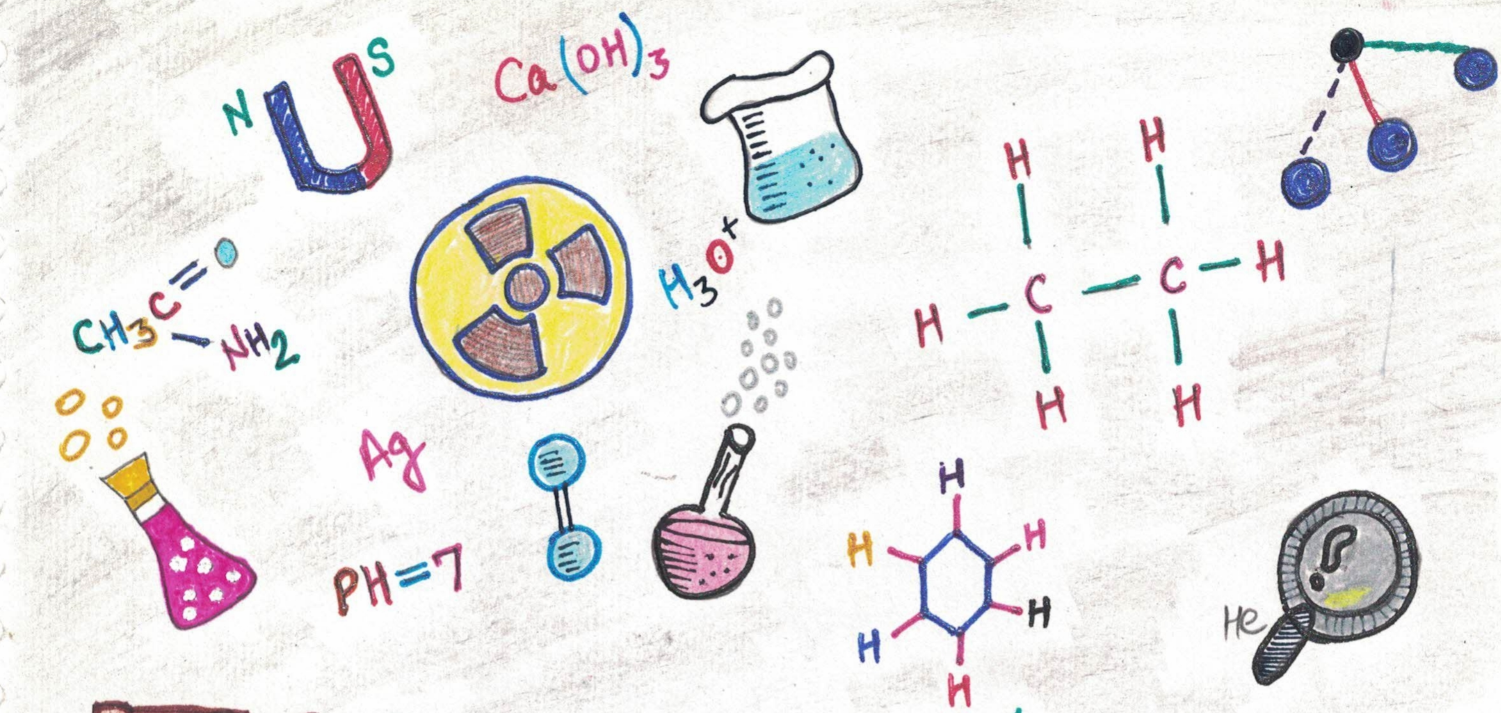
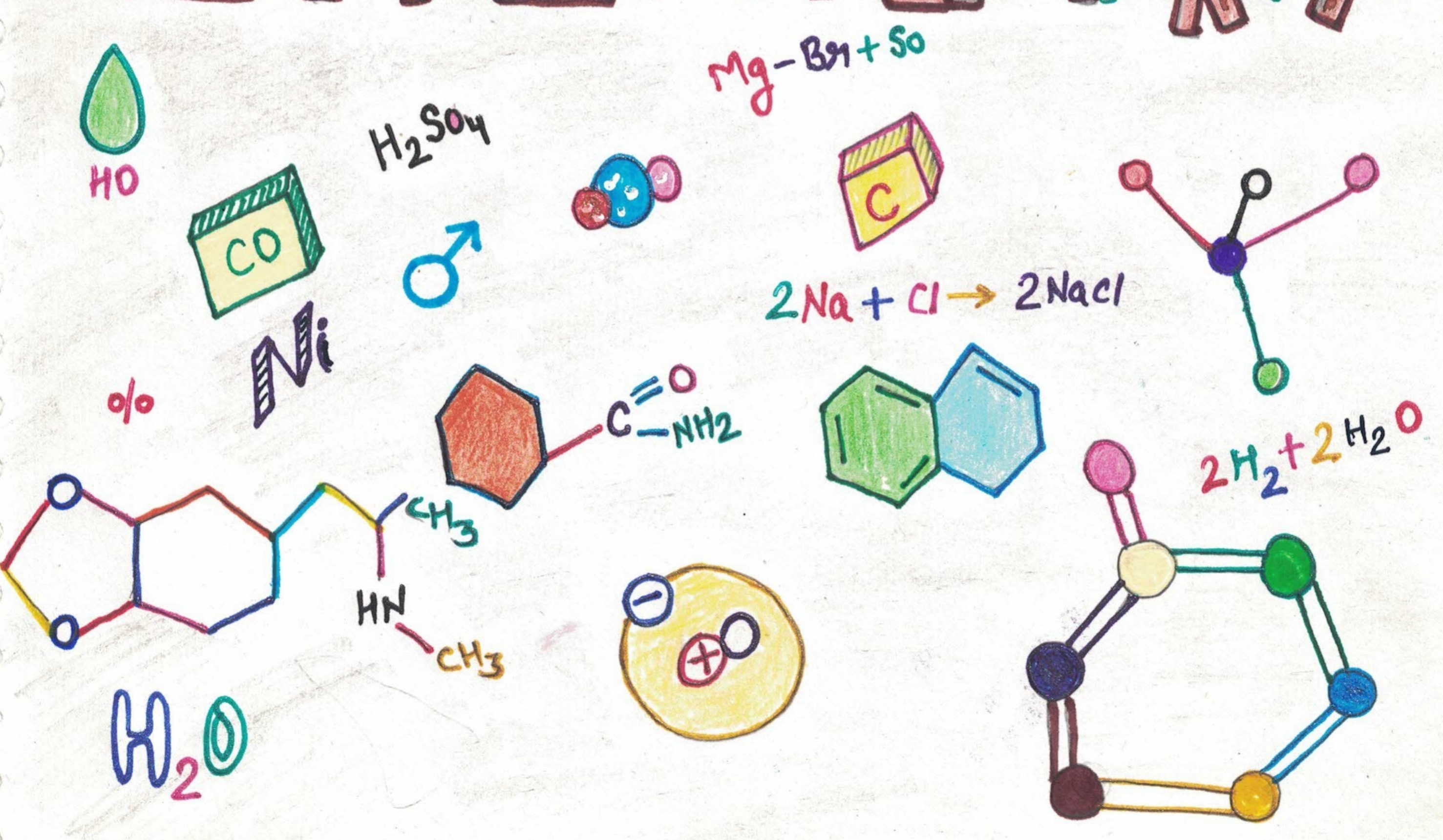


PHYSICAL CHEMISTRY



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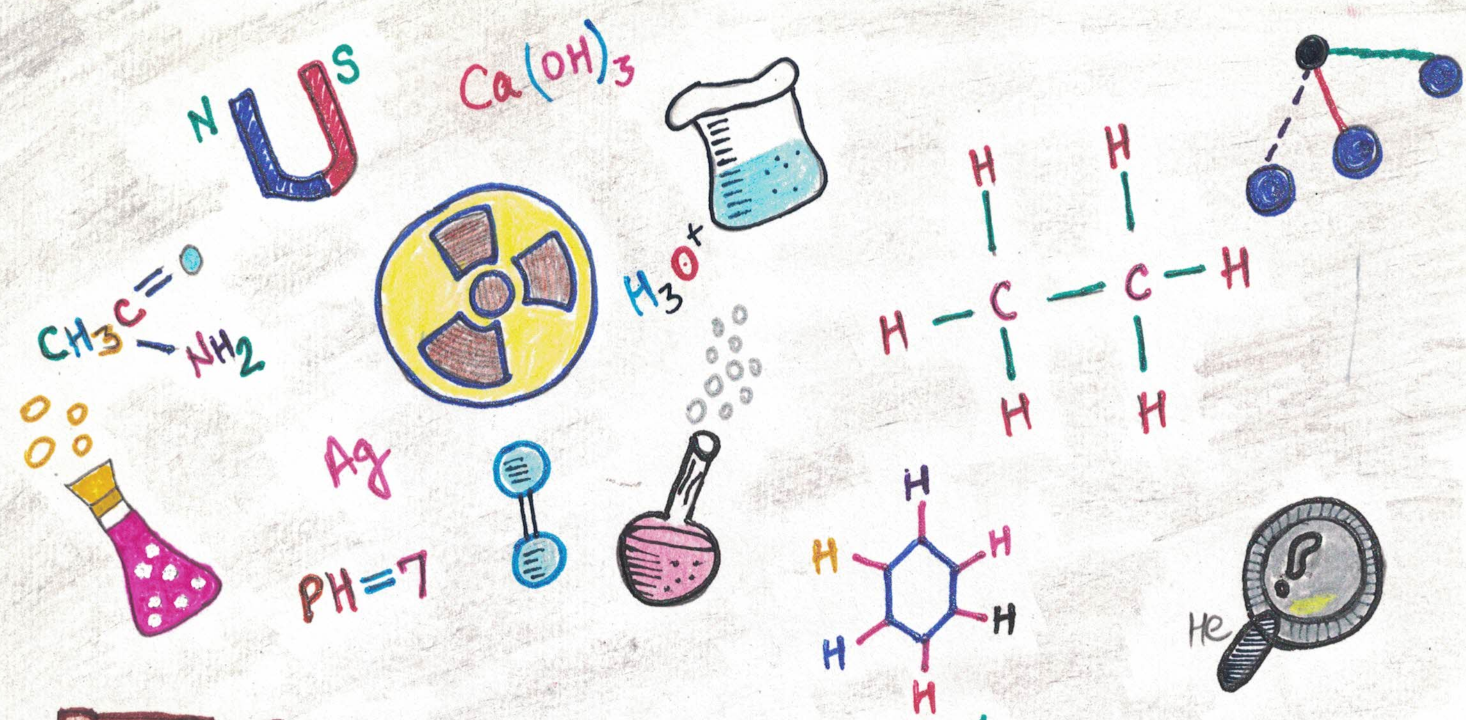
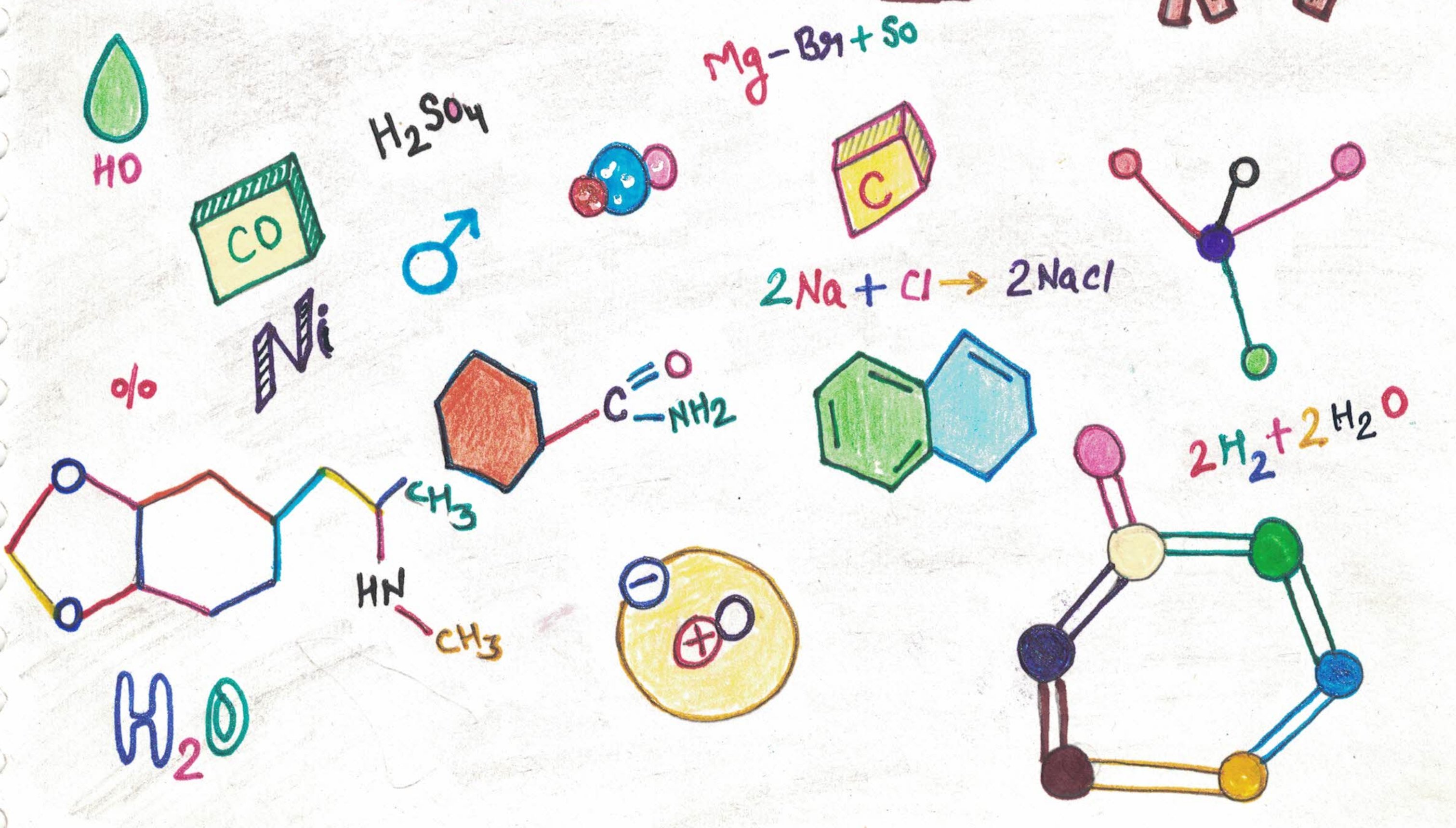
PHYSICAL CHEMISTRY



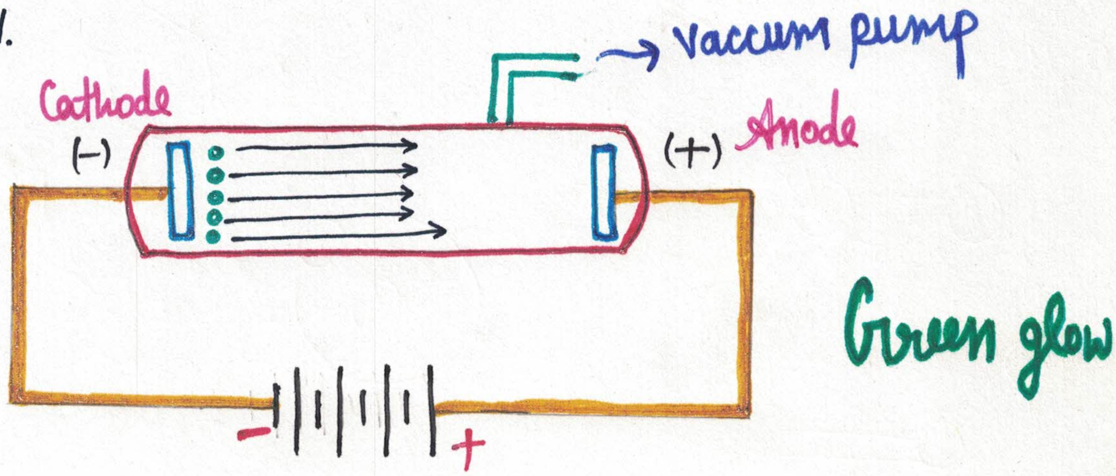
PHYSICAL CHEMISTRY



ATOMIC STRUCTURE

DISCOVERY OF ELECTRON

A. **CATHODE RAYS** – Julius Plucker was working on conduction through gases; on discharge tube. At low pressure and very high voltage, pressure was around [10^{-2}, 10^{-4}] atm, voltage was around [10^3, 10^4] V.



He observed a way coming from cathode to anode ; consisting of some charge and mass. He named it as cathode rays.

PROPERTIES

e^-

1. It travels in a straight line.
2. It Consists of mass as pedal wheel will rotate.
3. On applying electromagnetic field, he observed that the cathode rays are negatively charged.
4. It Produced green glow on zns screen.
5. It affects the photographic plate.

J. J. Thompson calculated the e/m ratio, i.e specific charge (charge/mass) for different gases and he observed that this ratio is a constant for all gases, and he named it is as electron.

The gases ionised to give e^- $\boxed{H \rightarrow H^+ + e^-}$

DISCOVERY OF PROTON

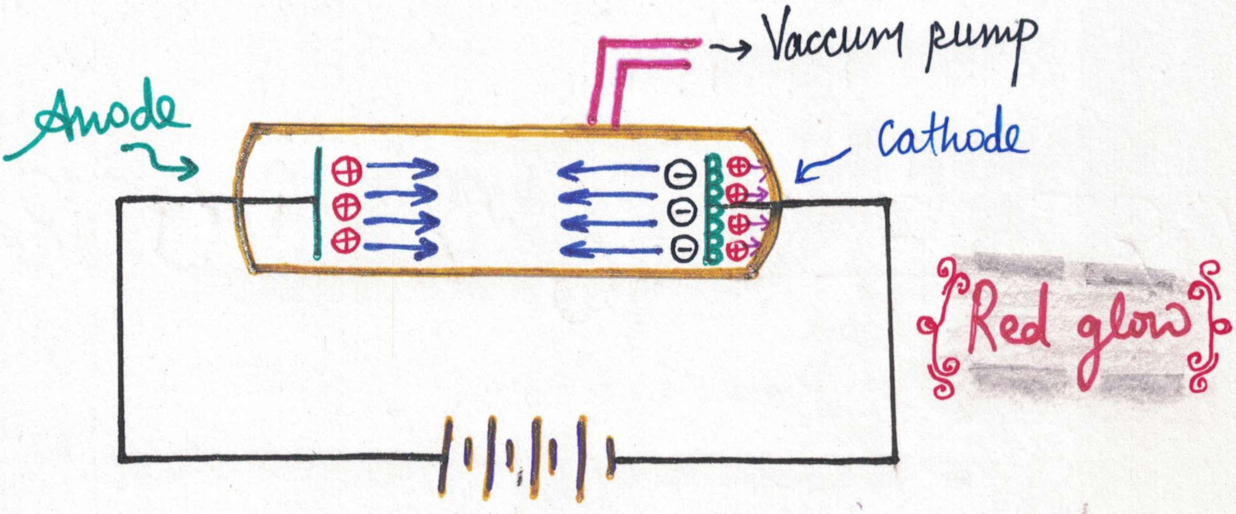
Goldstein started to work on perforated cathode in a discharge tube.

max (e/m) $H \rightarrow H^+ + e^- \longrightarrow e/m$ → changes as the charge is H^+

proton

$He \rightarrow He^+ + e^- \longrightarrow$ Different element

All Cathode rays are e^- but all anode rays are not **protons**.



These are called as anode rays (canal rays). It consists of positive charge. The specific charge (e/m) will be different for different gases. It is maximum for hydrogen gas. If 'H' gas is used, this will be a ray of protons.

DISCOVERY OF NEUTRON

Chadwick started experiment on be particles. on α bombardment on the Be particle, he observed 1 particle which is neutral. He named it as **neutron.**

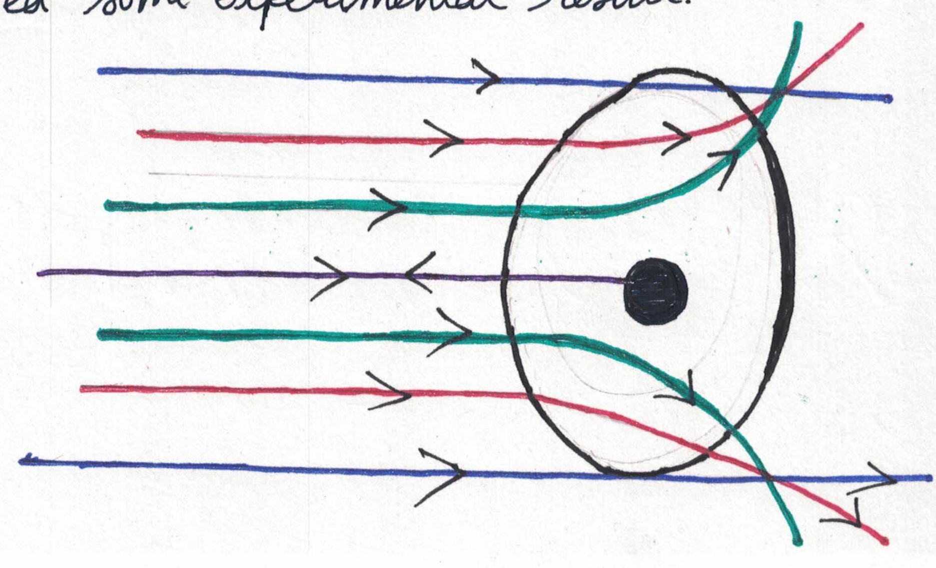
$$^{9}_{4}Be + ^{4}_{2}He \longrightarrow ^{12}_{6}C + ^{1}_{0}n$$

ATOMIC MODELS

(A.) S.S. Thompson Model – It is called "Plum-Pudding" model or Watermelon model. According to this model, atom is like a watermelon which consists uniformly distribution of positive charge and e^{-}'s are embedded like seeds in it.

(B) RUTHERFORD Model – He started experimental on gold foil with α-Particles. He observed some experimental result.

α-Particles



i. Most of the α-particles come straight on target.

ii. Some of α-particles get deviated through some angle.

iii. Very few α-particles return back.

α-particles is a set of (2 proton & 2 e^-)

When velocity is increased very high, then it goes inside the nucleus. Nothing on target is observed.

CONCLUSION

1. Most of the part of the atom is hollow. Total +ve charge will contain a fraction (small) of total volume of atome. It is called Nucleus.

As very few α-particles return back. e^- will revolve around nucleus in circular orbits.

He derived the radius of the neucleus $\boxed{r = r_0 A^{1/3}}$, $r = 1.33 \times 10^{-15}$ m.

No. of particles, $\boxed{N \propto \frac{1}{\sin^4(\theta/2)} \propto t \propto PE \propto \frac{1}{(KE)^2}}$ $\propto^{1/2}$

t = is the thickness of the fail

θ = Scattering angle

r = distance b/w the source of α-particles & fail

$\theta_{max} = 180°$

If there are 100 α-particles scattered at an angle $120°$; what will be no. of α-particles scattered at:-

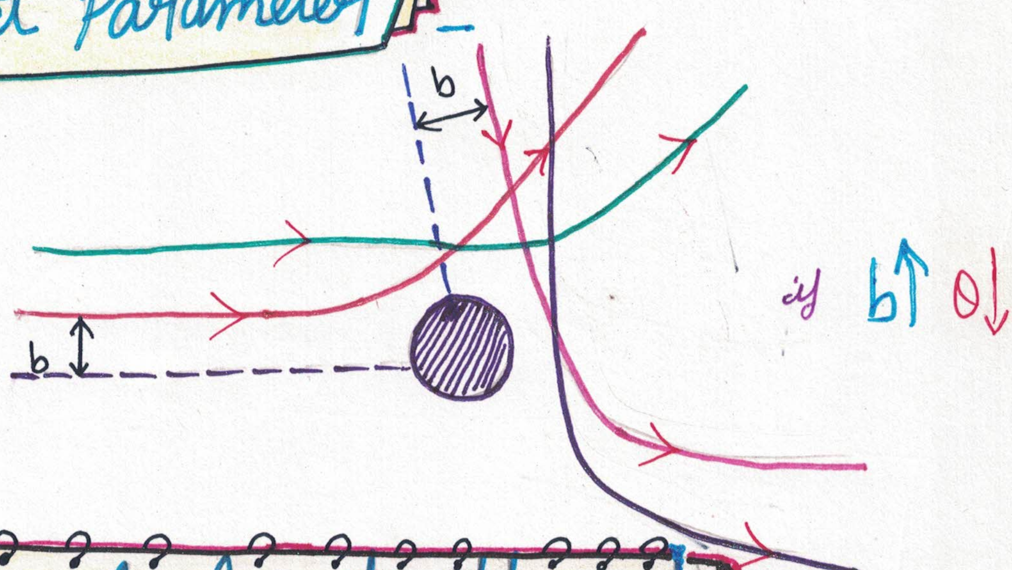
ⓐ. $120°$ ⓑ. $90°$ ⓒ. $180°$

ⓐ. $\frac{100}{N} \propto \frac{1/16}{9/16} \Rightarrow N = 900$ particles

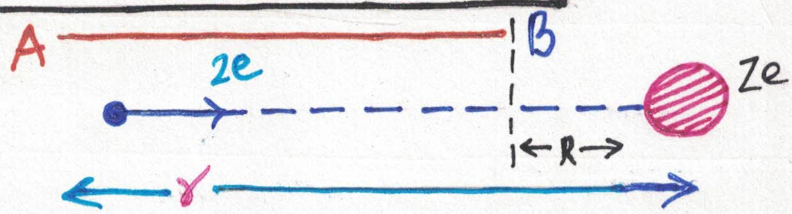
ⓑ. $\frac{100}{N} \propto \frac{\sin^4(45)}{(9/16)} \Rightarrow N = \frac{100 \cdot 9/16}{\sin^4(15)}$

ⓒ. $\frac{100}{N} \propto \frac{1}{9/16} \Rightarrow N = \frac{\overset{\cancel{25}\cdot 6\cdot 1}{\cancel{100}} \times 9}{\underset{\cancel{4}}{16}} = 7$ particles

Impact Parameter



Distance of closest approach



$E_A = E_B$

$$(E_A) = \frac{1}{2}mv_A^2 + \frac{k(2e)(2e)}{r}$$

$$(E_B) = \frac{1}{2}mv_B^2 + \frac{k(2e)(2e)}{R}$$

when pt (ze) is at infinity, $r = \infty$, $v_B = 0$

$$\therefore \frac{1}{2}mv_A^2 = \frac{K(2z)(e)^2}{R}$$

$$\boxed{R = \frac{4kze^2}{mv_A^2}}$$

$m = \alpha$ - particle

a. what will be radius of nuclius of Aluminium, $e = 2.7 gm$

ans. $r = 1.33 \times 10^{-15} \times 3 = 3.9 \times 10^{-15} = 3.9$ gm.

b. Also find the volume.

ans. Volume $= \frac{4}{3}\pi R^3 = \frac{4}{3} \times \pi \times (3.9 \times 10^{-15})^3 = \frac{4}{3} \times \pi \times (36)^3 \times 10^{-48} m^3$

$(V) = \frac{4}{3} \times \pi \times 36 \times 36 \times 36 \times 10^{-48} m^3 = 18.6 \times 10^{-44} m^3$

$$\boxed{\text{Volume of atom} = 10^5 \text{ times the Volume of nucleus}}$$

DRAWBACK OF RUTHERFORD MODEL

- He was unable to explain classical theory of physics i.e- when a charge particle moves in any field, it will lose energy. So it, should fall into nucleus after losing it's energy.
- He was unable to explain hydrogen spectrum.
- He was unable to explain stark's effect and Zeeman's effect.

REPRESENTATION OF ATOM

X_Z^A

Z ⇒ atomic no. (no. of protons) ⇒ No. of e^-

A ⇒ Mas (n+p) ⇒ no. of nucleus

A. ISOTOPS – Having some no. of protons but different no. of neutrons.

Eg – H_1^1, D_1^2, T_1^3

B. ISOBARS – Having some no. of nuclons, but different no. of protons.

Eg – C_6^{14}, N_7^{14}

C. **ISOTONES** - Having same no. of neutrons, $(A-Z) =$ Same

Eg - Ca^{40}_{20}, K^{39}_{19}

D. **ISOELECTRONIC** - They have same no. of e^-.
(Atom / molecular / ions).

Eg - [O_2, N_2^{-2}], [Na^+, Mg^{+2}, Al^{+3}]

E. **ISOSTERS** - They have same no. of atoms & same no. of electrons.

Eg - [N_2, CO, O_2^{+2}] [CO_2, N_2O]

F. **ISODIAPHERS** - They have the $(A-2Z) =$ same

PLANCK'S QUANTUM THEORY

⇒ Visible $\in [38, 78]$ A° IR > Visible > U.V
(Wave-length)

$$E = \frac{hc}{\lambda}, \quad V = \lambda\nu, \quad E = h\nu$$

⇒ In an EM wave, the electric and magnetic fields are 1^{st} In equilibrium, $(F)_E = (F)_m$

⇒ $qvB = qE = \boxed{v = \frac{E}{B}}$ ⟶ Velocity selector

$\Rightarrow F(x,y,z) = x^2y + y^2z + z^2x$

$$\frac{\partial F}{\partial x} = (2xy + 0 + z^2) \Rightarrow \frac{\partial F}{\partial z} = (y^2 + 2zx) \Rightarrow \frac{\partial F}{\partial y} = (x^2 + 2yz + 0)$$

A Wave is a plane progressive wave If $\frac{\partial^2 y}{\partial t^2} = \frac{v^2 \partial^2 y}{\partial x^2}$

$\Rightarrow y = A \sin(kx - wt)$, $k = \frac{2\pi}{\lambda}$ = angular wave no.

$W = \frac{2\pi}{T}$ = angular frequency, $\frac{1}{\lambda}$ = Wave no. = $\bar{\nu}$

$\Rightarrow$ when a black body is heated, it emits a wavelength & frequency to explain these radiation. we have Planck's Quantum theory.

(a) Substance radiate or absorb energy in form of small packets or bundle of energy.

(b) This energy will be quantised. $\boxed{E = nh\nu}$. It is proportional to the frequency of electromagnetic radiation.

$E \propto \nu \longrightarrow \boxed{E = nh\nu}$ $\boxed{n \in \omega}$ $\boxed{\nu = \frac{c}{\lambda}}$

If this electromagnetic radiation is light, then this quanta is called PHOTON.

$\boxed{E = \frac{nhc}{\lambda}}$

$h = 6.634 \times 10^{-34}$ Js

$c = 3 \times 10^8$ m/s

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

Que.

A Solution bulb ($\lambda = 5100 A^\circ$) is used for a process, if it is operated for 10 min and it is 100 W. What is the no. of photon emitted?

Ans. $(n)(66 \times 10^{-35})\left(\frac{3 \times 10^{8}}{51 \times 10^{-8}}\right) = (100)(600)$

$(n)\left(\frac{\cancel{66}^{11} \times \cancel{3}}{\cancel{51}_{17}}\right) \times 10^{-43} = 6 \times 10^{-4}$

$n = \frac{17}{11} \times 10^{39} = 1.5 \times 10^{23}$

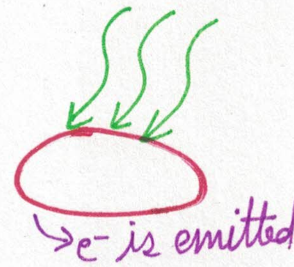
$\therefore \boxed{n = 15 \times 10^{22}}$

Work done by Battery = charge × Potential → In eV.

→ In form of kinetic energy.

⇒

$I \propto A^2$



If incident energy is more than work func", then photo e⁻ will be emitted.

$\boxed{h\nu - W_F = KE}$

Work Function

– It is minimum amount of energy for the emission of a photo electron.

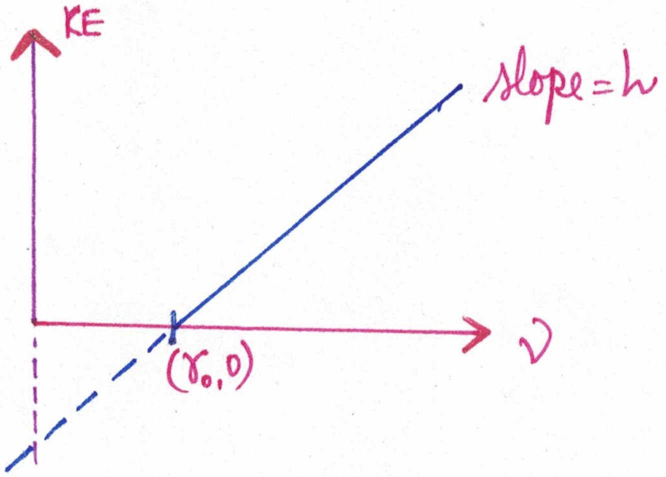
$$(W_F = h\nu_0) \rightarrow \nu_0 = \left(\frac{W_F}{h}\right)$$

'ν_0' is known as **threshold frequency**.

Threshold Wave-length is the max. wavelength for the emission of a photo electron $\left(\lambda = \frac{hc}{WF}\right)$

$$\boxed{h\nu - h\nu_0 = \frac{1}{2}mv^2}$$

$1eV = 1.6 \times 10^{-19} J$, also $\frac{1}{2}mv^2 = (qV) \longrightarrow$ Battery



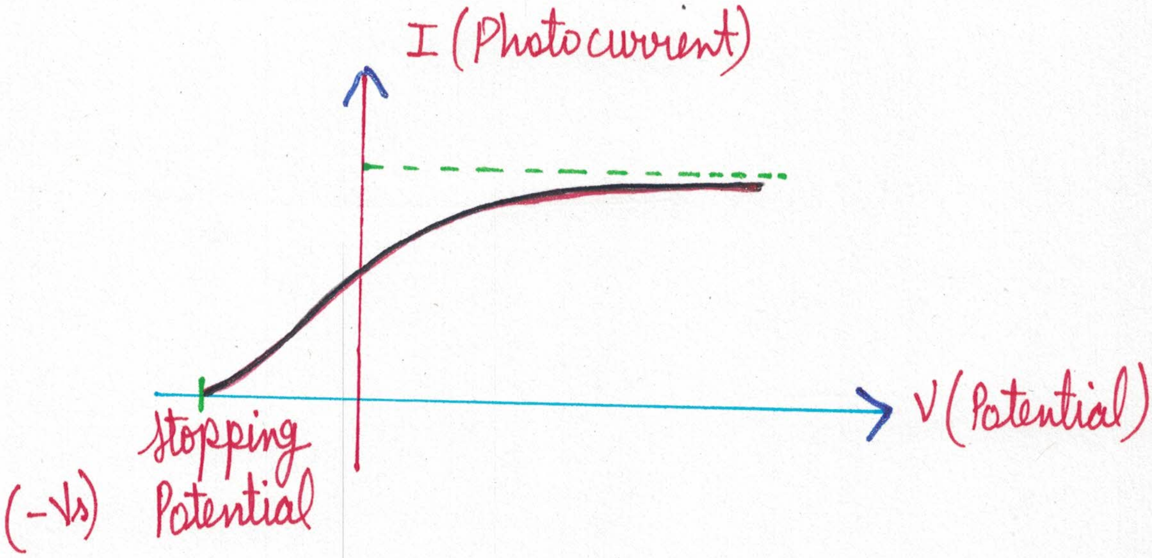
$\boxed{I \propto \frac{1}{r^2}} \rightarrow$ power source

QUE: A radiation of 5eV is incident on a metal having 1.05 WF = 2eV. Calculate velocity of photo electron.

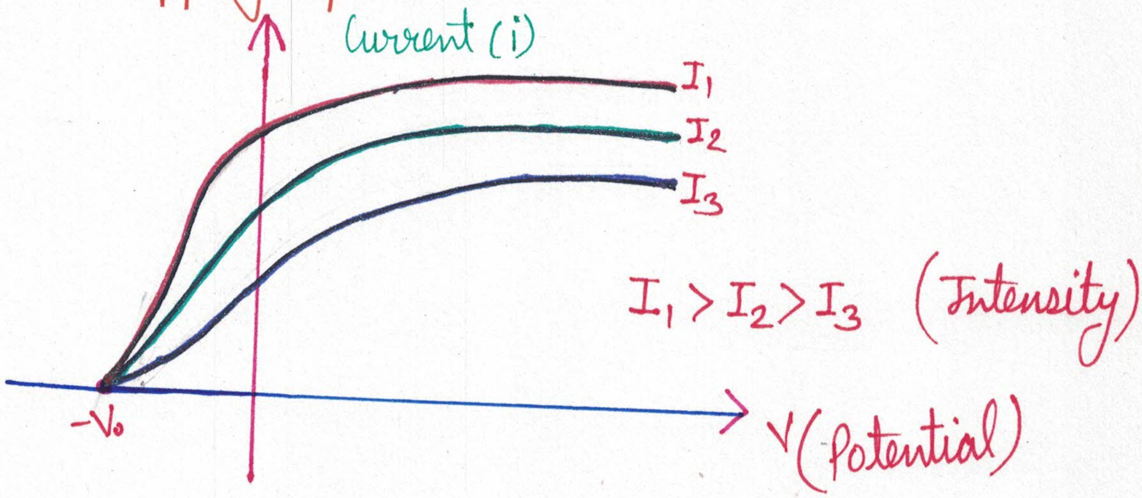
$h\nu - h\nu_0 = \frac{1}{2}mv^2 \Rightarrow 3.2\,(1.6 \times 10^{-19}) \Rightarrow (v^2)(9.1 \times 10^{-31})\,kg$

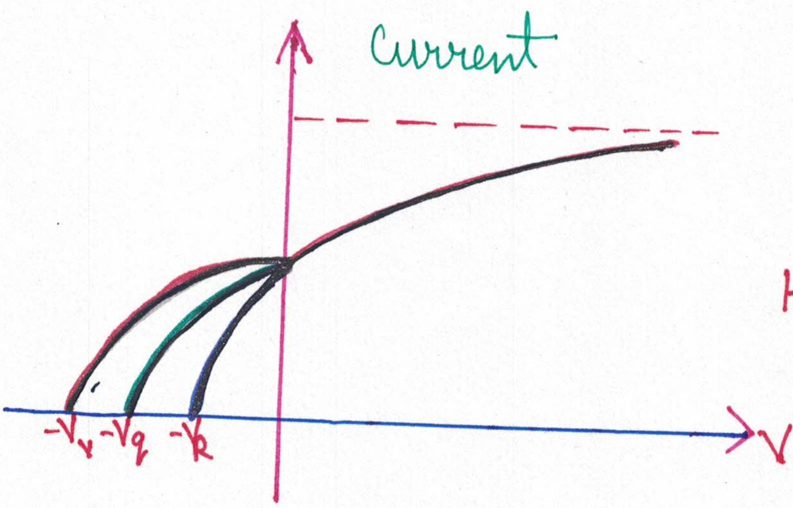
$$\frac{10^{12} \times 9.6}{9} = v^2$$

$$\boxed{v \approx 10^6\ m/s}$$



Negative potential which can stop the emission of photo-e^-, is called stopping potential.





Hw: stopping potential changes

stopping potential $\longrightarrow$ $h\nu - h\nu_0 = eV$

$$\Rightarrow \boxed{V = \left(\frac{h\nu}{e} - \frac{h\nu_0}{e}\right)}$$

Bohr's Atomic Model

– It's only for the hydrogen like atoms. atoms containing only $1e^-$.
or hydrogen

$$E = \frac{12400}{\lambda(\text{A}^\circ)}\ eV \rightarrow E = \frac{12435}{\lambda(\text{A}^\circ)}\ eV$$

(i) Calculate ration of second orbit's radius for the He^+ & Li^{2+} ion.

[i] $3/2$.

[ii] Given, He^+ ion $n=3$; Li^{2+} $(n=2)$, ratio of

(a) Force on e^-

$$F = \frac{(K)(ze)(e)}{r^2} \propto \frac{z^3}{n^4} \qquad \frac{F_1}{F_2} = \frac{(2/3)^2}{(3/2)^2} = \left(\frac{16}{81}\right)$$

(b) Ratio of ν of electron

$$\nu \propto \frac{1}{T} \propto \frac{v}{r} \propto \frac{Z/n}{n^2/Z} \propto \left(\frac{Z^2}{n^3}\right)$$

$$\therefore \frac{V_1}{V_2} = \frac{4/27}{9/8} = \left(\frac{32}{243}\right)$$

(c) Ratio of PE of an e^-

$$PE = -\frac{dv}{dr} \Rightarrow U = \int \vec{F}.\, d\vec{r}$$

$$\therefore \left(\frac{U_1}{U_2}\right) = \frac{4/9}{9/4} = \left(\frac{16}{81}\right)$$

(d) Ratio of $\vec{P}$ on e^-

$$\vec{P} = \frac{\cancel{m}v_1}{\cancel{m}v_2} = \frac{Z/n_1}{Z/n_2} = 4/9$$

Bohr's Postulates

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

b. $F_E = F_C \Rightarrow \frac{1}{4\pi\varepsilon_0} \cdot \frac{(ze)(e)}{r^2} = \frac{mv^2}{r}$

$$\Rightarrow mv^2 r = \frac{1}{4\pi\varepsilon_0} ze^2 \text{ ——— } (1)$$

$$mvr = \frac{nh}{2\pi} \text{ ——— } (2)$$

(1) ÷ (2)

$$(3) \text{ ——— } v = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2\pi e^2 z}{nh}$$

$$\boxed{v = 2.18 \times 10^6 \left(\frac{z}{n}\right) m/s}$$

Out (3) in (2);

$$r = \frac{\cancel{4\pi}\varepsilon_0 h^2}{\cancel{4\pi}^2 e^2 m} \cdot \frac{n^2}{z}$$

$$\boxed{r = 0.529 \times \frac{n^2}{z} A^\circ}$$

Que. - The radius of helium ion according to Bohr model is "a". Calculate radius of

(i) Hydrogen atom → (n = 3) (n = 1)

(ii) Li^{+2} (n=2)

(iii) Be^{+3} (n=2)

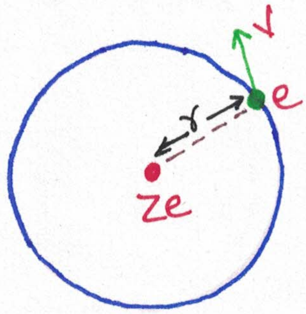
Ans. i) $a = \frac{1}{2}, \; r = \frac{9}{1} \Rightarrow \frac{a}{r} = \frac{1/2}{9/1} \Rightarrow \boxed{r = 18a}$

ii) $a = \frac{1}{2}, \; r = \frac{4}{3} \Rightarrow \frac{a}{r} = \frac{1/2}{4/3} \Rightarrow \boxed{\frac{a}{r} = \frac{3}{8}}$

iii) $a = \frac{1}{2}, \; r = \frac{4}{4} \Rightarrow \boxed{r = 2a}$

Energy of e^- in any orbit

$$E_{Total} = PE + KE$$
$$= \frac{-1}{4\pi\varepsilon_0} \cdot \frac{Ze^2}{r} + \frac{1}{2} mv^2$$



Also; $F_E = F_c$

$$\frac{1}{4\pi\varepsilon_0} \cdot \frac{Ze^2}{r} = \frac{mv^2}{r} \Rightarrow \frac{1}{2}\left[\frac{1}{4\pi\varepsilon_0} \cdot \frac{Ze^2}{r}\right] = \frac{1}{2} mv^2 = KE$$

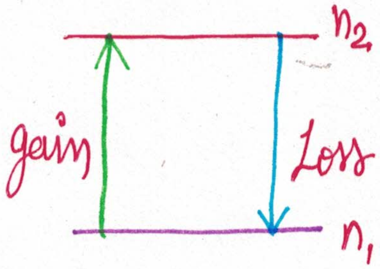
$$\therefore \; KE = \frac{1}{2}\left[\frac{Ze^2}{4\pi\varepsilon_0 r^2}\right], \quad PE = \frac{-Ze^2}{4\pi\varepsilon_0 r}, \quad T.E = -\frac{1}{2}\left[\frac{Ze^2}{4\pi\varepsilon_0 r^2}\right]$$

$$\boxed{KE = \frac{|PE|}{2}} \qquad \boxed{T.E = \frac{PE}{2}}$$

$$E_{Total} = -\frac{1}{2} \cdot \left(\frac{1}{4\pi\varepsilon_0}\right)\left(\frac{e^2 Z}{4\pi\varepsilon_0}\right)\left(\frac{4\pi^2 e^2 m}{h^2}\right)\left(\frac{Z^2}{n^2}\right)$$

$$\boxed{E = -13.6 \cdot \frac{Z^2}{n^2} \; (eV)}$$

According to Bohr, e^- will not lose any energy in stationery orbits, but if it makes transition from one orbit to another orbit it will absorb or gain energy equal to difference of energy of orbits in form of the radiation.



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

$$\frac{hc}{\lambda} = +13.6\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

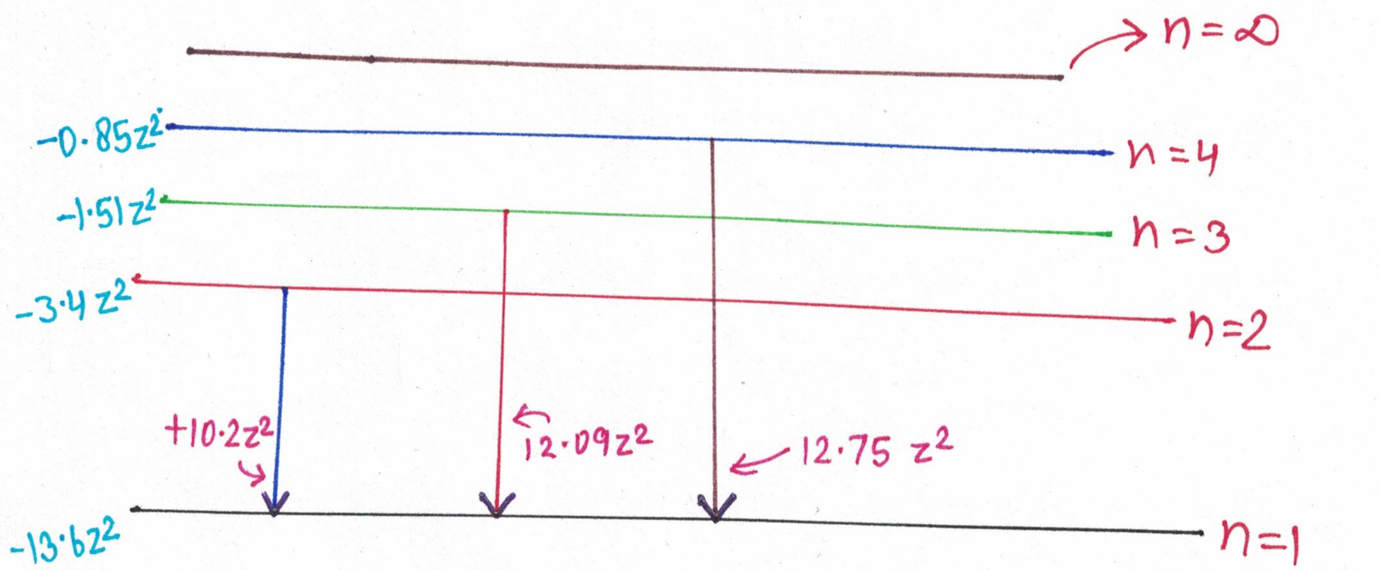
$$\frac{1}{\lambda} = \frac{13.6}{hc}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] z^2$$

$\frac{13.6}{hc}$ → Rydberg Constant

$$\boxed{\frac{1}{\lambda} = R_0\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] Z^2}$$

$$\boxed{\frac{1}{R_0} = 9/2\ \text{Å}}$$

Difference in energy = always (+)

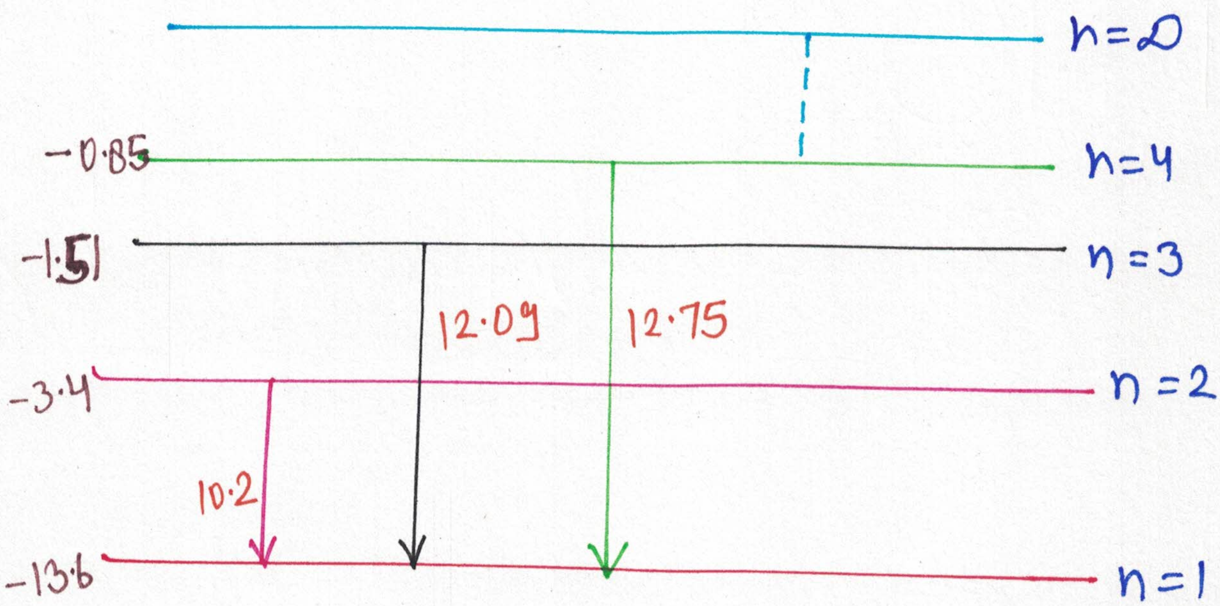


Energy Level diagram for hydrogen or hydrogen like atoms.

only the photon which has the energy equal to the difference in energy levels will be absorbed.

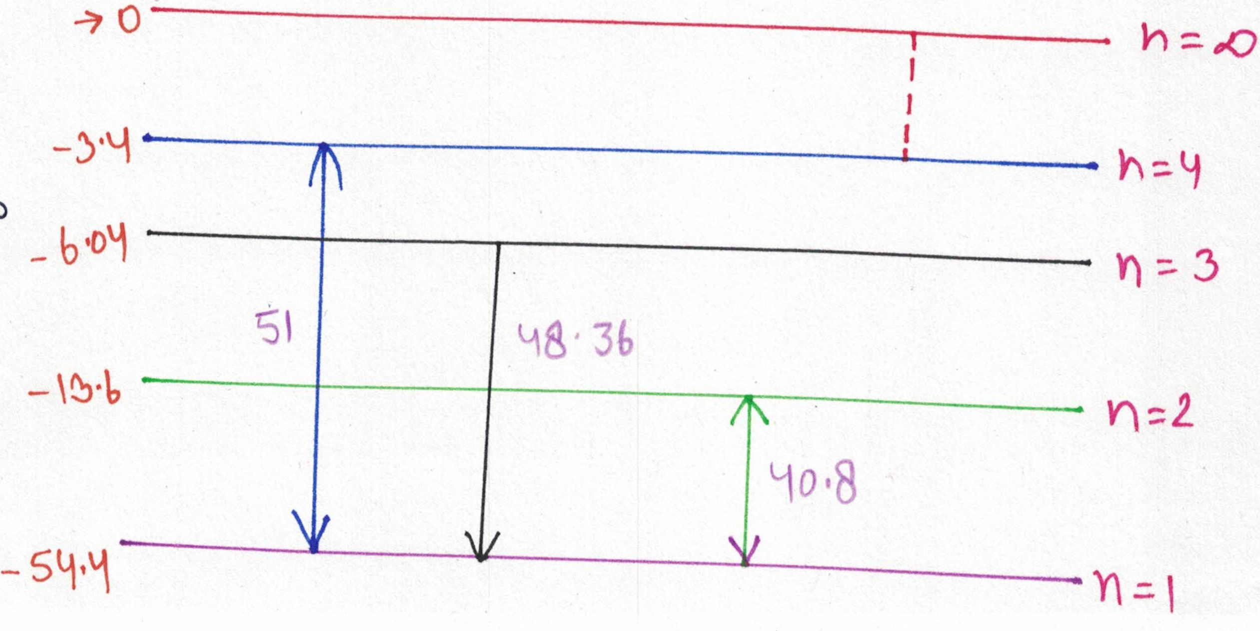
eg:- when $12.75z^2$ energy's given, jumps from 1 to 4. when $12z^2$ energy given, no change in position.

Energy level diagram for ① Hydrogen

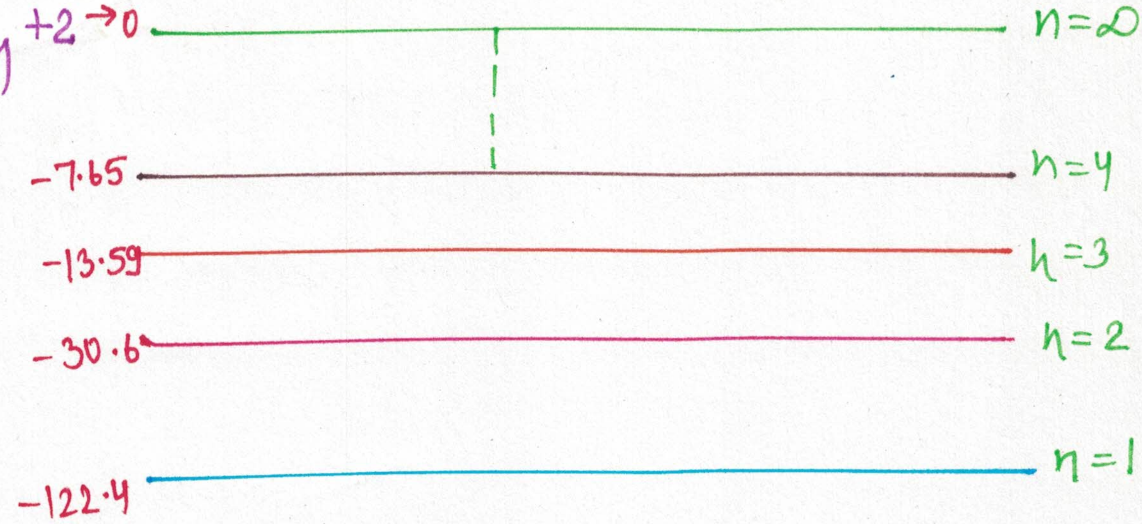


② Helium^{+1}

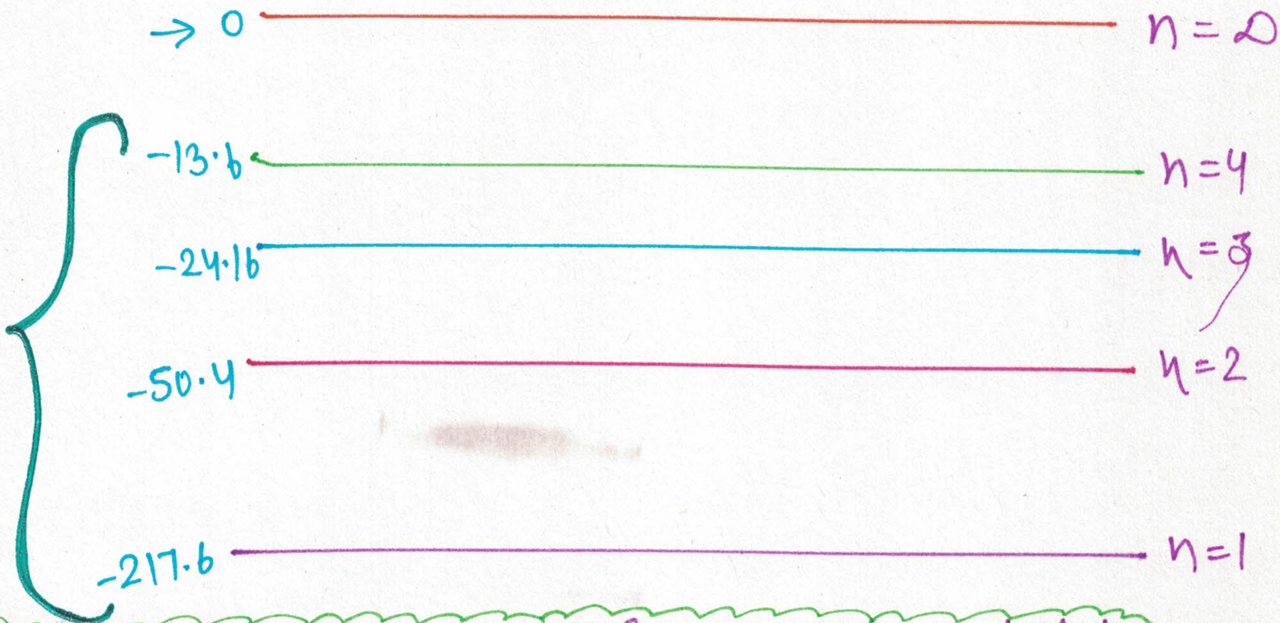
n=2 to n=4 में जाने में 10.2eV लगेगा



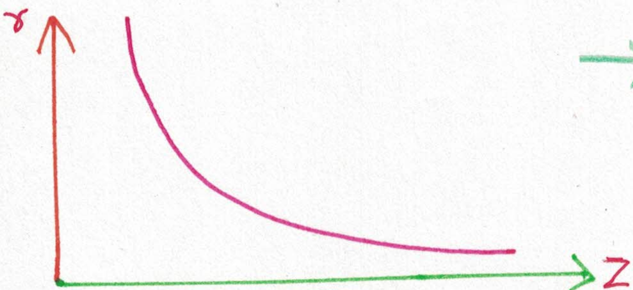
③ Lithium^{+2}



④ Beryllium^{+3}

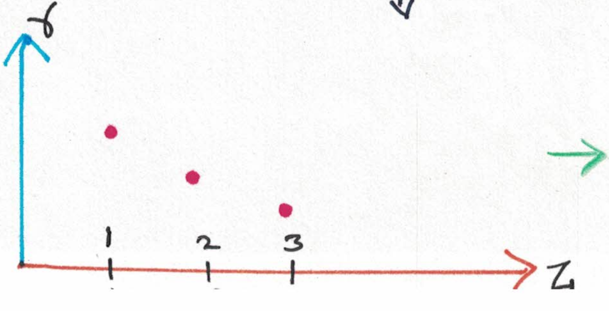


Suppose an e^- goes from $n=1$ to $n=3$, then energy required is $12.09Z^2$ (ev), they potential will also be same.



→ This is wrong as z is no. of proton & it will be a discontinuous graph.

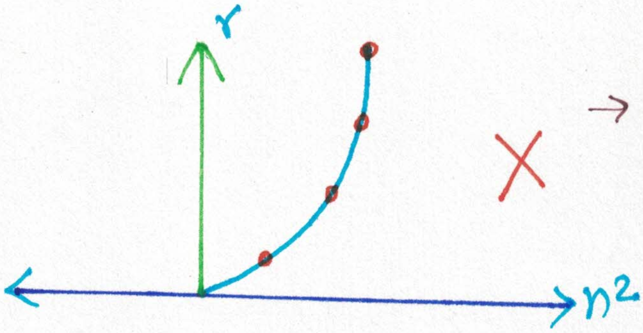
↓ It must be



→ All graphs w.r.t Z must be like this.

$r \propto n^2$

$r \propto \frac{1}{Z}$ →



X → (Wrong Graph)

Ground State – It is the Lowest energy state of an atom (n=1) most stable configuration.

Excited state – except n=1, all other orbits are called excited state. n=2 → Ist excited state
n=3 → IInd excited state.

Excitation Potencial – Potencial required to promote an e^- from the ground state to excited state.

2nd excitation potential for H ⇒ n=1 to n=3 = 12.75 V

Excitation energy – It is the energy required to promote an e^- from G.S to E.S

I.E – It is the minimum amount of energy require to remove an e^- from G.S.

Ground State

I.E for H atom = 13.6 eV
I.E for He^+ atom = 54.4 eV
I.E for Li^{+2} atom = 122.4 eV
I.E for Be^{+3} atom = 217.6 eV

Binding energy - It is the energy req. to remove one e^- from any E.S.

E.S

B.E for $n=2 \longrightarrow (3.4 z^2)$ eV

B.E for $n=3 \longrightarrow +(1.51 z^2)$ eV

$$\longrightarrow \frac{(13.6)(z^2)}{n^2}$$

$$\text{excitation (potential / energy)} = -13.6 z^2 \times \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

Que. What will be Excitation potential for (Ist) excited for Li^{+2} ion.

Ans :- $E_v = -13.6 \left(\frac{z^2}{n^2}\right) = -\frac{(\cancel{13.6}^{3.4})(9)}{\cancel{(4)}} = -30.6$ eV

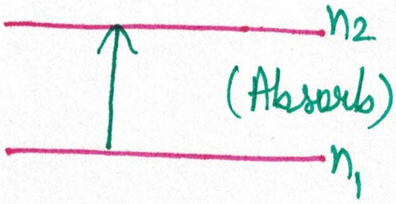
$(E_1) = -54.4$ eV

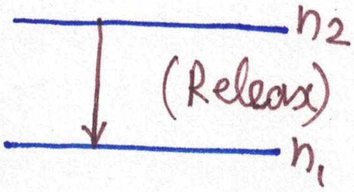
$\therefore$ excitation potential $= -30.6\ V + 54.4\ V = 24.4\ V$

SPECTRUM

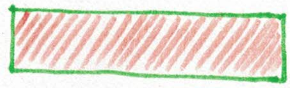
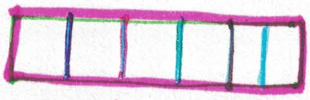
a. - **Absorption spectrum**: It is observed when atom absorbs a photon and it goes to a higher level from the lower energy level.

b. **Emmission spectrum**: when e^- will radiate energy. Due to it, it will come in a lower energy level from a higher energy level.





It is of two kinds :- Cont., Discont.

- Continuous 
- Discontinuous  

(Line) (Band)

Bohr explained only the line spectrum.

eg - If hydrogen goes from $n=1$ to $n=2$,

$$(E) = -13.6\left(\frac{1}{1}-\frac{1}{4}\right) = (10.2)\ eV$$

$$(10.2)\ eV = \frac{12400}{\lambda(A^\circ)} \Rightarrow \lambda = \checkmark$$

UV Visible I.R.
↓
$(3800\ \text{to}\ 7800)\ A^\circ$

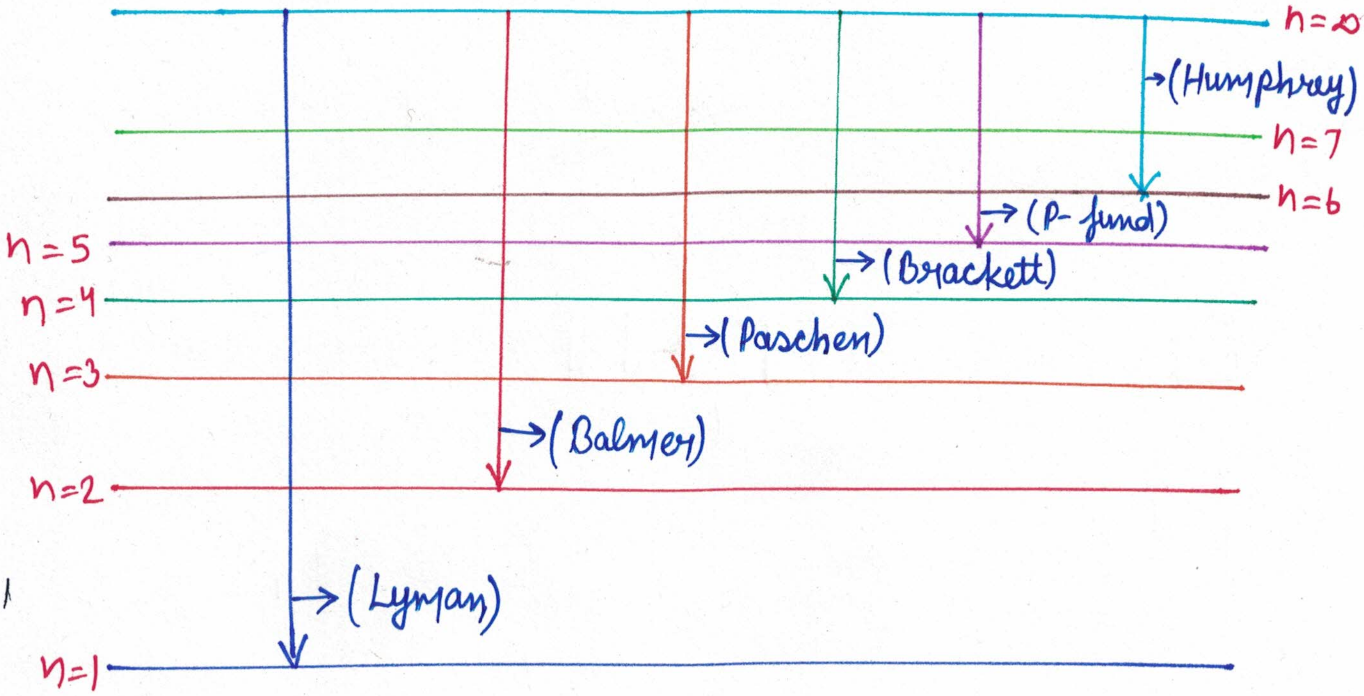
⇒ Max. no. of spectrum lines -

a. If e^- is present at n^{th} orbit & makes a transition from $n = n$ to $n = 1$ ⟶ ① $({}^{n}C_2)$

b. If e^- makes a transition from n_2^{th} orbit to n_1^{th} orbit

$$\longrightarrow {}^{(n_2-n_1+1)}C_2$$

For hydrogen or hydrogen-like atom, we have emission spectual series;



a. **LYMAN SERIES** – $\frac{1}{\lambda} = \bar{\nu} = Rz^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

Here $n_1 = 1$ (always), $n_2 = \{2, 3, \ldots \infty\}$

Longest Wavelength $\Rightarrow \frac{1}{\lambda} = (R)(1)\left(\frac{1}{1} - \frac{1}{4}\right) \Rightarrow \lambda = \frac{3}{4R}$

Shortest Wavelength $\Rightarrow \frac{1}{\lambda} = (R)(1)\left(\frac{1}{1} - \frac{1}{\infty}\right) \Rightarrow \lambda = \frac{1}{R}$

For Lyman, $\lambda \in [912, 1216] \rightarrow$ (ultrawide region)

$$\Delta E \in [10.2\, z^2, 13.6\, z^2]$$ → It's is in Lyman region

b. **BALMER SERIES** – All spectral lines will terminate on $n=2$, or I^{st} excited state.

$n_1 = 2$, $n_2 = n \rightarrow \frac{1}{\lambda} = Rz^2\left[\frac{1}{4} - \frac{1}{n_2^2}\right]$, $n_2 \in [2, 3, 4, \ldots n]$

First line of Balmer Series $\rightarrow n_1 = 2$, $n_2 = 3$

First line of Lyman series $\rightarrow$ $n_1 = 1,\ n_2 = 2$
Third line of Balmer series $\rightarrow$ $n_1 = 2,\ n_2 = 5$

$$[\lambda_\alpha]_B = \frac{36}{5R} = \left(\frac{36}{5} \times 912\right) A^\circ = 6566\ A^\circ$$

$$[\lambda_\beta]_B = \frac{16}{3R} = \left(\frac{16}{\cancel{3}} \times \overset{304}{\cancel{912}}\right) A^\circ = 4864\ A^\circ$$

$$[\lambda_\gamma]_B = \frac{100}{21R} = \left(\frac{100 \times \overset{304}{\cancel{912}}}{\cancel{21}_7}\right) A^\circ = 4342\ A^\circ$$

$$[\lambda_\delta]_B = \frac{9}{2R} = \left(\frac{9}{\cancel{2}_1} \times \overset{456}{\cancel{912}}\right) A^\circ = 4104\ A^\circ$$

In Balmer series; $H_\alpha, H_\beta, H_\gamma, H_\delta \longrightarrow$ Visible

only 4 lines are in visible region.

$\lambda_{longest} = 6566.4\ A^\circ$, $\lambda_{shortest} = 3648\ A^\circ$

$$\Delta E \in \left[1.89\, Z^2,\ Z^2 (3.4)\right] eV \longrightarrow \text{Balmer region.}$$

c. PASCHEN SERIES - Terminates on $n = 3$

$$\frac{1}{\lambda} = (R) Z^2 \left[\frac{1}{9} - \frac{1}{n_2^2}\right] \quad n = \{4, 5, 6 \ldots n\}$$

$$\lambda_{Longest} = \frac{144}{7R} = \frac{\overset{20.5}{\cancel{144}} \times 912}{7}\ A^\circ \simeq 18761\ A^\circ$$

$$\lambda_{shortest} = 9 \times 912\ A^\circ = 8208\ A^\circ$$

All Lines will lie in the in-frared region.

d. BRACKETT SERIES - Terminates on $n = 4$, $n_1 = 4$

$$\frac{1}{\lambda} = R \left[\frac{1}{16} - \frac{1}{n_2^2}\right]$$

$$\lambda_{shortest} = 16 \times 912 = 14592\ A^\circ$$

$$\lambda_{Longest} = \frac{\overset{228}{\cancel{912}} \times 9}{\cancel{400}_{100}} = \frac{2052}{100} = 20.40533\ A^\circ$$

$$= \frac{400 \times \cancel{912}}{9}\ 11.3$$

All Lines will lie in the I.R. region.

e. P- FUND SERIES − $n_1 = 5$, $n_2 = n$

$$\frac{1}{\lambda} = RZ^2 \left[\frac{1}{25} - \frac{1}{n_2^2}\right]$$

$$\lambda_{longest} = \frac{25 \times \cancel{36}^{4} \times 912}{\cancel{9}_{11}} \simeq 91200\ A^\circ$$

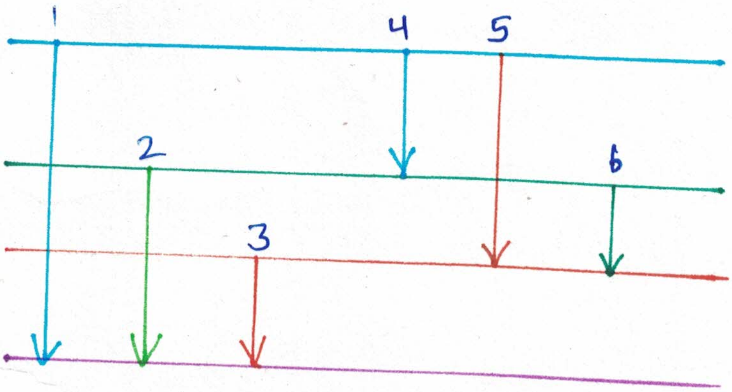
$$\lambda_{shortest} = \frac{10}{4} \times \cancel{912}\ 233 = 22800\ A^\circ$$

All lines lie in the I.R. region

Q. a. In a H-atom, e^- absorb 12.75 eV from G.S. in an emission spectrum lines (no.) that lie in infrared radiation?

ans.

$n = 4$ to $n = 1$ ⟶ $^4C_2 = 6$

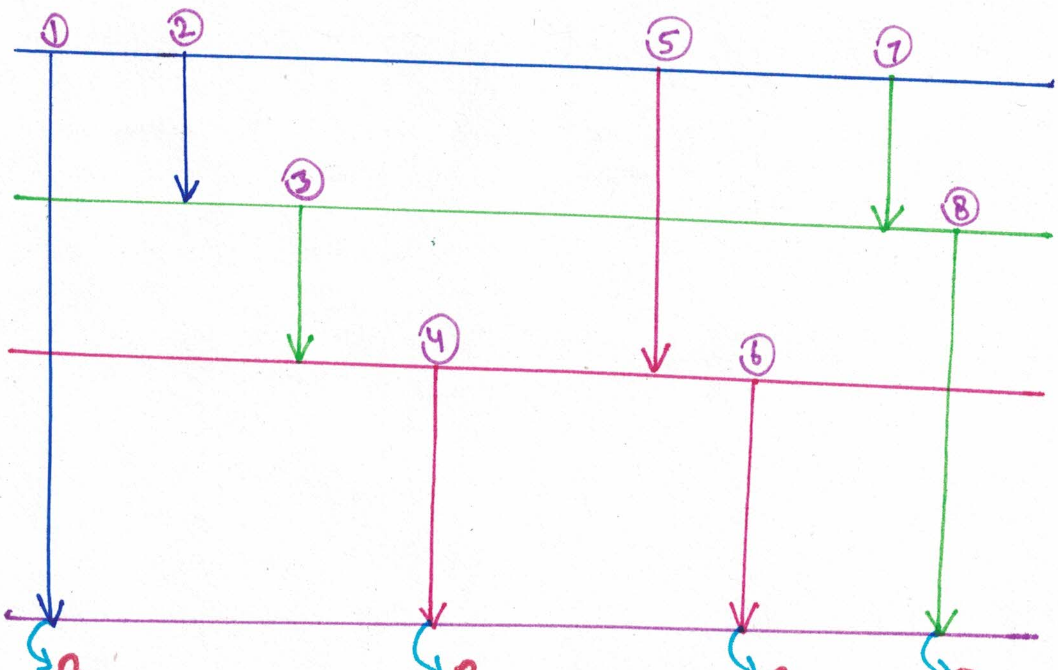


Vis → 2
IR → 1
UV → 3

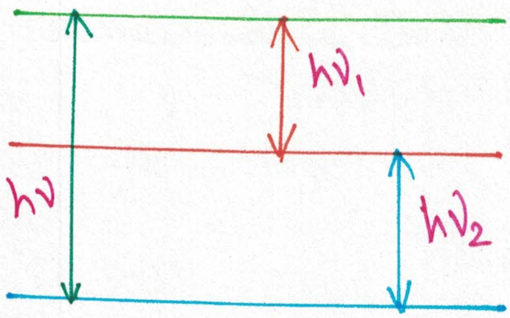
b. How many minimum atoms will require for getting all spectral lines

ans.

In ⑦, ⑧ the line ⑦ gets repeated thus not allowed



(A, B) are the observed lines → 4 → No. repeatation
In C the line ⑥ is same as ④.



$(h\nu) = h\nu_1 + h\nu_2 + \ldots\ldots$

$$\boxed{\nu = \nu_1 + \nu_2 + \ldots\, \nu_n}$$

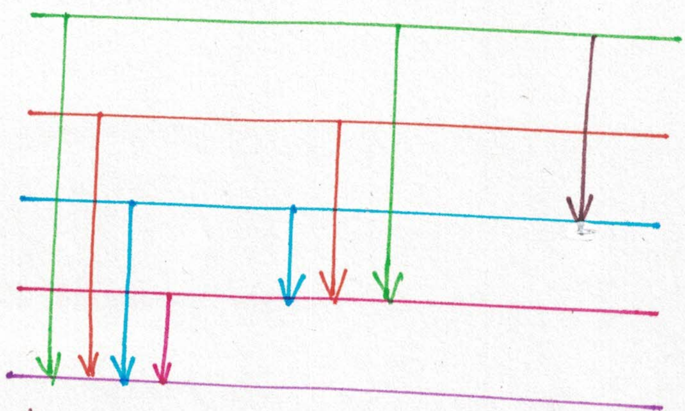
$$\frac{hc}{\lambda} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2} + \ldots\ldots \frac{hc}{\lambda_n}$$

$$\boxed{\frac{1}{\lambda} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2} + \ldots\, \frac{1}{\lambda_n}}$$

Que: An e^- absorbs 13.056 eV photon in its G.S. of the H-atom How many visible lines will be obtained.

Ans. $n = 1$ to $n = 5$

$$\frac{\lfloor 5}{\lfloor 2 \cdot \lfloor 3} = (10)$$



$5 - 2 + 1 C_2$
$= {}^4C_2$
$= \frac{\lfloor 4}{\lfloor 2 \cdot \lfloor 2}$
$= 6$

∴ Visible line $= 3$

$\boxed{\text{K.E of Charge particle} = (q)(V)}$ (V → Potential)

DRAWBACKS OF BOHR'S MODEL

- He was unable to explain spectrum of multi e-atoms.
- He was unable to explain fine spectrum (spectrum obtained from ultra-spectroscopy).
- He was unable to explain Zeeman effect (spectral lines obtained in magnetic field) & stark effect (spectral lines obtained in electronic field)
- He was unable to explain Heisemberg uncertainity principle.

DUAL NATURE OF ELECTRON

Electron behaves as a particle & as a wave thus, every particle has a wavelength, given by;

$$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2m(KE)}}$$

For charged particle:- $\lambda = \frac{h}{\sqrt{2m(qV)}}$

For an electron = $\boxed{\lambda = \sqrt{\frac{150}{V}}\ A^{o}}$ → only for an e^-

Q. (i) A 100 g ball is moving with 5 m/s velocity what will be λ?

Ans. $\frac{6.6 \times 10^{-33}}{5} = 1.3 \times 10^{-33}$ m

(ii) An e^- is moving with 2×10^7 m/s. Calculate it's wavelength?

Ans. $\frac{6.6 \times 10^{-34}}{2 \times 10^7 \times 9 \times 10^{-31}} = \frac{10^{-10} \times \cancel{66}\ 11}{\cancel{18}\ 30} \simeq 0.3\ A^{o}$

Q. A hydrogen like atom is observed to emit 6 wavelengths, originating from all possible transitions b/w a group of levels. These levels have energies between the -0.85 eV and -0.544 eV (including both values). Find the atomic no. of atom.

Ans. $E_n = -13.6\left(\frac{Z^2}{n^2}\right)$

$-0.85 = -13.6\left(\frac{Z^2}{n_1^2}\right)$ —— ① $-0.544 = -13.6\left(\frac{Z^2}{n_2^2}\right)$ —— ②

Divide ① & ②;

$\frac{n_2^2}{n_1^2} = \frac{25}{16} \Rightarrow n_2 = \frac{5}{4}n_1$ also; $n_2 - n_1 + {}^{1}C_2 = 6 \Rightarrow$

$\frac{5}{4}n_1 - n_1 + 1 \quad c_2 = 6$

$\Rightarrow \boxed{n_1 = 12}, \boxed{n_2 = 15}$ Put n_1 in ①;

$$-0.85 = -13.6\left(\frac{Z^2}{(12)^2}\right) \Rightarrow \boxed{Z = 3}$$

An e^- is moving with 3eV. It is accelerated with a 2V potential. Calculate wavelength associated.

$(KE)_T = (3eV + 2eV) = (5eV)$.

Ans. $\lambda = \sqrt{\left(\frac{150}{V}\right)} = \sqrt{\left(\frac{150}{5}\right)} = \boxed{\sqrt{30}\ A^\circ}$

What will be the ratio of λ associated with α particle & p^+ at same potential?

Ans. $$\frac{\lambda_1}{\lambda_2} = \frac{\frac{1}{\sqrt{(m_\alpha)(q_\alpha)}}}{\frac{1}{\sqrt{m_e(q_e)}}} = \sqrt{\frac{(m_e)(q_e)}{(m_\alpha)(q_\alpha)}} = \sqrt{\frac{9\times10^{-31}\times \cancel{1.6\times10^{-19}}}{4\times1.6\times10^{-27}\times2\times\cancel{e}}}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{3}{2}\sqrt{\frac{10^{-2}}{16\times10}} = \left(\frac{3}{2}\right)\left(\frac{10^{-1}}{4}\right)\cdot\left(\frac{1}{3}\right) = \boxed{\frac{1}{2\sqrt{2}}}$$

Wavelength is only associated with a fast moving charged particle.

$$mvr = \left(\frac{nh}{2\pi}\right)$$

$$\boxed{2\pi r = \frac{nh}{mv} = n\lambda}$$

No. of waves = orbit no.

Q. Calculate no. of waves in 4th orbit of He^+

Ans. 4.

Newton Desk. Com

HEISENBERG UNCERTAINTY PRINCIPAL

According to this, it is impossible to calculate exact calculation of momentum and position of any small fast moving particle. If $\Delta x =$ error in calculation of position & $\Delta p =$ error in calculation of momentum, then;

$$\boxed{\Delta x \cdot \Delta p \geq \frac{h}{4\pi}}$$

$(\Delta x = 0 \longrightarrow (\Delta p \rightarrow \infty))$, $(\Delta p = 0 \longrightarrow (\Delta x \longrightarrow \infty))$

$$\left(\frac{\Delta p}{\Delta E} \cdot \Delta t\right) \cdot \Delta x \geq \frac{h}{4\pi}$$

$\Rightarrow$ $(F \cdot \Delta x) \cdot \Delta t \geq \left(\frac{h}{4\pi}\right)$

$\Rightarrow$ $\boxed{\Delta E \cdot \Delta t \geq \frac{h}{4\pi}}$

Thus. energy also changes with Time.

When speed tends towards velocity of light, $m = \frac{m_0}{\sqrt{1-(v/c)^2}}$

$\therefore$ $\boxed{p = \frac{m_0 c}{\sqrt{1-(v/c)^2}}}$

If mass is given in (eV) units, then it is the PE.

If $m = 5$ meV, then $E = mc^2 \Rightarrow (5 \times 10^6) = (m)(c^2)$

WAVE - MECHANICAL MODEL

It is the latest atomic model. According to this, e^- will show dual nature → particle as well as wave.

SCHRODINGER'S-WAVE-EQUATION

$$\psi = A\sin(kx - wt), \quad \frac{\partial \psi}{\partial x} = A\cos(kx - wt)k$$

$$\frac{d^2\psi}{dx^2} = -Ak^2 \sin(kx - wt) \quad \text{—①} \quad , \quad \lambda^2 = \frac{h^2}{2m(KE)}$$

$$T.E = KE + U$$

$$KE = (E-U), \quad \lambda^2 = \frac{h^2}{2m(E-U)} \qquad KE = \frac{h^2}{(2m\lambda^2)}$$

$$\frac{d^2\psi}{dx^2} = -k^2(y) = -\left(\frac{2\pi}{\lambda}\right)^2 y = \frac{-8\pi^2 m(E-U)y}{h^2}$$

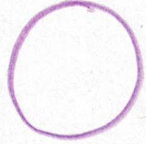
$$\boxed{\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} + \frac{8\pi^2 m(E-U)\psi}{h^2} = 0}$$

Solution of Schrodinger wave eqⁿ provides us exact location of e^- around nucleus. It also defines concept of orbital & quantum no's.

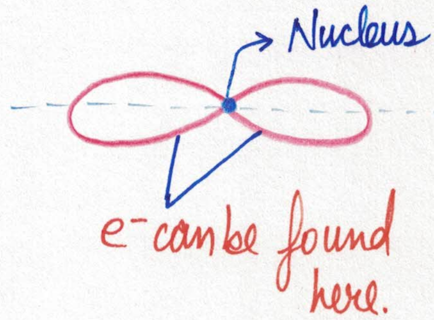
ORBITAL

It is the space around nucleus, where the probability of finding an e^- is maximum. It's of four kinds. There are only $2e^-$ which can accomodate in 1 orbital.

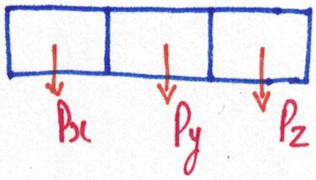
a. **Δ ORBITAL** – It is *spherical*

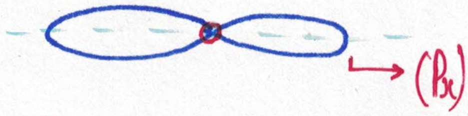


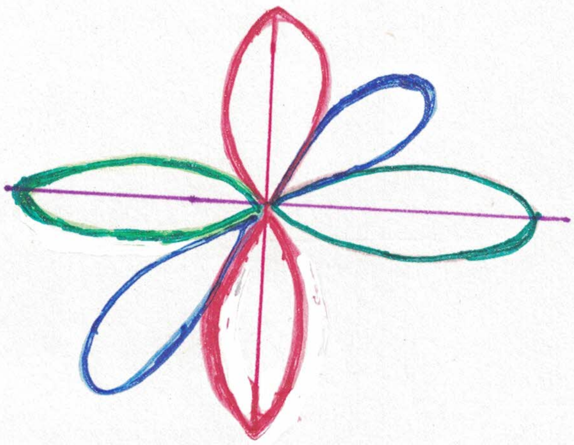
b. **p - ORBITAL** – It is dumbell shaped.



It is of 3 kinds – (P_x, P_y, P_z).
max^n 6 e⁻ can be accomodated

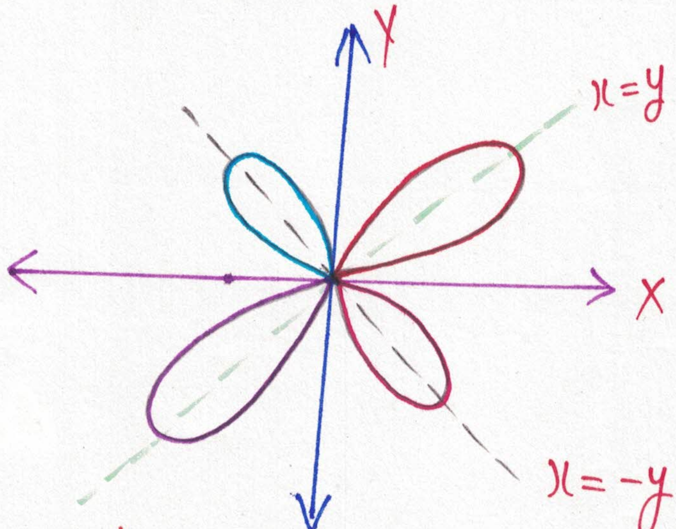




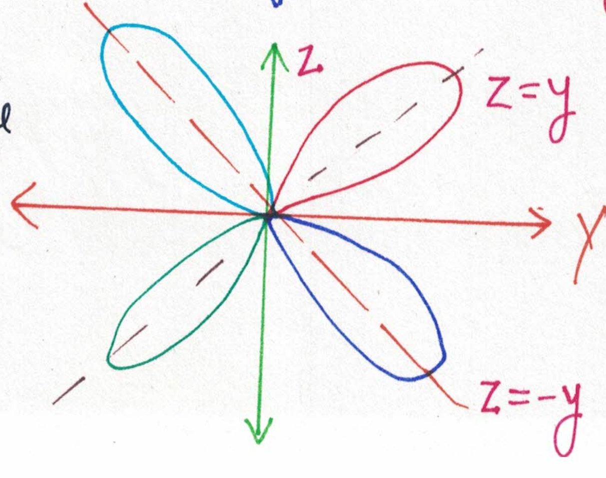


→ 3 mutually $\perp^r$.

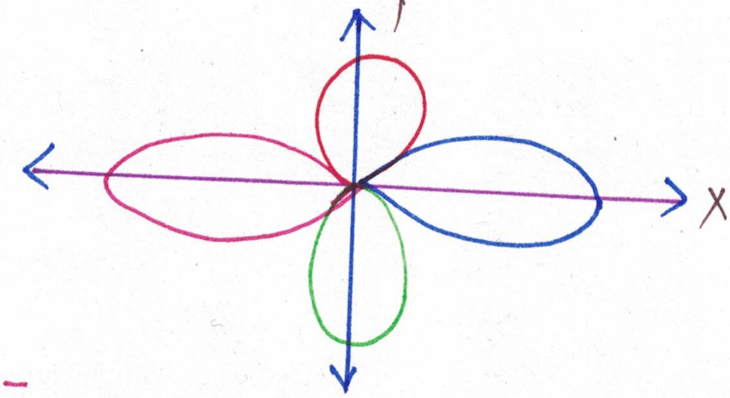
c. **d - ORBITAL** – It is double – dumbled.



There are 3 d- orbitals in plane (d_{xy}, d_{yz}, d_{zx})

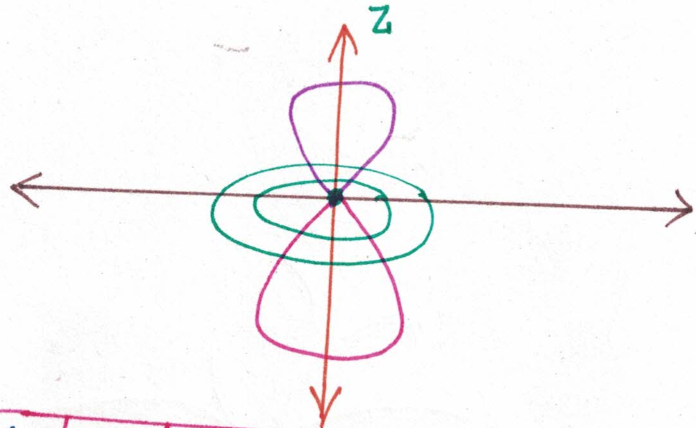


$\boxed{d_{xz} = d_{zx}}$



$d_{x^2-y^2}$ = Axial

Max → $10e^-$



d_{z^2} = Axial

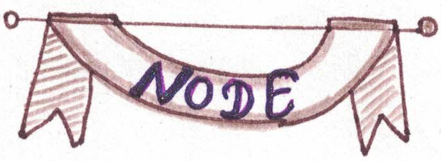
↑↓	↑↓	↑↓	↑↓	↑↓
d_{xy}	d_{yz}	d_{zx}	$d_{x^2y^2}$	d_{z^2}

→ Total $10e^-$

d. F-ORBITAL – Complicated str. (leaf like). There are 7 f-orbitals. → max^m $14e^-$

ψ^2 is called "probability density" of an electron

$\psi^2 dv$ = Probability



– It is a pt or plane at which e^- finding probability will zero. If it is a pt, then it's called node & if it's a plane it's called nodal plane.

$$p = \psi^2 dv$$

therefore for node, $\boxed{\psi = 0}$

STANDING WAVE ;- $y = \underbrace{2A \sin kx}_{A^\circ} \cos \omega t = A_0 \cos \omega t$

POLAR CO-ORDINATES

- The pts. where radial function is zero are radial nodes.
  The pts. where angular function is zero are angular nodes.

No. of radial nodes = $(n-l-1)$. no. of angular nodes = l

No. of total nodes = $n-1$.

PRINCIPAL QUANTUM NUMBERS - (Learn what = they represent)

It represents orbit of an e^- Represented by 'n' total no. of e^- in an orbit = $2n^2$

AZIMUTHAL QUANTUM NUMBERS

It provides info^n about subshell.

Total no. of subshell in any orbit will be equal to the principal q. no. ⇒ $l = 0$ to $n-1$

l	orbital
0	s
1	p
2	d
3	f

$$\psi = \underbrace{R(r)}_{\substack{n,l \\ \text{Radial function}}} \cdot \underbrace{\Theta(\theta) \cdot \Phi(\phi)}_{\substack{l,m \quad m \\ \text{Angular func}^n}}$$

Angular momentum = $\frac{h}{2\pi}\sqrt{l(l+1)}$

MAGNETIC QUANTUM NUMBERS

It provides the info^n about the orientation of an e^- in it's orbital. $m = -l$ to l.

l	m
0	0
1	-1 0 1
2	[-2, 2]
3	[-3, 3]

SPIN QUANTUM NUMBERS

In any orbital, max. two e^- can accomodate, they will move in opposite spin in any orbital.

↑	+ ↻	$+\frac{1}{2}$
↓	- ↺	$-\frac{1}{2}$

Total spin of e^- in any atom is equal to $n(+\frac{1}{2})$, $n(-\frac{1}{2})$

ELECTRONIC - CONFIGURATION

a. Aufbau rule-

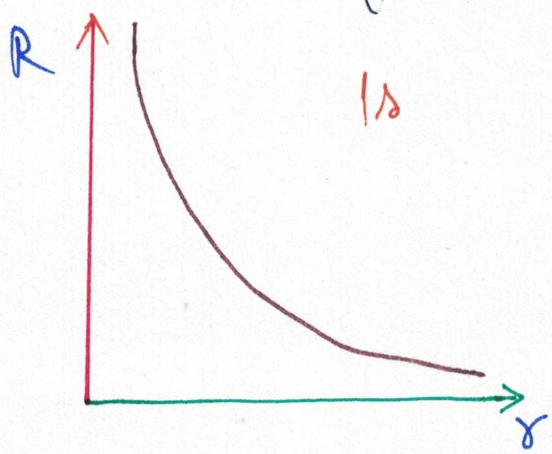
e^- will be filled first in the minimum energy orbital then higher energy of orbital will be defined as $(n+l)$ as value of $(n+l)$ low will have low energy. If $(n+l)$ value is same for two orbitals, then the e^- will in the orbital in which value of 'n' is less.

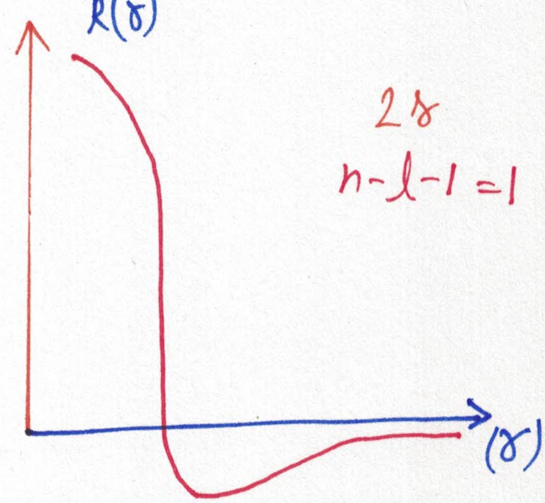
b. Pauli-exclusion principle-

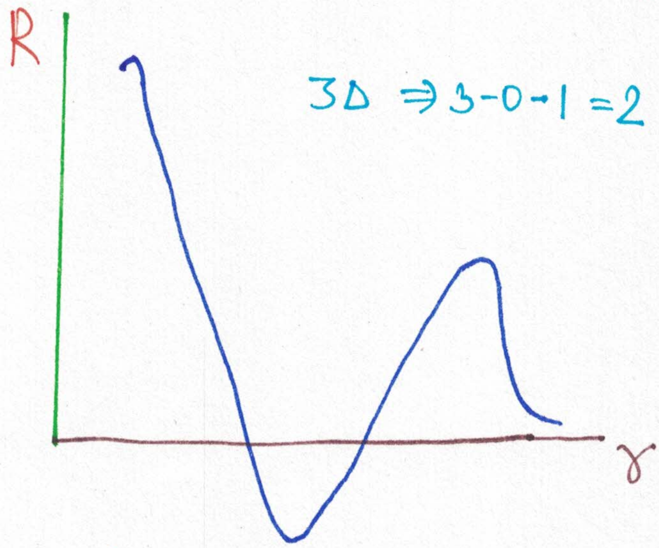
No. two e^- in any atom will have same set of all Quantum number.

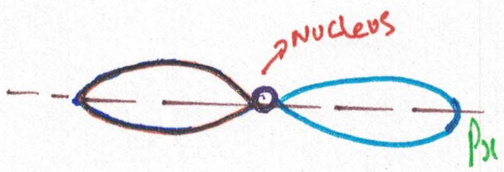
c. Hund's Rule of max. multiplicity-

e^- will be in different orbitals are added single then pairing will occur as half or fully filled orbital will show more stability.



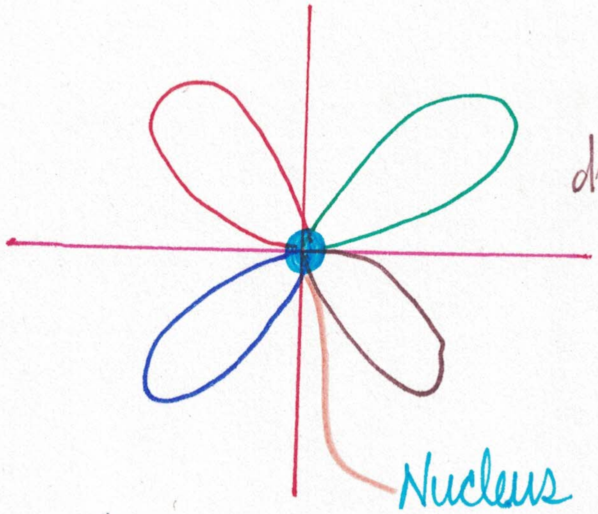






$\longrightarrow$ No. of nodal planes = 1 = (YZ)

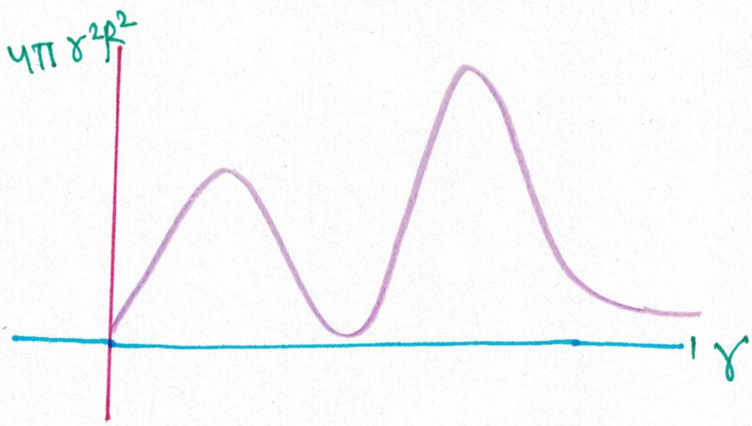
Any 'p' orbital has 1 nodal plane.



d_{xy} → no. of nodal plane =

In Nuncleus, probability of finding an e^- = 0

1s → No. of nodes = 0



2s → Nodes = 1

origin is never counted as nodes.

If $\psi = (x^2+4x+5)(e^{-}(f(x)))$ → always put $\psi = 0$ to find the roots → i.e. No. of nodes

Values of x = nodes → where $y=0$

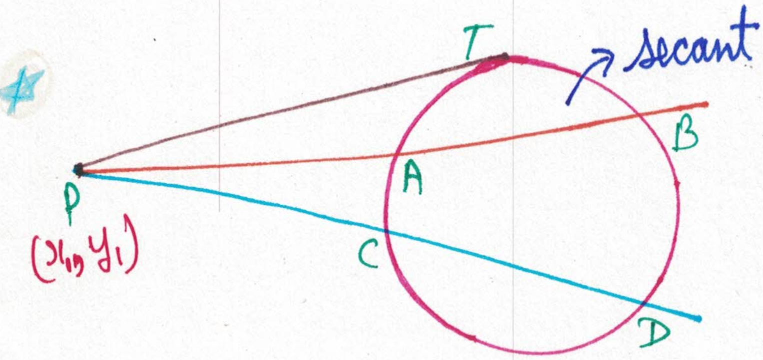
Question:- Uncertainity in position of an e^- ($m = 9\times10^{-31}$ kg) with a Velocity 300 m/s accurate upto 0.001% will be ?

Answer:- Given $\frac{\Delta V}{V} \times 100 = 10^{-3} \Rightarrow \Delta V = 3\times10^{-3}$

$$\Delta x \cdot \Delta V \geq \frac{h}{4\pi m} \Rightarrow \Delta x \geq 1.92\times10^{-2}\ m$$

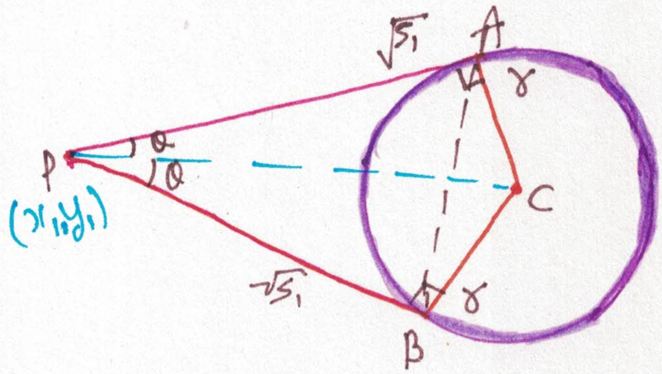
Question:- e/m ratio for (e, p, n, α) is ?

Answer:- $n < \alpha < p < e$



($S_1 = PT \times PT = PA \times PB = PC \times PD$)

S_1 denotes power of a point



(i) Area of quad. PACB;

$= \frac{1}{2}\sqrt{S_1} \times r + \frac{1}{2} \times \sqrt{S_1} \cdot r$

$= r\sqrt{S_1}$

$\tan\theta = \left(\frac{r}{\sqrt{S_1}}\right)$

(ii) Area of $\Delta PAB = \frac{1}{2}\sqrt{S_1} \cdot \sqrt{S_1} \cdot \sin 2\theta$

$Ar.(\Delta PAB) = \frac{1}{\cancel{2}}(S_1) \cdot \cancel{2}\sin\theta \cdot \cos\theta = (S_1)\left(\frac{r}{PC}\right)\left(\frac{\sqrt{S_1}}{PC}\right) = \frac{r(S_1)^{3/2}}{(PC)^2}$

(iii) Area of $\Delta ABC = \frac{1}{2}r^2 \sin(\pi - 2\theta) = \left(\frac{r^2 \sin 2\theta}{2}\right)$

Length of AB ; $AB = 2AM = 2\sqrt{r^2 - (CM)^2}$

Length of AB $\longrightarrow$ $T = 0$ (All conic)