{n}{p}$ ratio ↓se. (p↑ is by 1 & n↓ by 1)

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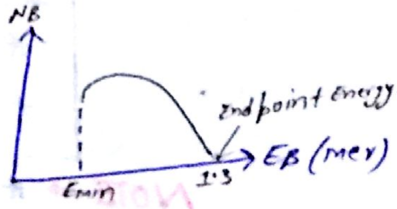
Energy spectrum of β-particle →

Diff energy of β-particle which is emitted from same Radiactive substance is explain with linear momentum conservation.

$$_{Z\pm1}Y^{A} \equiv {_{Z}X^{A}} \rightarrow \beta^+/\beta^-, \ \nu/\bar{\nu}$$



$$P_f = -(\vec{P}_D) + \vec{P}_{\nu/\bar{\nu}}$$

$$K.E_\beta = \frac{P_\beta^2}{2m_\beta} = f(Q)$$

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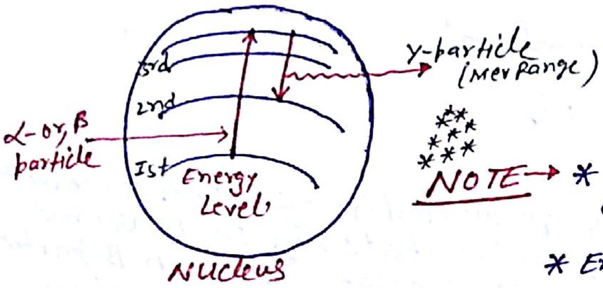
A → β-particle Energy Spectrum is continuous.
R → β-deacay is a spontenious statical process.
Ans → A

NOTE → A/c to pauli $\nu/\bar{\nu}$ hypothesis we explain –
* spin angular momentum conservation
* Diff. energy of β-particle.

[C] γ or, γ Emission [$_0n^0$] →

$$_ZX^A \longrightarrow {}_0n^0(\gamma\text{ particle}) + {}_ZX^A$$

Emission of γ-particle is explain with energy level of nucleus when nucleus emit α-or, β-particle. It become excited & comes in high energy level when It again comes in low energy level release energy in form of radiation which is called γ-particle



Recoil K·E Daughter Nucleus

$$K \cdot E_D = \frac{P_D^2}{2m_D} = \frac{(h\nu/c)^2}{2m_D}$$

*** NOTE → * Emission of γ-particle is takes place after emiting α or, β-particle.

* Emission of α-&β-particle not takes place simultaniously.

* Emission of 2 particle simultaneously not possible from same nucleus.

EX → Identify correct order of α, β & γ emission.

→ γ, α ✗
→ γ, β ✗
→ α, β, γ ✗
→ β, α, γ ✗
→ α, γ, β, γ ✓
→ β, γ, α, γ ✓
→ α β, γ ✗
→ α, β, γ, γ ✗
→ β, γ, γ ✗

\# $$_{Z_1}X^{A_1} \xrightarrow{n\alpha,\ n\beta} {}_{Z_2}Y^{A_2}$$

$$n_\alpha = \frac{A_1 - A_2}{4}$$

$$n_\beta = 2n_\alpha - Z_1 + Z_2$$

IIT 2016 ***

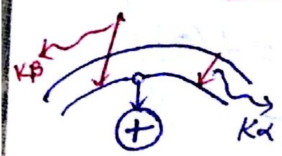
\# Electron kepture or, K-epbture →

Nucleus pulls an e^- from K-shell. Inside the nucleus & a proton combines with this e^- to ↑ $\frac{n}{p}$ ratio.

***
* Atomic no. ↓ by 1.
* Mass no. does not change.
* $\frac{n}{p}$ ratio ↑.
* p ↓ by 1 & n ↑ by 1.

NOTE → * To fill the vacancy created in K-shell, K_α or, K_β line X-rays can be emitted.

* nucleus can only pull e^- from K-shell.



$$Q = (m_X + m_e - m_Y)c^2$$

(mass of nucli)

** $$Q = [M_X - M_Y]c^2$$

Rutherford-sodi law or, Disintegration law →

Disintegration rate ∝ to active nucleus present at that instant.

***

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

- $-\frac{dN}{dt}$ → D.I Rate (Disintegration Rate)
- N → Active nucleus
- λ → Decay / Disintegration const.

$$\lambda = \frac{1}{N}\left(-\frac{dN}{dt}\right)$$

* unit → sec^{-1}, min^{-1}, $hour^{-1}$, day^{-1}, $mounth^{-1}$.

***NOTE → * Decay const, half life, Mean life depend on nature of substance it is independent from quantity, temp, press, time or, any other physical or chemical change.

* For stable nucleus
  - $\lambda = 0$
  - $T_{1/2} = \infty$ * $T_{1/2} = \frac{0.693}{\lambda}$
  - $T_m = \infty$

Relation b/w Active nucleus & Time →

$$\log(M) - \log(N) = \log\frac{M}{N}$$

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

- N → Active nucleus at time 't'
- N_0 → Initial Active nucleus

* Active nucleus at time 't' ⇒ $N = N_0 e^{-\lambda t}$
* " " " $t = 0$ ⇒ N_0
* Disactive nucleus at time 't' = $N' = N_0 - N$
  $N' = N_0(1 - e^{-\lambda t})$

* Active mass at $t = 0$ ⇒ M_0
* " " " $t =$ ⇒ $M = M_0 e^{-\lambda t}$
* Disactive mass at time 't' ⇒ $M' = M_0 - M = M_0(1 - e^{-\lambda t})$

***NOTE → * Active nucleus & Active mass ↓ Exponential w.r.t time.
* Disactive nucleus & Disactive mass Exponentially ↑ w.r.t time.
* Total no. of nucleus & mass of sample remain unchange w.r.t time.
* Rutherford sodi law is applicable on large no. of nucleus.
* More the value of decay const 'λ', faster is the decay of Radioactive sample.

packing fraction (f) →

$$f = \frac{M-A}{A}$$

* It may be ⊕ve, ⊖ve, may be zero
* It's ⊖ve value explain more stability of nucleus

special condition

$\lambda <<< 1$ (short Range)

$$e^x = 1 + \frac{x^1}{L^1} + \frac{x^2}{L^2} + \frac{x^3}{L^3} \cdots$$

$L^1 = 1$

$L^2 = 2 \times 1$

$L^3 = 3 \times 2 \times 1$

$\vdots$

$L^n = n(n-1)(n-2) \cdots 1$

*****

BASIC DEFINATION

|i| → Half life ($T_{1/2}$ or, $t_{1/2}$)

|ii| → Mean life (T_m)

|iii| → Activity (R)

|iv| → Specific Activity (R_{gm})

|i| → Half life → Time in which active nucleus remain 50% or, half of Initial value.

** $$T_{1/2} = \frac{\ln 2}{\lambda} = \frac{0.693}{\lambda}$$

***** NOTE → If half life of sample is given as $t_{1/2}$

at $t = 0$, $N = N_0$

at $t = t$, $N = N$

no. of half lives $= \frac{t}{t_{1/2}} = n$

*** $$N = N_0 (2)^{-n}$$

*** $$A = A_0 (2)^{-n}$$

(ii) → **Mean life** → Time in which active nucleus remain 37% of Initial Value or, disintegrate 63% call mean life.

$$T_{Mean} = \frac{\text{Sum of lives of all nuclei}}{\text{Total no. of nuclei}}$$

*** $\langle T \rangle = \frac{1}{\lambda}$

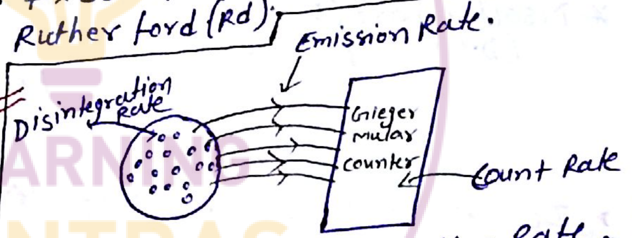
* $T_m = \frac{1}{\lambda}$
* $T_{1/2} = \frac{0.693}{\lambda}$
* $T_m > T_{1/2}$
* $T_{1/2} = 0.693\, T_m \simeq 69.3\%$ of T_m
* $T_m = 1.44\, T_{1/2} \simeq$ More than 44% $T_{1/2}$.

(iii) → **Activity (R)** → Disintegration Rate of Radioactive substance.

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

*** **unit** → * 1 D.P.S (Disintegration per sec) = 1 Bq (Baqurel) (S.I)

* 1 cu (curi) = 3.7×10^{10} dps. (C.G.S)
* practicall unit → Ruther ford (Rd)
* 1 Rd = 10^6 Bq.
* 1 mcq = 37 Rd
  (milicuri)



* Activity = Disintegration Rate
* Count Rate = Emission Rate.
  (Emission Rate ≠ Disintegration Rate)

*** **NOTE** → Activity depend on nature of substance. It will ↓ exponentially w.r.t time & ↑ linearlly w.r.t quantity/ Mass.

(iv) → **Specific Activity** : → Activity of 1gm sample.

NOTE → Sp. Activity Remain unchange w.r.t time.

$M = 1gm$, $R = R_{gm}$

*** $$R_{gm} = \left(\frac{N_A}{A} \times 1\right)\left(\frac{0.693}{T_{1/2}}\right)$$

(A ← gm)

*** **# Standard Result** –

* Sp. Activity of R^{226} is 1 cu/gm

1 gm = 1 cu
X gm = X cu
1 mgm = 1 mcu

Prob. based on Radioactivity →

$$N = N_0 e^{-\lambda t}$$
$$M = M_0 e^{-\lambda t}$$
$$R = R_0 e^{-\lambda t}$$
$$I = I_0 e^{-\lambda t}$$

$$X = X_0 e^{-\lambda t}$$

Case-I → If time given in terms of half life or, Active part is complete Multiple of Half.

$$X_0 \xrightarrow{T_{1/2}} \frac{X_0}{2} \xrightarrow{T_{1/2}} \frac{X_0}{4} \xrightarrow{T_{1/2}} \frac{X_0}{8} \xrightarrow{T_{1/2}} \cdots \xrightarrow{T_{1/2}} \frac{X_0}{2^n}$$

* n = no. of half life.
* Time in 'n' half life ⇒ $t = n T_{1/2}$
* Active value after 'n' half life $= X = \frac{X_0}{2^n}$
* Disactive " " " " $X' = X_0 - X = X_0\left(1 - \frac{1}{2^n}\right)$
* Active part (AP) / Active fraction (A·fr) / probability of Activness (A·A) or, Probability of survival (P·S) $= \frac{X}{X_0} = \frac{1}{2^n}$
* Disactive part (D·P) / Disactive fraction (D·fr) / probability of Disactivness (P·D) or Probability of death (P·D) $= \frac{X'}{X_0} = 1 - \frac{1}{2^n}$

Case II → If time is given in terms of Mean life.

$$X_0 \xrightarrow{T_m} \frac{X_0}{e^1} \xrightarrow{T_m} \frac{X_0}{e^2} \xrightarrow{T_m} \frac{X_0}{e^3} - - - - \xrightarrow{T_m} \frac{X_0}{e^n}$$

* n = no. of mean life.
* Time in 'n' Mean life $= t = n T_m$
* Active value After 'n' mean life $= X = \frac{X_0}{e^n}$
* Disactive " " 'n' " " $= X' = X_0 - X = X_0\left(1 - \frac{1}{e^n}\right)$
* A·P/A·fr/P·A/P·S → $A\cdot P = \frac{X}{X_0} = \frac{1}{e^n}$
* D·P/D·fr/P·D/D·D → $D\cdot P = \frac{X'}{X_0} = 1 - \frac{1}{e^n}$

$$A\cdot P + D\cdot P = 1$$

Case III → If Active part not in complete Multiple of Half →

$$t = 3.32\, T_{1/2} \log_{10}\left(1/A\cdot P\right)$$

**** AIIMS 2016

Case IV → carbon dating or, Radioactive dating method.

In most of the element nitrogen after receiving cosmic Rays (neutrons) convert them into carbon(14) which is Radioactive element.

In all the live element, there is a fixed ratio of c^{14} & c^{12}, which remain const., till the element as alive, but when it becomes dead, c^{14} disintegrates continue & its ratio with c^{12} decreases. This decreased ratio is used to find the age of particular Rock & It is known as carbon dating.

JIPMER 2016 * Living body $c^{14} : c^{12} = \boxed{1:1}$

↑ Active ↑ disactive

* $\boxed{A \cdot P = \frac{X}{X+4}}$

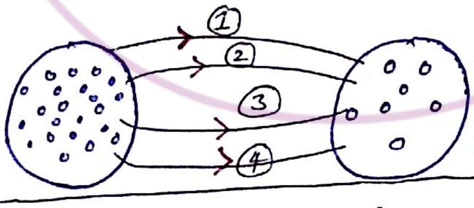
* Age of sample $\boxed{t = 3.32 \left(T_{1/2}\right)_{c^{14}} \log_{10}\left(\frac{1}{A \cdot P}\right)}$ **

*** 2016 AIIMS

* $T_{1/2}$ of c^{14} is 5700 or, 5730 yrs.
* $T_{1/2}$ of α is 12 yrs
* $T_{1/2}$ of β is 3 yrs

IVI → Case V → Radioactive branching concept →

If radioactive substance disintegrated by different process & disintegration rate of sample is a scalar addition of Iddition of Indivisual procss.



* $$\left(\frac{-dN}{dt}\right)_{net} = \left(\frac{-dN}{dt}\right)_1 + \left(\frac{-dN}{dt}\right)_2 + \cdots + \left(\frac{-dN}{dt}\right)_{net}$$

$$R_{net} = R_1 + R_2 + \cdots R_N$$

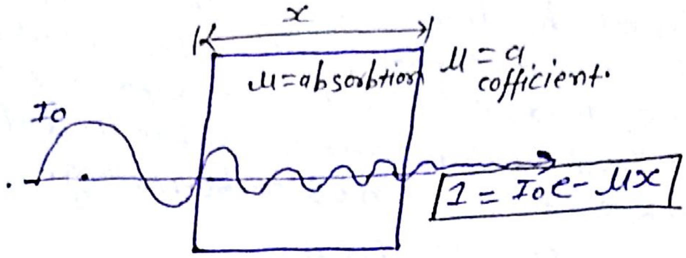
* $$\lambda_{net} = \lambda_1 + \lambda_2 + \lambda_3 \cdots + \lambda_N$$

* $$\frac{1}{(T_{1/2})_{net}} = \frac{1}{(T_{1/2})_1} + \frac{1}{(T_{1/2})_2} + \cdots \frac{1}{T_{mN}}$$

* $$\frac{1}{(T_m)_{net}} = \frac{1}{(T_m)_1} + \frac{1}{(T_{1/2})_2} + \cdots + \frac{1}{T_{mN}}$$

Case VI → Absorbtion of Radation or, Absorption of X-ray →

Intensity of Radiation ↓ exponentially w.r.t thickness of material.



**

μ_{max} = Pb(Lead)
μ_{min} = Air

$I = I_0^{-\lambda t}$

(Thickness) t = X

λ = ab. cofficient

$I = I_0 e^{-\mu X}$

|i| → Half life = $T_{1/2} = \frac{0.693}{\lambda}$

|ii| → Mean life = T_m = $1/\lambda$

|iii| → $t = n T_{1/2}$ (n ↑ no. of Half life.)

|iv| → $t = 3.32\, T_{1/2} \log_{10}\left(\frac{1}{A.P}\right)$

|V| → $A.P_2 = (AP_1)^{t_2/t_1}$

|i| → Half life yr = $X_{1/2} = \frac{0.693}{\mu}$

|ii| → Mean thickness = $1/\mu$

|iii| → $X = n X_{1/2}$ (n ↑ no. of half thickness.)

|iv| → $X = 3.32\, X_{1/2} \log_{10}(1/A.P)$

|V| → $A.P_2 = (AP_1)^{X_2/X_1}$

* penetration power → $\alpha < \beta < \gamma$ (γ — velo. of light; α — $\frac{1}{10}$; β — $\frac{1}{3}$ to $\frac{9}{10}$)

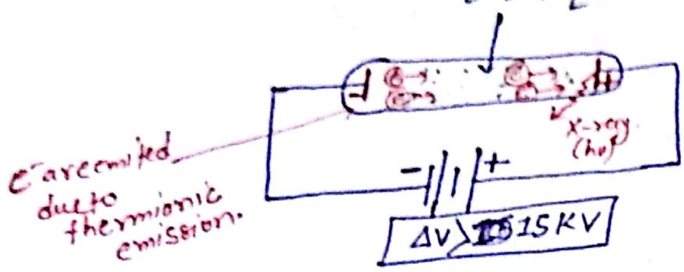
'X- RAYS'

Like photon. ↑ — undeflected from electric & magnetic field.

* Reverse of P.E.E.

condⁿ → * When highly energetic e's are made to strike metal target, Electromagnetic radiation of the order 0.01A° to 100A° was observed & known as X-ray.

|1| → Roengton Exp:→ In ⊕nce of high potential & low potential. sum invisible Radiation is emitted from anode wich is called X-ray.

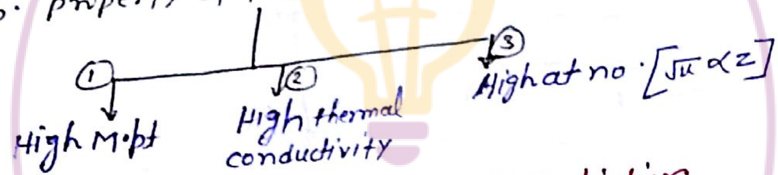


Basic requirment of X-ray production

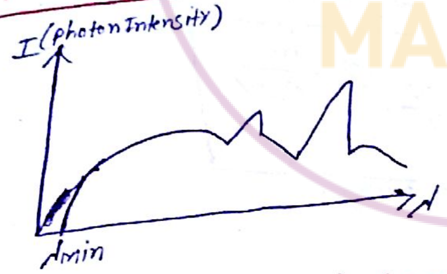
|a| → e^- producing source

|b| → e^- Acclerating source (more than 15 KV pot.)

|c| → Sp. property of target.



Graph b/w Intensity & Wavelength of Radiation

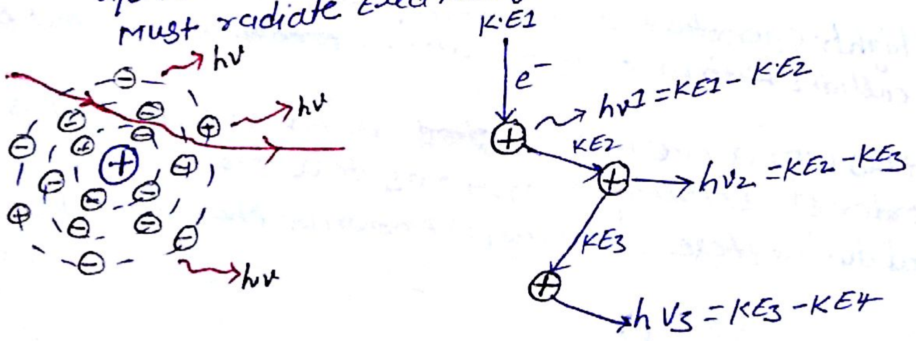


* There was a wavelength, below wich no radiation was obtain, this λmin was named as cuttoff wavelength.

* If we observe the graph, then we see there are two type of variation, one is conti & the other is disconti or, in form of peak.

Production (Explanation) of continuous X-ray / White X-ray.

When highly energetic e's passed through an atom with very high K.E, they are strongly deaccelerated in electric field of nucleus & a/c to maxwell electromagnetic theory every deeclerating charge particle must radiate Electromagnetic radiation & Hence photon are emitted.



In successive collision e^- losses some part of its K·E energy & new photon with lost energy is generated.

** If accelerating voltage across coolidge tube is 'V_0'
K·E of e^- just before hitting the target

$$\frac{1}{2}mV_e^2 = eV_0$$

$$V_e = \sqrt{\frac{2eV_0}{m}}$$

** Photon with highest energy is librated when an e^- loose all its K·E in a single collision & crossponding to this loss only one photon come out.

$$h\nu_{max} = eV_0 = K{\cdot}E$$

$$\frac{hc}{\lambda_{min}} = eV_0$$

$$\text{cutoff wave length} = \lambda_{min} = \frac{hc}{eV_0}$$

** other photons will have lesser energy so their wavelength will vary from λ_{min} to ∞.

** $$\Delta \cdot K_{Loss} = E_{x\text{-}ray} = \frac{1}{2}m(V_1^2 - V_2^2)$$

$$\lambda_{x\text{-}ray} = \frac{hc}{E_{x\text{-}ray}} = \frac{hc}{\frac{1}{2}m(V_1^2 - V_2^2)}$$

** Range of $V_2 = 0 - \infty$

* $V_2 - V_1 = E_{x\text{-}ray} = 0 \Rightarrow \lambda_{max} = \infty$
* $V_2 = 0 \Rightarrow (E_{x\text{-}ray})_{max} = \frac{1}{2}mV_1^2 = W = e\Delta V$

$$\lambda_{min} = \frac{hc}{(E_{x\text{-}ray})_{max}} = \frac{hc}{\frac{1}{2}mV_1^2} = \frac{hc}{e\Delta V}$$

$$\lambda_{min} = \frac{12400}{\Delta V\,(\text{volt})} \text{A}^\circ$$

**

NOTE→ Min wavelength of continuous x-ray only depend on anode potential. It is independent from at·no and nature of target.

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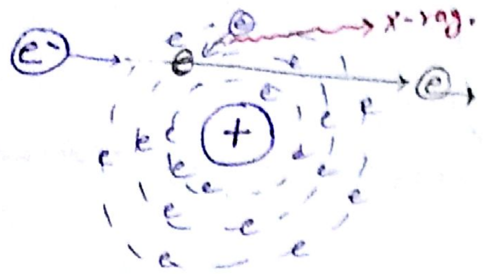
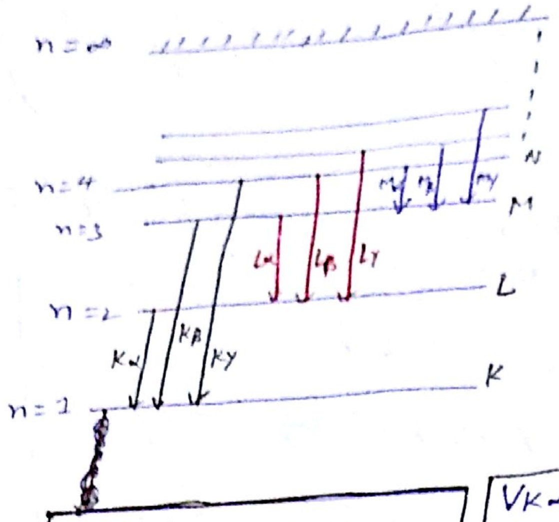
Explanation or, production of chararasteristic x-ray or, Explanation of peaks →

When highly energetic e^- enters into an atom, there is also some possibility that it collides with an e^- of the atom & ~~knocks~~ knowks out of the shell. In this way a cacancy is ~~filled~~ created in shell, which is fielled by Higher order es by making transitions to a lower stage, radiation emitted during these transition is known as charackeristic x-ray.





$\nu_{K\alpha} < \nu_{K\beta} < \nu_{K\gamma}$

$\lambda_{K\alpha} > \lambda_{K\beta} > \lambda_{K\gamma}$

$\nu_{K\alpha} > \nu_{L\alpha} > \nu_{M\alpha}$

$\lambda_{K\alpha} < \lambda_{L\alpha} < \lambda_{M\alpha}$

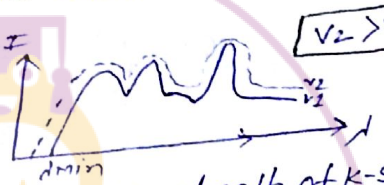
NOTE → Energy (E_K, E_L, E_M, E_N) are not found from Bohr model.

If e^- is knocked out from L-shell.

$L\alpha$, $L\beta$, $L\gamma$ or y

$h\nu_{L\alpha} = E_L - E_M$

$h\nu_{L\beta} = E_L - E_N$



$V_2 > V_1$

* In a same transition (α, β, γ) wavelength of K-series is min.

* In a same series (K, L, M) wavelength of α-transition is max.

* Wavelength of characteristic X-ray doesn't depend on Accelerating voltage, they depend only on target material.

Moseley's Law → Square root of frequency $\propto$ to effective atomic no. of multi e^- system.

$\sqrt{\nu} \propto Z_{eff}$

$\sqrt{\nu} = a Z_{eff}$

$Z_{eff} = Z - b$ (Z → At no.)

b or 6 → Screening const.

**
- K ⇒ b ≈ 1
- L ⇒ b ≈ 7.2
- M = b ⇒ 18.2

Imp ***

Screening const (6) → He explained screening const. as when an e^- makes a transition from a heigher shell to lower shell, for Eg → K-shell whose a vacancy is created, then the effective nuclear charge ↓ by a factor '6' known as screening const.

In 'K' shell there is only one e^-, which belongs to 's'-orbitals i.e spherically symetry so for K-line, Effective nuclear charge become $Z - 1$

**

* For Kα-line: $\sqrt{\nu_{K\alpha}} = \sqrt{\frac{3RC}{4}}(Z-1)$

* For Kβ-line: $\sqrt{\nu_{K\beta}} = \sqrt{\frac{8RC}{9}}(Z-1)$

* For Kγ-line: $\sqrt{\nu_{K\gamma}} = \sqrt{\frac{15RC}{16}}(Z-1)$

!! *** → By this observation he concluded that property of material/atom depend on atomic no. not on atomic mass.

$$a = \text{propotional const} = \sqrt{Rc\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)}$$

NOTE→ 'a' depend on transition & 'b' depend on series but both are independent from at. no. of element.

$$\sqrt{V} = a(z-b)$$

$$V = R(z-b)^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

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

$$E = hv = Rch = (z-b)^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

* R = Redeberg const = $10^7 m^{-1}$
* $\frac{1}{R}$ = 912 A°
* 1 Rydberg = Rch = 13.6 eV (unit of energy)

$$E = 13.6(z-b)^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) eV$$

$$V = 2\times10^{15}(z-b)^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

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A → crystalline solid can cause x-ray to diffract.

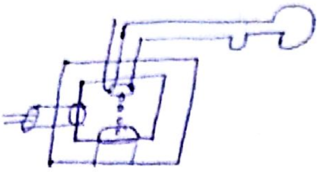
R → Interatomic distance in crystalline solid is of order of 0.1 nm.

Ans → A

'POSITIVE RAY'

|1| → Millikan oil drop exp →

|i| → By M.O. drop exp practically prove quantization of charge.



|a| $E = 0$

$\uparrow F_v = 6\pi\eta r v_1$

$\uparrow F_b = (V d_m) g = m'g$

$V_1 \downarrow$ m ● v

$\downarrow mg$

$E_{net} = 0 \Rightarrow a \Rightarrow 0 \Rightarrow v = const$

$F_v + F_b = mg$

$6\pi\eta r v_1 = m'g = mg$

$mg - m'g = 6\pi\eta r v_1$ —(1)

|b| → $E \neq 0$

$\uparrow F_e = qE$

$\uparrow F_b = V d_m g = m'g$

$V_2 \uparrow$ m ● q

$\downarrow mg$

$\downarrow F_v = 6\pi\eta r v_2$

$F_e + F_b = mg + F_v$

$qE = m'g = mg + 6\pi\eta r v_2$

$qE = (mg - m'g) + 6\pi\eta r v_2$

$qE = 6\pi\eta r v_1 + 6\pi\eta r v_2$

2016 AIIMS → ** $q = \dfrac{6\pi\eta r(v_1 + v_2)}{E}$ (r → Radius of drop; η → Viscous const.)

$V_1 \Rightarrow$ Terminal velo. in absence of electric field

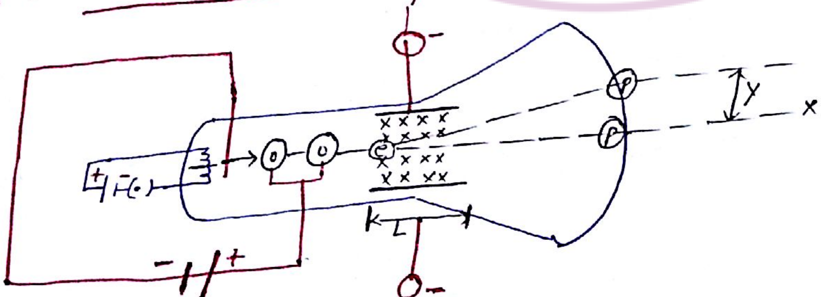
$V_2 \Rightarrow$ Terminal velo. in presence of Electric field.

From eqn (1)

$mg - m'g = 6\pi\eta r v_1$

** $r = \sqrt{\dfrac{9}{2}\dfrac{\eta r v_1}{d_b - d_m}}$

|2| → Thomson $\left(\frac{e}{m}\right)$ exp: →



|a| → $a = 0, B = 0 \Rightarrow e^-$ strike at point P.

|b| → $E \neq 0, B = 0$

X: $x = ut$ —(1) ; $t = \dfrac{x}{u}$

Y: $y = \left(\dfrac{eE}{m}\right)t^2$ —(11) ; $y = \dfrac{eE}{2m}\dfrac{x^2}{u^2}$

$x = L$: $\dfrac{e}{m} = \dfrac{2yu^2}{EL^2}$

|c| → $E \neq 0, B \neq 0$, e^- strike at point 'p' ; $u = E/B$; $\dfrac{e}{m} = \dfrac{2yE}{B^2L^2} = 1.78 \times 10^{11} \dfrac{cb}{Kgm}$

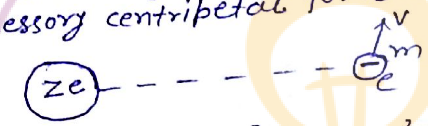
'ATOMIC STRUCTURE'

Spectrum of a matter.
When a body is heated it emits Radiation, which consist of various wave length. When these wavelength are ploted against a calibrated scale then, this part is called spectrum of matter.
In case of Hydrogen radiation of 6562 A° & then radiation 4860 A° was obserbed, these lines denoted the spectrum of Hydrogen.

Bohr Model of Hydrogen like atom → This model was developed Specifically for hydrogenic atom which const of 1e⁻.
Ex → H - atom, He^{+}, Li^{++}

NOTE → Although bohr model seems appropriate for hydrogen like atom & it is able to explain line of spectrum but still it doesn't give the true picture of even H-atom.
The true picture is derived from quantum mechanics affair which is different from Bohr Model in 2 fundamental way.

* 1st postulate →
  * Mass of nucleus is very large.
  * e⁻ is orbiting in circular orbit.
  * Necessory centripetal force is given by coulumbing attraction.



$$\frac{1}{4\pi\epsilon_0}\frac{Ze^2}{r^2} = \frac{mv^2}{r} \quad \text{—(1)}$$

$$\boxed{mv^2 = \frac{Ze^2}{4\pi\epsilon_0 r}}$$

* 2nd postulate →
  * Angular momentum of e⁻ is integral multiple of $\frac{h}{2\pi}$ or $\hbar$.

For nth orbit, $\boxed{mvr = \frac{nh}{2\pi}}$ —(2)

orbital angular momentum of e⁻ could not have any value. A/c to this postulate. While moving around these stable orbit charged particle does not emit any kind of Electromagnetic Radiation. Energy of e⁻ is const.

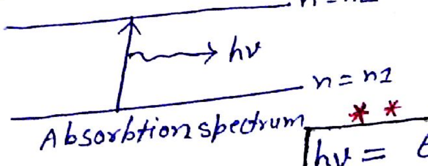
* 3rd postulate →

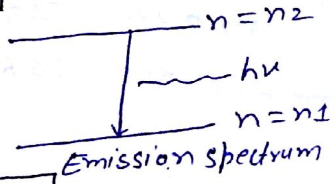
$$P.E = \frac{1}{4\pi\epsilon_0}\frac{Ze^2}{r} \quad \text{(For nth orbit)}$$

$$K.E = \frac{1}{2}mv^2$$

$E_{Total} = K.E + P.E$ = const. for a stable orbit.

$$\boxed{E_{Total} = \frac{1}{2}mv^2 - \frac{Ze^2}{4\pi\epsilon_0 r}}$$





$$\boxed{h\nu = E_{n_2} - E_{n_1}}$$

* Radius of orbit →

$$r = \frac{n^2h^2\epsilon_0}{\pi m Z e^2} = 0.53\frac{n^2}{Z}A^\circ$$

* velocity of e^- in nth orbit →

$$V = 2.18 \times 10^6 \frac{Z}{n} m/sec$$

|i| → current in nth orbit $\propto Z^2/n^3$
|ii| → Time period of nth orbit $\propto n^3/Z^2$
|iii| → Angular Momentum$(\omega) \propto Z^2/n^3$
|iv| → Magnetic Induction$(\vec{B}) \propto Z^3/n^5$
|v| → Magnetic moment$(\vec{\mu}) \propto n$

* current $= i = 2\frac{V}{2\pi r}e$
* Time period $= T = \frac{2\pi r}{V}$
* $\omega = \frac{V}{r}$
* $B = \frac{\mu_0 i}{2r} \propto \mu_0 \frac{Z^2}{n^3} \times \frac{Z}{n^2}$
* $\mu = iA = i \times \pi r^2 \propto \frac{Z^2}{n^3} \times \frac{n^4}{Z^2} \propto n$

Total energy in nth orbit

$PE = \frac{-1}{4\pi\epsilon_0}\frac{Ze^2}{r}$

$K.E = \frac{1}{2}mv^2 = \frac{1}{2}\frac{Ze^2}{4\pi\epsilon_0 r}$

$K.E = \frac{1}{2}|PE| = -\frac{1}{2}PE$

E_n = Totel energy $= K.E + PE = \frac{PE}{2} = -\frac{Ze^2}{8\pi\epsilon_0 r}$

$E_n = -13.6\frac{Z^2}{n^2}eV$

$= 13.6 = Rhc$

1 Rhydberg Energy $= 13.6ev \Rightarrow R = \frac{2\pi^2 mk^2e}{ch^3}$

Rhydberg const $= R = \frac{2\pi^2 mk^2e^4}{Ch^3} = 1.09 \times 10^7 m^{-1}$

Different Energy level.

$n=3, E_3 = \frac{-13.6}{9}Z^2$

$n=2, E_2 = \frac{-13.6}{4}Z^2$

$n=1, E_1 = -13.6Z^2$

** → For H-atom →
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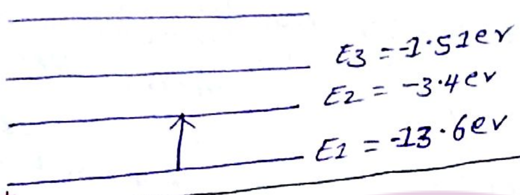
$E_1 = -13.6$ ev
$E_2^* = -3.4$ ev
$E_4 = -0.85$ ev
$E_5 = -0.54$ ev

Excitation of e^- in an atom → Whenever an e^-, in lower energy state or, ground state get some energy from external source it may make a transition to a energy level, this process is called excitation & the upper or, heigher energy state of e^- is termed as excited state.

For Ex – Hydrogen atom



** For excitation to $n=2$ i.e '1st excited state'
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$\Delta E = E_2 - E_1 = 10.2$ eV

For excitation to $n=3$ i.e 2nd excited state.
$\Delta E = E_3 - E_1 = 12.09$ ev

e^- can absorb energy in the form of photon or, form of calliding particle –

(i) → From photon → An e^- will absorb photon only of the energy 10.2 ev, 12.09 ev, 12.75 ev - - - - for its excitation.

(ii) → From calliding particle → The callision with the calliding particle must be inelastic so that K.E lost during the callision can be used to excite the atom.

We can use fallowing Law –

(a) → conservation of Linear momentum.
(b) → conservation of Energy.

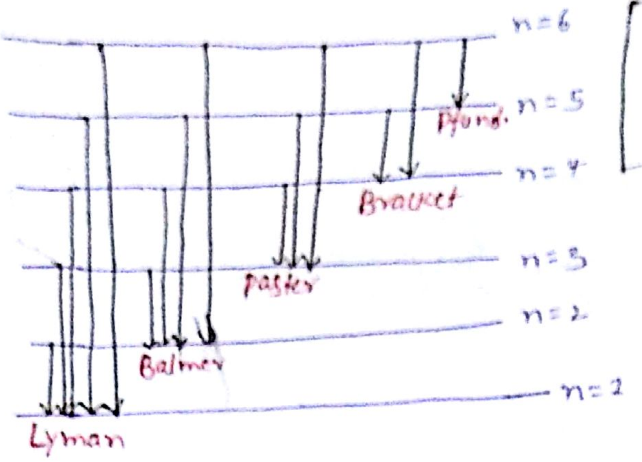
Ionisation Energy or, Ionisation potential : → For H-atom.

Min energy needed to remove the e^- from Ground state. **

$E = 13.6$ ev ⇒ B.E of e^-

Ionisation pot. is the min pot. through which an e^- must accelerate before making callision with the e^- of H-atom to knock out it.

Spectral line of H-atom



NOTE →
* For e^- in nth state, spectral line = $^nC_2$
* Max no. of photon Emitted = n − 1

NOTE → * No two element will have identical spectral line, since no two element have identical energy level. Therefore the in of sp. of element described as fingerprints of atom differing from each other like finger prints of Human.

* In H-atom an e^- jumps from six energy level to 1st excited state. The no. of lines crossponding to the Lyman series are → zero, bcoz e^- is not jumping in Ground state.

'COMMUNICATION SYSTEM'

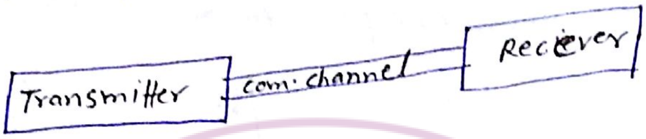
COMMUNICATION → It is process of transmittion of information from one place to another place without distortion.

Each & Every communication system have 3-basic part.

|i| → Transmitter → It is source of Information which propagate the Information towards the distant end with via communication channel.

|ii| → Reciver → It is device wich recive the information from communication channel wich transmited by transmiter.

|iii| → Communication channel → It is medium in b/w transmitter & receiver which propagate the signal from one place to another place.



Classification of communication system

on the basis of Information →

|1| → voice communication → Eg → Radio, Mobile, Telephone, T.V

|2| → picture communication → Eg → T.V, Internet, mobile.

|3| → Document communication → Eg → FAX (Fascimile transmission)

|4| → code communication → Eg → Internet, telegraphy.

on the basis of signal →

|i| → Analog communication.
|ii| → Digital communication.

on the basis of channel → (20Hz to 20KHz)

$$I = (P/A) \propto a^2 f^2$$

|1| → Line communication
|a| → Two wire communication
|b| → co-axial "
|c| → optical fibre

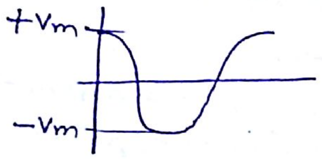
|2| → Wireless communication
|a| → Ground wave propagation
|b| → sky wave propagation
|c| → space wave propagation.

On the basis of Modulation (MHz to GHz)

$y = A\sin(\omega t + \phi)$

|i|→ Amplitude Modulation (A·M)
|ii|→ Frequency Modulation (F·M)
|iii|→ Phase Modulation (P·M)

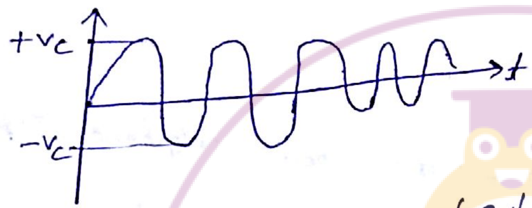
|1|→ Message signal → only electricity Wich contain the information.



$V_m = V_m \cos W_m t$ → 20 Hz to 20 KHz

|2|→ carrier Wave → It is a high frequency Wave Wich propagate the Message signal from one place to another place without distortion.

$V_c = V_c \cos(\omega_c t + \theta)$ → MHz to GHz



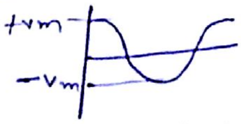
Modulation → It is process of superimposing of low frequency msg. signal (20 Hz to 20 KHz) over high frequency carrier Wave (MHz to GHz)
or, variation in Amplitude or, frequency or, phase of carrier Wave a/c to the msg. signal is known Modulation.

Modulation is 3-type

|1|→ A·M → to change in amplitude of carrier Wave a/c to msg. signal by keeping the phase & Freq const.

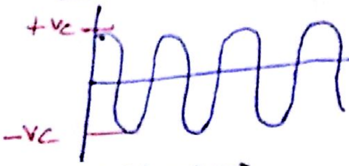
|a|→ Message signal →

$V_m = V_m \cos W_m t$



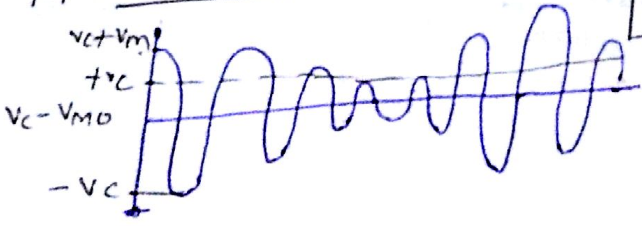
|b|→ carrier Wave →

$V_c = V_c \cos(\omega_c t)$



|c|→ A·M Wave →

$V_{AM} = (V_c + V_m \cos W_m t) \cos_c t$



**

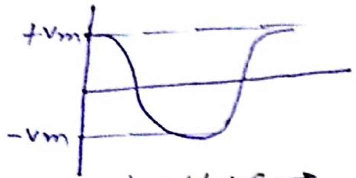
$$P_T = P_c\left(1+\frac{m^2}{2}\right)$$

P_T = total power require to transmittion A·M Wave from Radio station.

P_c = power carrier.

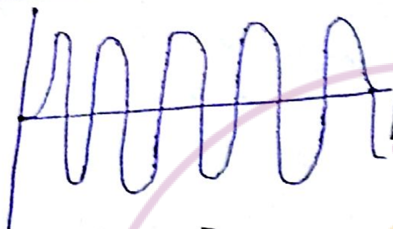
|2| → F·M → to change in the frequency in the carrier Wave a/c to the message signal by keeping the amplitude $ phase const.

|i| → Message signal →



$V_M = V_m \cos \omega_m t$

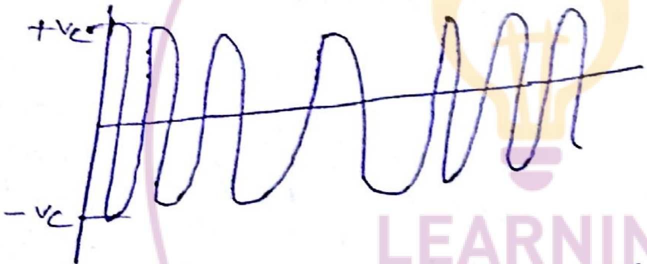
|ii| → carrier Wave →



$V_c = V_c \cos \omega_c t$

$V_{FM} = V_c \cos(\omega_c t + K V_m \cos \omega_m t)$

|iii| → F·M Wave →



* F·M radio is true only in range 88 MHz to 108 MHz

AMU 2016 * Any unwanted signal is known as the noice.

Comparision b/w A·M $ F·M

A·M

* cost of A·M radio station is low bcoz its transmitter ckt is not complex.
* In A·M we are adding the signal (valtage) In Amplitude (valtage)
* Less frequency band width is required so can transmit more no. of signals at a time.
* Here noise corruption is easy so quality of signal is not so good.
* Range of A·M radio is less.

F·M

* cost of F·M radio station is very high bcoz its transmitter ckt is very complex.
* In F·M we are adding the signal (valtage in frequency).
* More frequency band width is required so, we can transmitt less no. of signals at at time.
* Here noise corrption is not easy so, quality of signal is very good.
* Range of F·M radio is more.

*→ For Good reception of signal, height of antena must be $\lambda/4$

Need of Modulation →

|a|→ To increase the power of signal → When we shift the low freq. over high freq. carrier wave than freq. of signal is ↑ so power of signal is ↑ so we can transmit the signal over longer distance without distortion.

|b|→ To make the height of Antena practics →

* Before Modulation (20Hz to 20KHz)

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{10KHz} = 3\times10^4 m = 30 Km$$

height of Antena $= \lambda/4 = 7.5 Km$

* After Modulation (MHz to GHz)

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{20MHz} = 30m$$

height of antena $(\lambda/4) = 7.4 m$.

|c|→ To avoid the mixing of noise & signal → noise & voice both are lies in same frequency range, so, large chance of Interference b/c freq. gap is less but as we modulate the signal (voice) Freq. gap b/w voice & noise is ↑ so less chance of mixing & Interference.

|d|→ To avoid the mixing of signal wich are transmitted from diff transmitter → When large no. of signals are lies in short range (20Hz to 20KHz). so Freq gap b/w signal is less so, large chance of Interference (mixing). but when these signals are shifted over large Freq. range (MHz to GHz). so Freq gap ↑ so less chance of mixing.

Wireless communication → propagate without wire information is in the form of EMW.

|a|→ Ground wave propagation

|b|→ Sky wave propagation (Ionosphere)

|c|→ Space wave propagation.

Space wave propagation (line of sight communication)

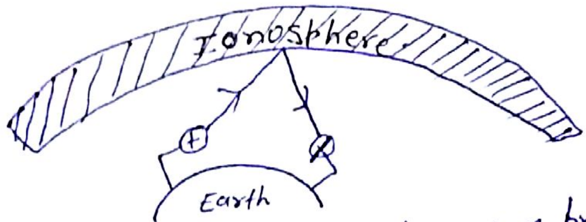
Here, EMW (signal) is transmitted from transmitting antena to receving antena in straight line so, it is only possible up to that distance there is no obstracle b/w them.

BCECE 2016 / $d = \sqrt{2hR}$ $d \propto h^{1/2}$

$d = \sqrt{2h_1R} + \sqrt{2h_2R}$ →If two tower than add.

Sky Wave propagation → Here, signal (EMW) are transmitted from transmiteding antenna towards the SYK. It is reflected back. From Ionosphere by T.I.R phenomena. towards receving antena. those signals Wich have freq. in (< 30MHz) is reflected from Ionosphere.

Those signal have freq > 30MHz refracted from Ionosphere (not Reflected) From ionospher and for it satellite is used as a reflector.



Critical Freq (c) → Max freq. of SkyWave propagation up to that the reflection from ionosphere will detect place or, Just after that signal is reflected.

It depend on ion density of that place & Its value is

$$f_c = 9\sqrt{N_0}$$

N_0 → Max ion density $\left(\frac{Ion}{m^3}\right)$

Sky wave propagation is possible $f \le f_c$

$$N_0 = \frac{f_c^2}{81}$$