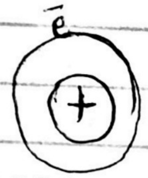
CH # 19

"Atomic Spectra"

Bohr Atomic Model:

① electrons revolve around the nucleus in circular orbits.
and F_c is



provided by columb force of attraction.

$$F_c = \frac{m V_n^2}{r_n} \quad \text{———} \quad (1)$$

$$F_c = K \frac{e^2}{r_n^2} \quad \text{———} \quad (11)$$

combine (I) and (II) :

$$\boxed{\frac{m V_n^2}{r_n} = \frac{K e^2}{r_n^2}}$$

② Electron can only revolve in that particular orbit whose Angular momentum is the integral multiple of $\left(\frac{h}{2\pi}\right)$.

$$\boxed{m V_n r_n = \frac{nh}{2\pi}}$$

③ As long as electron is moving in its own particular orbit, it will neither absorb or radiate energy.

④ When $\bar{e}$s make transition from low to high energy is absorb and vice versa.

$$\Delta E = E_n - E_P$$

$$n = 1, 2, 3 \dots$$

$$P = 1+P,\ 2+P,\ 3+P \text{ etc.}$$

Applications of Bohr's Atomic model to Hydrogen Atom:-

① Expression for the Radii of Quantized orbits:-

①

$$F_c = \frac{m V_n^2}{r_n} \quad \text{——— (i)}$$

$$F_c = K \frac{e^2}{r_n^2} \quad \text{——— (ii)}$$

equate (i) and (ii)

$$\frac{mV_n^2}{\cancel{r_n}} = \frac{Ke^2}{r_n^{\cancel{2}}}$$

$$mV_n^2 = \frac{Ke^2}{r_n}$$

$$Ke^2 = mV_n^2 r_n$$

$$\boxed{r_n = \frac{Ke^2}{mV_n^2}} \text{ --- (iii)}$$

Applying 2nd postulate of Bohr:

$$mvr = \frac{nh}{2\pi}$$

$$v = \frac{nh}{2\pi m r_n} \text{ --- (iv)}$$

$$r_n = \frac{Ke^2}{m\left(\frac{nh}{2\pi m r_n}\right)^2}$$

$$r_n = \frac{Ke^2}{m\left(\frac{n^2h^2}{4\pi^2 m^2 r_n^2}\right)}$$

$$\cancel{r_n} = \frac{Ke^2}{\cancel{m}}\left(\frac{4\pi^2 m^{\cancel{2}} r_n^{\cancel{2}}}{n^2h^2}\right)$$

$$\left(\frac{4\pi^2 m Ke^2}{n^2h^2}\right) r_n = 1$$

$$\boxed{r_n = \frac{n^2 h^2}{4\pi^2 m K e^2}} \quad \text{—— (V)}$$

$$r_n = n^2(0.529 A^\circ)$$

$$r_n = n^2 r_1 \quad \text{—— (VI)}$$

$n = 2$

$$r_n = 4 r_1$$

$n = 3$

$$r_n = 9 r_1$$

$\vdots \qquad \vdots$

Electron can't go inside the nucluse - In that case it will hav $V > C$.

$$r_N \sim 10^{-15}\, m$$

$$\Delta x \sim 10^{-15}\, m$$

$$\Delta x (\Delta P) \approx h$$

$$\Delta x (m \Delta V) \approx h$$

$$\Delta V = \frac{h}{m \Delta x}$$

$$\Delta V = 10^{10}\, m/s$$

. Which is against Einstein

(11) Expression for the Energy of electron in an orbit:-

$$E_n + (K.E)_n + (P.E)_n$$

$$F_c = \frac{mv_n^2}{r_n}$$

$$F_e = \frac{Ke^2}{r_n^2}$$

$$\frac{mv_n^2}{\cancel{r_n}} = \frac{Ke^2}{r_n^{\cancel{2}}}$$

$$mv_n^2 = \frac{Ke^2}{r_n}$$

÷ing b.s by.

$$\frac{mv_n^2}{2} = \frac{Ke^2}{2r_n}$$

$$(K.E)_n = \frac{Ke^2}{2r_n}$$

$$P.E = W.D$$

$$P.E = \vec{F_e} \cdot \vec{d}$$

$$P.E = F_e d \cos\theta$$

$$P.E = F_e d \cos(180^\circ)$$

$$P.E = + F_e \cdot d$$

$$(P.E)_n = -\frac{Ke^2}{r_n^{\cancel{2}}} \cancel{r_n}$$

$$(P.E)_n = -\frac{Ke^2}{r_n} \quad \text{——} \; 3$$

Put eq 2 & 3 in 1,

$$E_n = \frac{Ke^2}{2r_n} + \left(-\frac{Ke^2}{r_n}\right)$$

$$E_n = \frac{Ke^2 - 2Ke^2}{2r_n}$$

$$E_n = -\frac{Ke^2}{2r_n} \quad \text{——} \; 4$$

$$\because \; r_n = \frac{n^2h^2}{4\pi^2 mKe^2} \quad \text{——} \; 5$$

$$E_n = \frac{-Ke^2}{2\left(\frac{n^2h^2}{4\pi^2 mKe^2}\right)}$$

$$E_n = \frac{-Ke^2}{\cancel{2}}\left(\frac{\cancel{4}^{2}\pi^2 mKe^2}{n^2h^2}\right)$$

$$\boxed{E_n = -\frac{2\pi^2 m K^2 e^4}{n^2 h^2}} \quad \text{--- (6)}$$

$$E_n = \frac{-2.17 \times 10^{-18} J}{n^2}$$

$$1 eV = 1.6 \times 10^{-19} J$$

$$E_n = \frac{-2.17 \times 10^{-18}}{n^2 (1.6 \times 10^{-19})} eV$$

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

(For Hydrogen)

$n = 1$

$E_1 = -13.6 eV$

$n = 2$

$E_2 = -3.4 eV$

$n = 3$

$E_3 = -1.51 eV$

$n = 4$

$E_4 = -0.85 eV$

$n = 5$

$E_5 = -0.54 eV$

3. Expression for the Emission & Absorption of Energy:-

$$E = E_n - E_p \quad \text{—} \ (1)$$

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

$$E_p = \frac{-2\pi^2 m k^2 e^4}{p^2 h^2}$$

$$(1) \Rightarrow \ E = \frac{-2\pi^2 m k^2 e^4}{n^2 h^2} - \left(-\frac{2\pi^2 m k^2 e^4}{p^2 h^2} \right)$$

$$E = \frac{-2\pi^2 m k^2 e^4}{n^2 h^2} + \frac{2\pi^2 m k^2 e^4}{p^2 h^2}$$

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

$$E = \frac{2\pi^2 m k^2 e^4}{h^2} \left(\frac{1}{p^2} - \frac{1}{n^2} \right) \quad \text{—} \ (2)$$

Expression for Frequancy:

$$E = hf$$

$$f = \frac{2\pi^2 m k^2 e^4}{h^3}\left(\frac{1}{p^2} - \frac{1}{n^2}\right)$$

Wavelength:

$$c = f\lambda$$

$$f = \frac{c}{\lambda}$$

$$\frac{c}{\lambda} = \frac{2\pi^2 m k^2 e^4}{h^3}\left(\frac{1}{p^2} - \frac{1}{n^2}\right)$$

$$\frac{1}{\lambda} = \frac{2\pi^2 m k^2 e^4}{c h^3}\left(\frac{1}{p^2} - \frac{1}{n^2}\right)$$

$$\frac{2\pi^2 m k^2 e^4}{c h^3} = R_H$$

$$\frac{1}{\lambda} = R_H\left(\frac{1}{p^2} - \frac{1}{n^2}\right)$$

$$\boxed{R_H = 1.0974 \times 10^{7}\, m^{-1}}$$

Energy level Diagram :-

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

$n = 1$

$E_1 = -13.6 \, eV$

$n = 2$

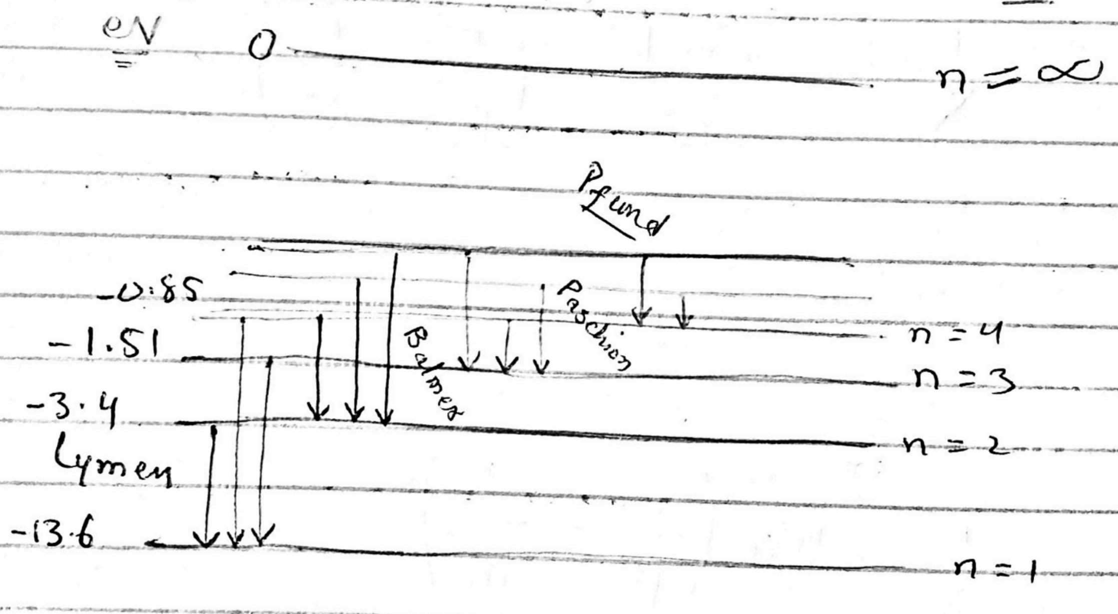
$E_2 = -3.4 \, eV$

$n = 3$

$E_3 = -1.51 \, eV$

$n = 4$

$E_4 = -0.85 \, eV$



$$\frac{1}{\lambda} = R_H \left(\frac{1}{p^2} - \frac{1}{n^2} \right)$$

$p = 2, 3, 4, \ldots$

$$\frac{1}{\lambda} = R_H \left(\frac{1}{1^2} - \frac{1}{n^2} \right) \Rightarrow \text{Lymen Series}$$

(Ultraviolet)

Zeman = Spliting in magnetic field
Stark = Spliting in electric field.

$$\frac{1}{\lambda} = R_H\left(\frac{1}{2^2} - \frac{1}{n^2}\right) \Rightarrow \text{Balmer Series}$$

(Visible Light)

$$\boxed{E_{max} = \frac{hc}{\lambda_{min}}}$$

$$\boxed{E_{mini} = \frac{hc}{\lambda_{max}}}$$

Limitations of Bohr's Atomic Model :-

① Bohr's Atomic Model is aplicable to unielectron System.

i.e H, He^+, Li^{++}

Debroglie's Hypothesis & Bohr Atomic Model :-

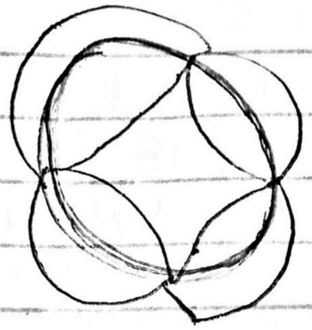
$$mV_n r_n = \frac{nh}{2\pi}$$

prof :-

$$\lambda_n = \frac{h}{P_n}$$

For electron (particle)

$$\lambda_n = \frac{h}{mV_n} \quad \text{---} \quad (1)$$



$n = 2$

Circumference

$$L = 2\pi r_n \quad \text{——} \quad (2)$$

$$L = n\lambda_n \quad \text{——} \quad (3)$$

$$n\lambda_n = 2\pi r_n$$

$$\lambda_n = \frac{2\pi r_n}{n} \quad \text{——} \quad (4)$$

Compare (1) & (4):

$$\frac{2\pi r_n}{n} = \frac{h}{m v_n}$$

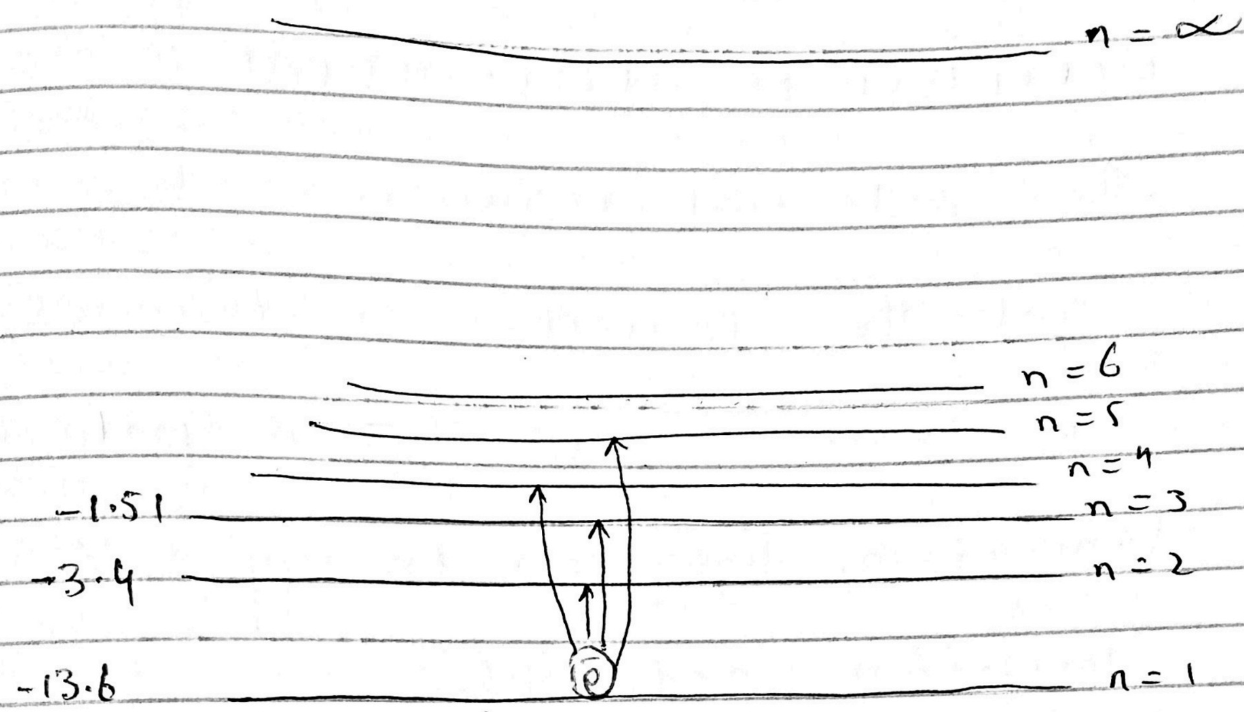
$\cancel{2\pi r_n}$

$$2\pi m r_n v_n = nh$$

$$\boxed{m v_n r_n = \frac{nh}{2\pi}}$$

which is the required proof of Bohr's Momentum...

Excitations, Excitation Energy & Excitation Potential :-



(Ground Energy State)

A process in which an electron get enough energy to in its ground State to go to any excited State is called Excitation energy and the process is called Excitation.

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

$n = 1$

$$E_1 = -13.6\ eV$$

$n = 2$

$$E_2 = -3.4\ eV$$

$$(E_{ex})_1 = E_2 - E_1$$

$$= 10.2\ eV$$

$(E_{ext}) = 10.2\ eV$

$(E_{ext}) = (10.2V)\ e$

EXCITATION POTENTIAL:-

The potential required to get the desired excition energy is called excitation potential

Ionization, Ionization Energy & Ionization potential:-

* A process in which an electron gets enough energy in its ground state to go to the infinity is called Ionization. The Energy required is called Ionization energy.

$n = \infty$

$E_\infty = \frac{-13.6}{\infty}\ eV$

$E_\infty = 0$

$E_i = E_\infty - E_1$

$$E_i = 0 - (-13.6\,eV)$$

$$E_i = 13.6\,eV$$

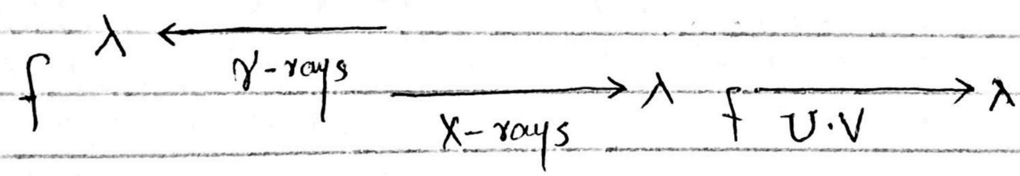
$$\boxed{E_i = (13.6V)\,V}$$

The potential required to get the desired value of Ionization energy is Called ~~excitation~~ Ionization potential....

Exam Ques

27 Dec 2017 :

Inner shell transition & X-rays:-



X-rays having shorter wavelength then UV & Longer wavelength then γ-rays.

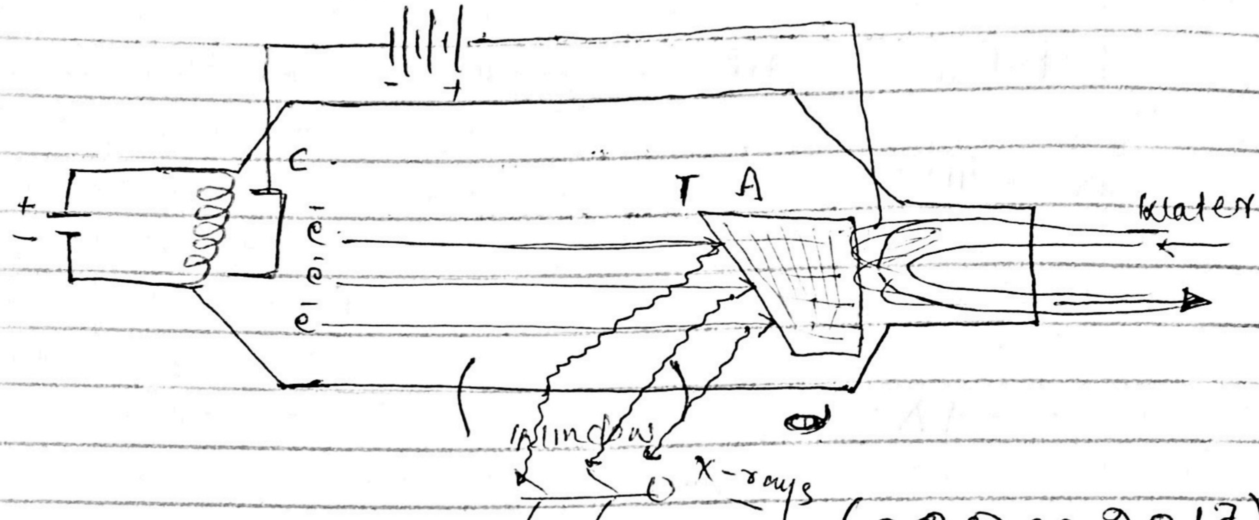
$$E = hf$$

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

* X-rays are more Energetic than UV & less then γ-rays

production of X-rays:-

How we can produce X-rays in Hospitals etc ??



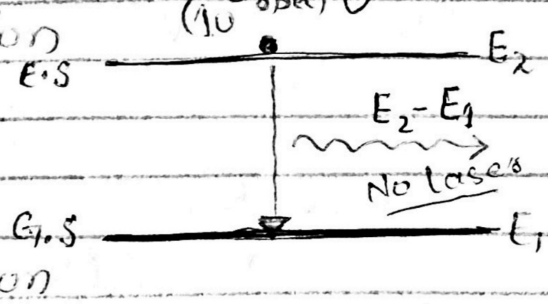
(28 Dec 2017)

LASER principles & Operations:-

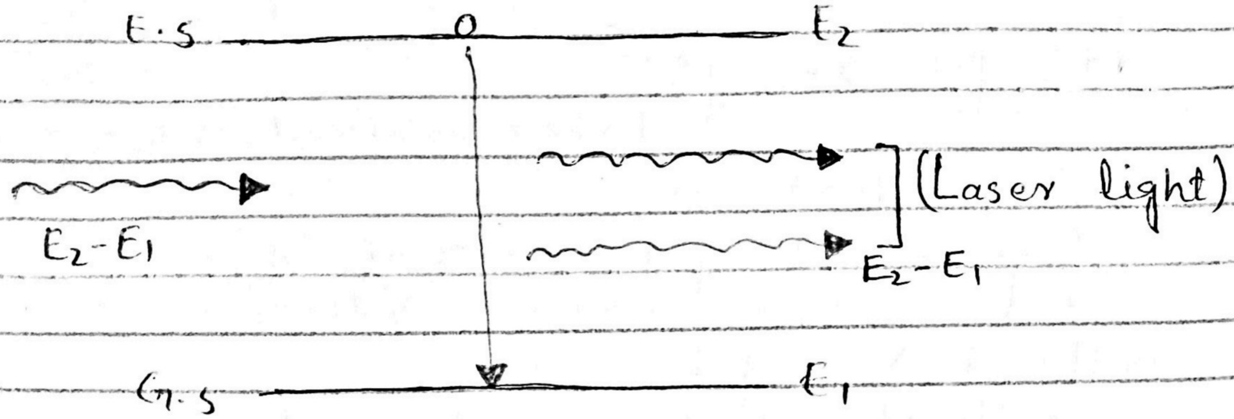
Exam Ques (Light Amplification (Intensification) by Stimulated emission of Radiations)

* Stimulated emission = Basic principle of LASER.

1. Spontanious Emission



2. Stimulated Emission



This is Stimulated emission. Bcz the

$\lambda \sim 1\,\mathring{A}$

$\lambda\ 10^{-12} \sim 10^{-10}m \sim 10^{-9}m$

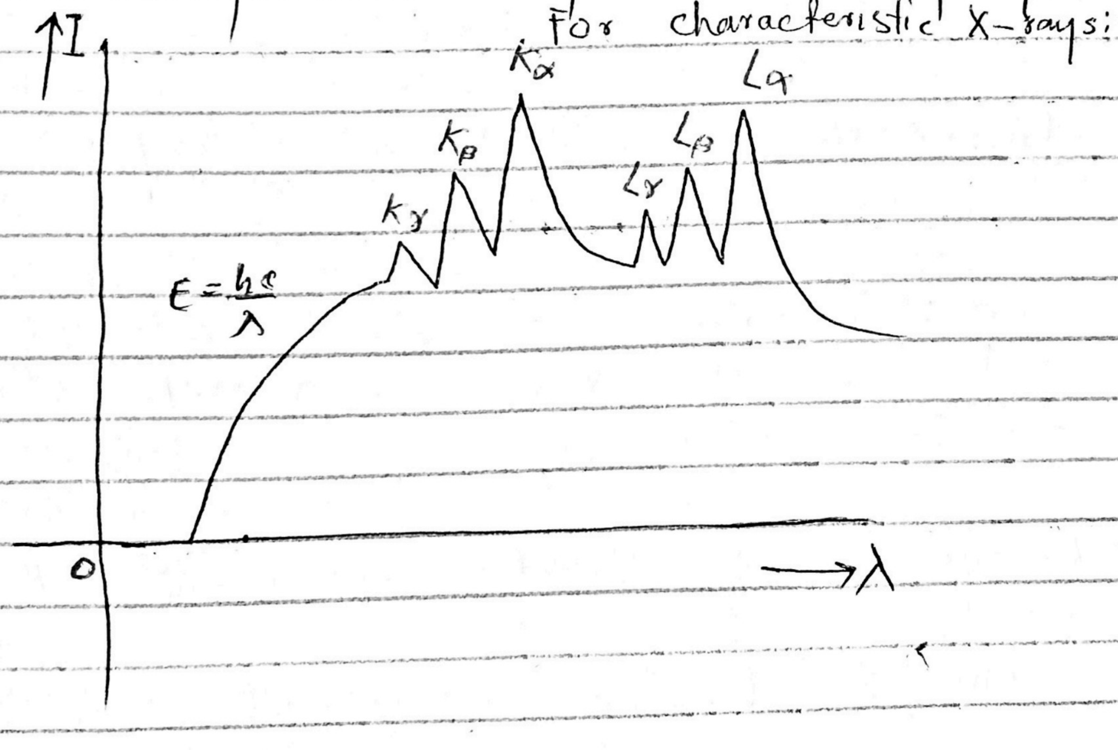
$E \sim 1\,KeV$ —— $100\,KeV$

1. characteristic X-rays:-

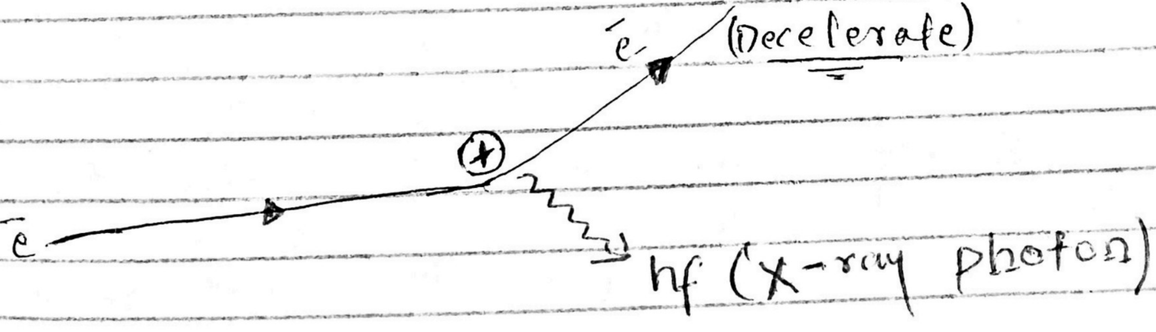
2. Continous X-rays:-

Intensity ~~wavelength~~ ~~Diag~~ graph:-

For characteristic X-rays:



Continous X-rays:-



* X-rays is also Called Bremsstr-aulung. → Brake Radiation.

$$\Delta(K.E)_{gain} = eV \text{ ——— } (I)$$

$$\Delta(K.E)_{loss} = hf \text{ ——— } (II)$$

$$(I) = (II)$$

$$eV = hf$$

$$c = f\lambda$$

$$f = \frac{c}{\lambda} \text{ ——— } (III)$$

$$eV = h\left(\frac{c}{\lambda}\right)$$

$$\boxed{\lambda = \frac{hc}{eV} \text{ ——— } (IV)}$$

$$\lambda \propto \frac{1}{V}$$

(V = accelerating voltage)

(I) Soft X-rays: Longer Wavelength radiation.
* Less energetic radiation
* Less accelerating voltage.

(II) Hard X-rays:-
* Short Wavelength radiation.
* More energetic radiation.

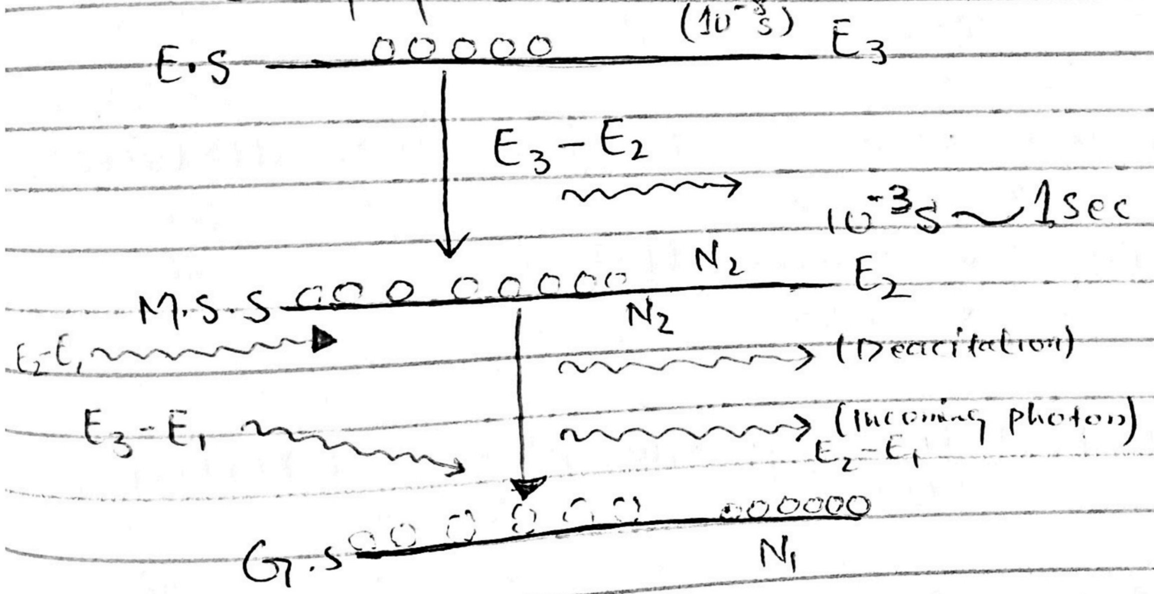
atom is de-excite Before 10^{-8} s.

(*) The photons are intensified in this Case. So It is LASER LIGHT.

When there are three energy states In a Simplo, then LASER light will be emitted when the following two conditions are Satisfied.

(i) Meta Statble State:- More Stable then excited & less stable then the g.s.

(ii) population Inversion:



At Start:

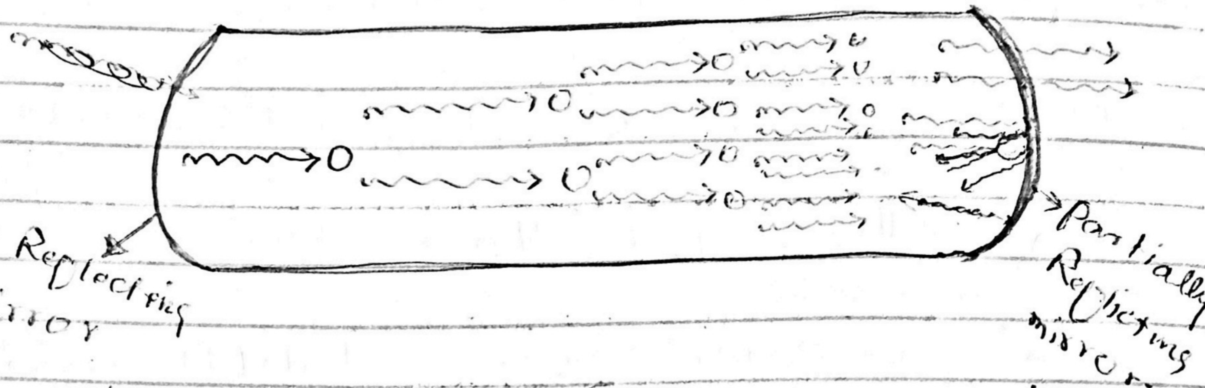
$$N_1 > N_2$$

After sometime:

$$N_2 > N_1$$

This is called population Inversion

* Solid LASER: Lasing Madium (Madium in which Laser Action takes place) is Solid.



* Liquid LASER:- Lasing Madium is liquid.

* Gass LASER:- Lasing Madium is gass.

Helium-Neon LASER:-

* We use a Mixture of Helium & Neon.

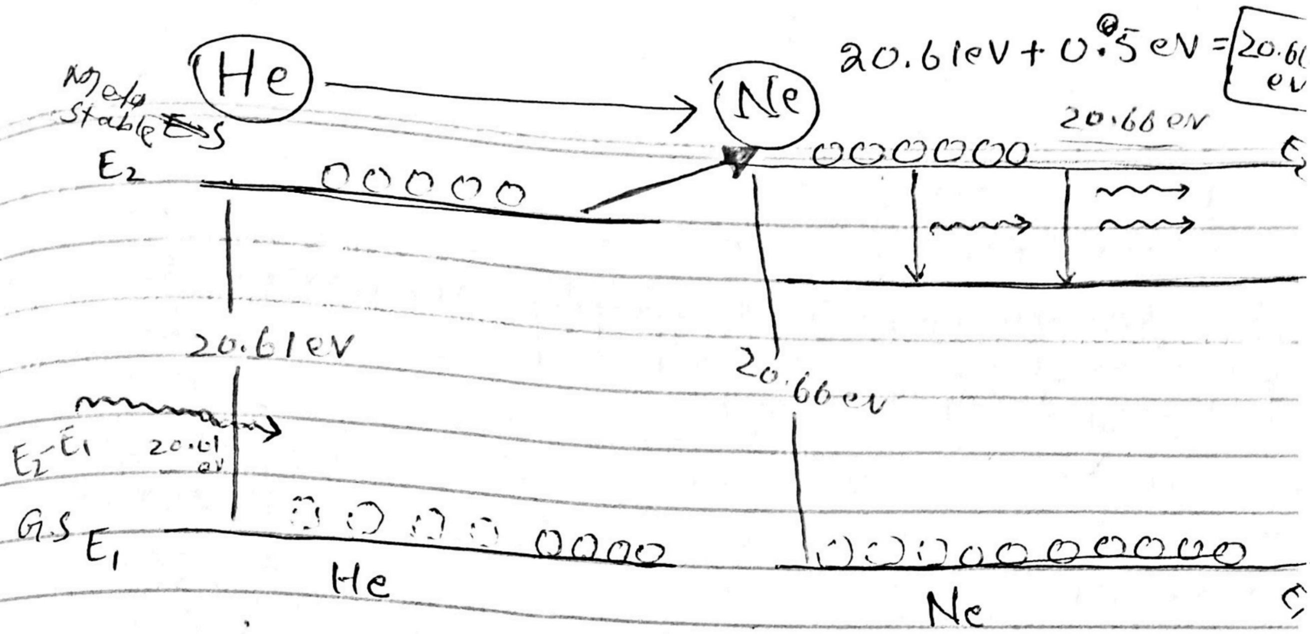
(i) * 85% Helium
* 15% Neon

(ii) For He gap b/w Meta & Excited state is 20.61 eV

(ii) For Ne it is 20.66 eV

(iii) He → Pumping Madium

Ne → Lasing Madium



practically Red light is emited

when Ne atoms dearcite.
It's wavelength is ($\lambda = 632.8nm$)

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

$$\boxed{E = 1.96 eV}$$

It shows that there is another

energy state in Ne whose energy

is 1.96 eV.

When ~~ato~~ atoms come to this State

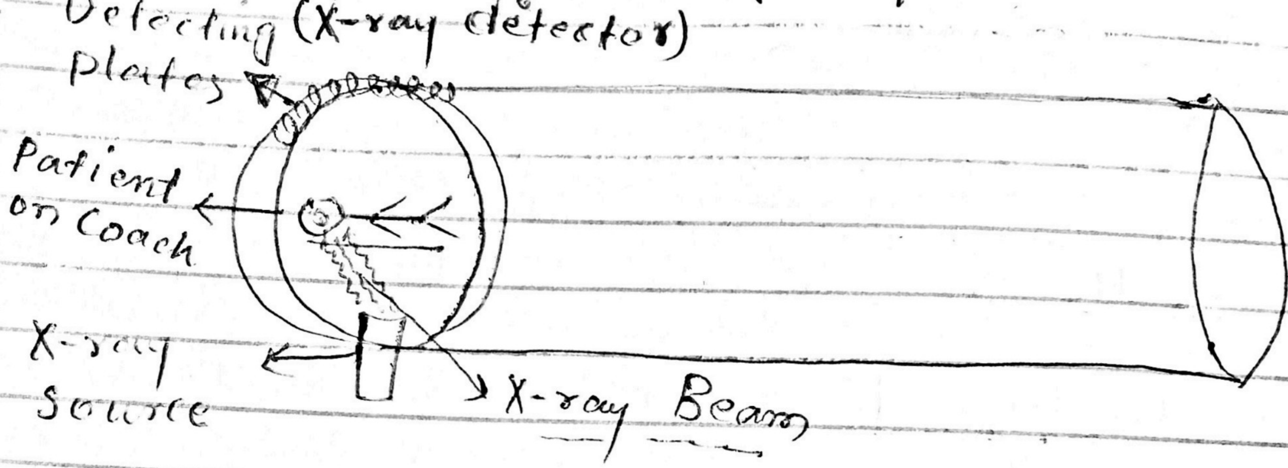
reasonance takes place and

two photons are emitted.

So, Ne is Acting lasing madium

CT Scanner:-

Computer Tomography Scanner:.



CT-Scan Image is 3Dimensional
X-rays = 2Dimensional...