PARISHRAM

2026

Atoms

PHYSICS **One Shot**

BY - RAKSHAK SIR

Topics *to be covered*

1. Poora Chapter krenge LLs

One Shot

Unit–VII	**Dual Nature of Radiation and Matter**	12
	Chapter–11: Dual Nature of Radiation and Matter	
Unit–VIII	**Atoms and Nuclei**	
	Chapter–12: Atoms	
	Chapter–13: Nuclei	

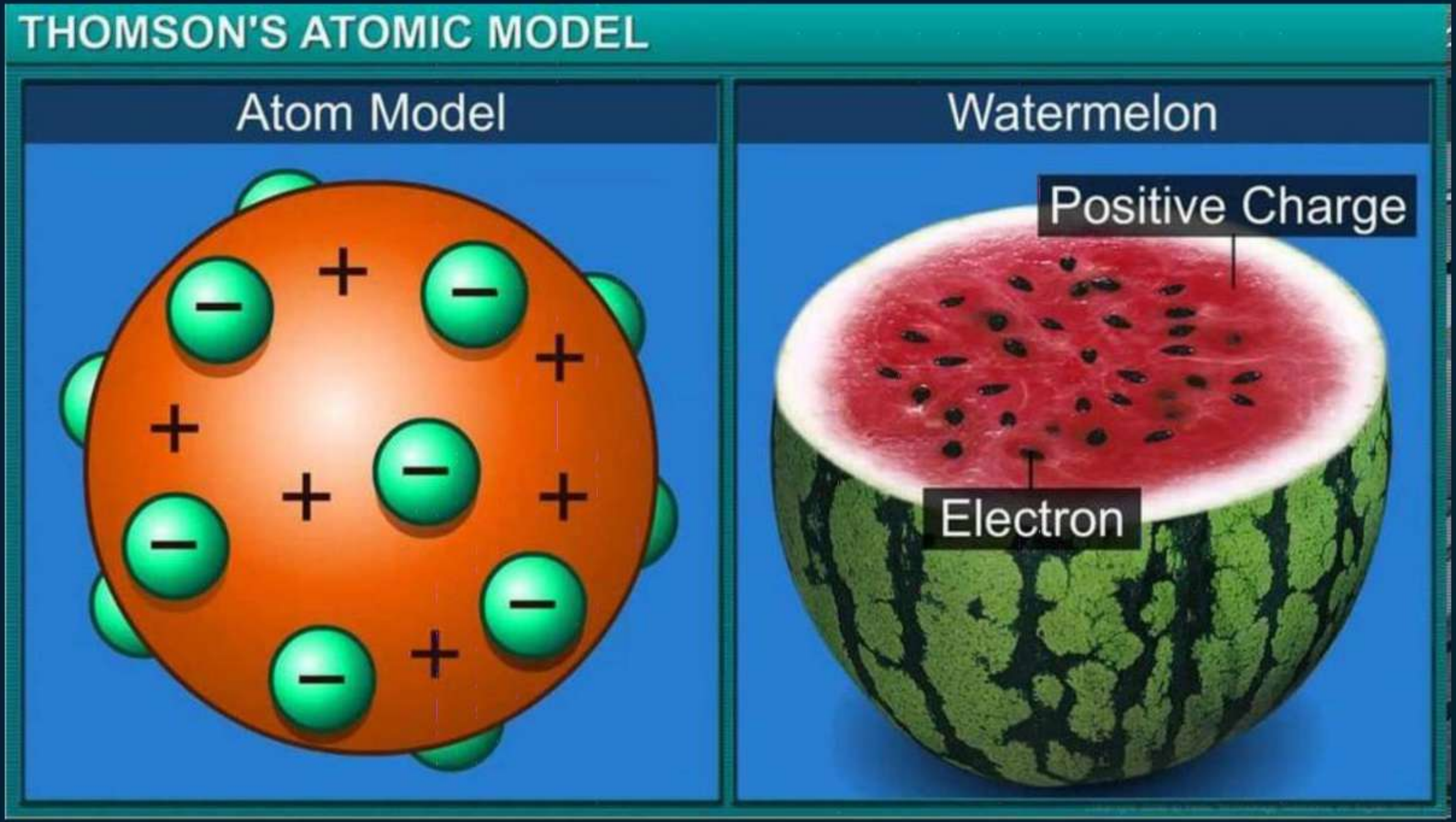
Unit VIII: **Atoms and Nuclei**

Chapter–12: Atoms

Alpha-particle scattering experiment; Rutherford's model of atom; Bohr model of hydrogen atom, Expression for radius of nth possible orbit, velocity and energy of electron in nth orbit, hydrogen line spectra (qualitative treatment only).

THOMSON MODEL

Atom is a positively charged sphere with electrons in it like seeds.



* Atom is electrically neutral.

$Q_{net} = 0$

$|q_+| = |q_-|$

RUTHERFORD MODEL

: α-particle Scattering experiment

$\alpha^{++} = He^{2+}$

(Helium Nucleus)

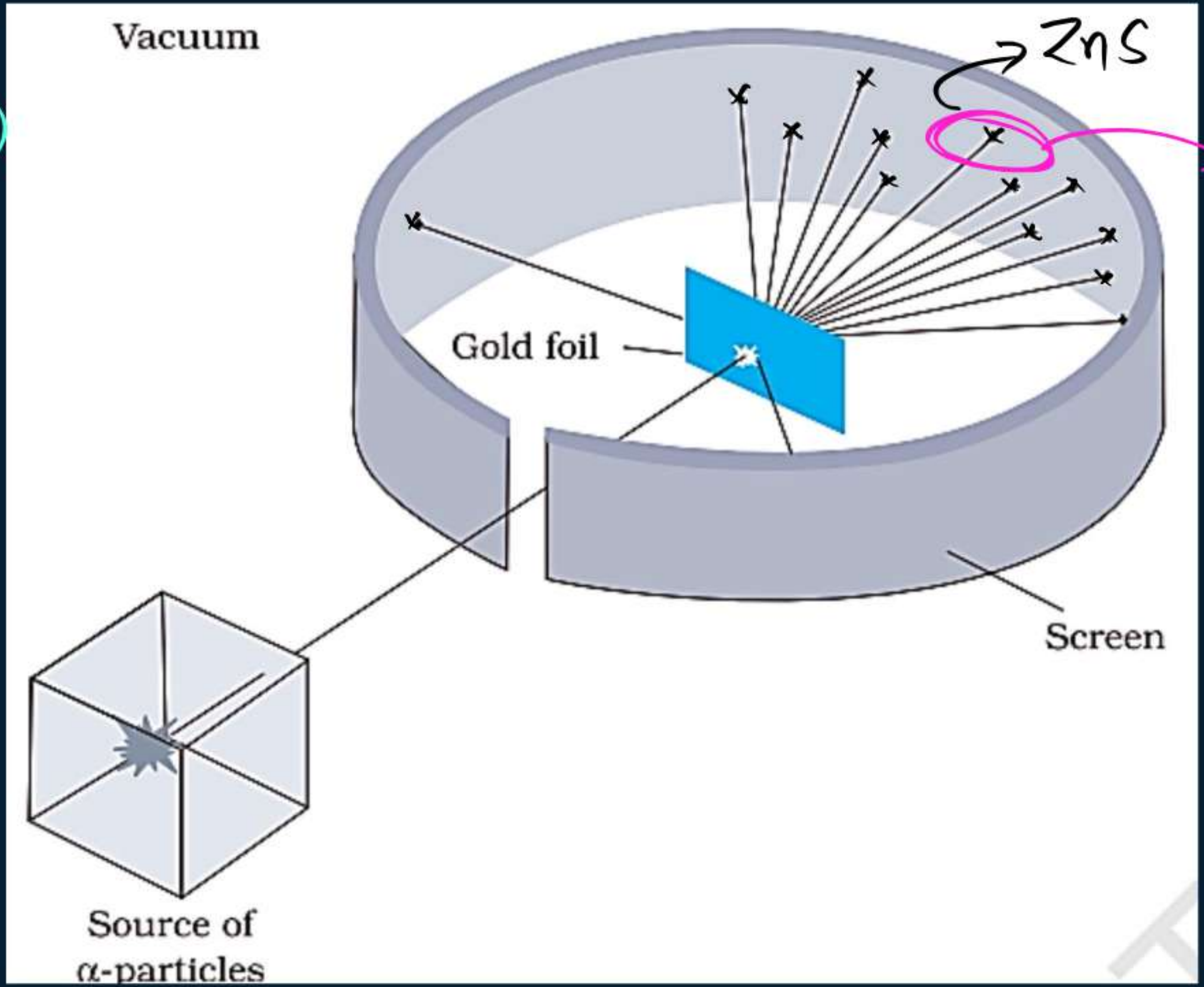
① Size v. small

② Unreactive Nature

Gold Foil (Au)

① Atom size Big

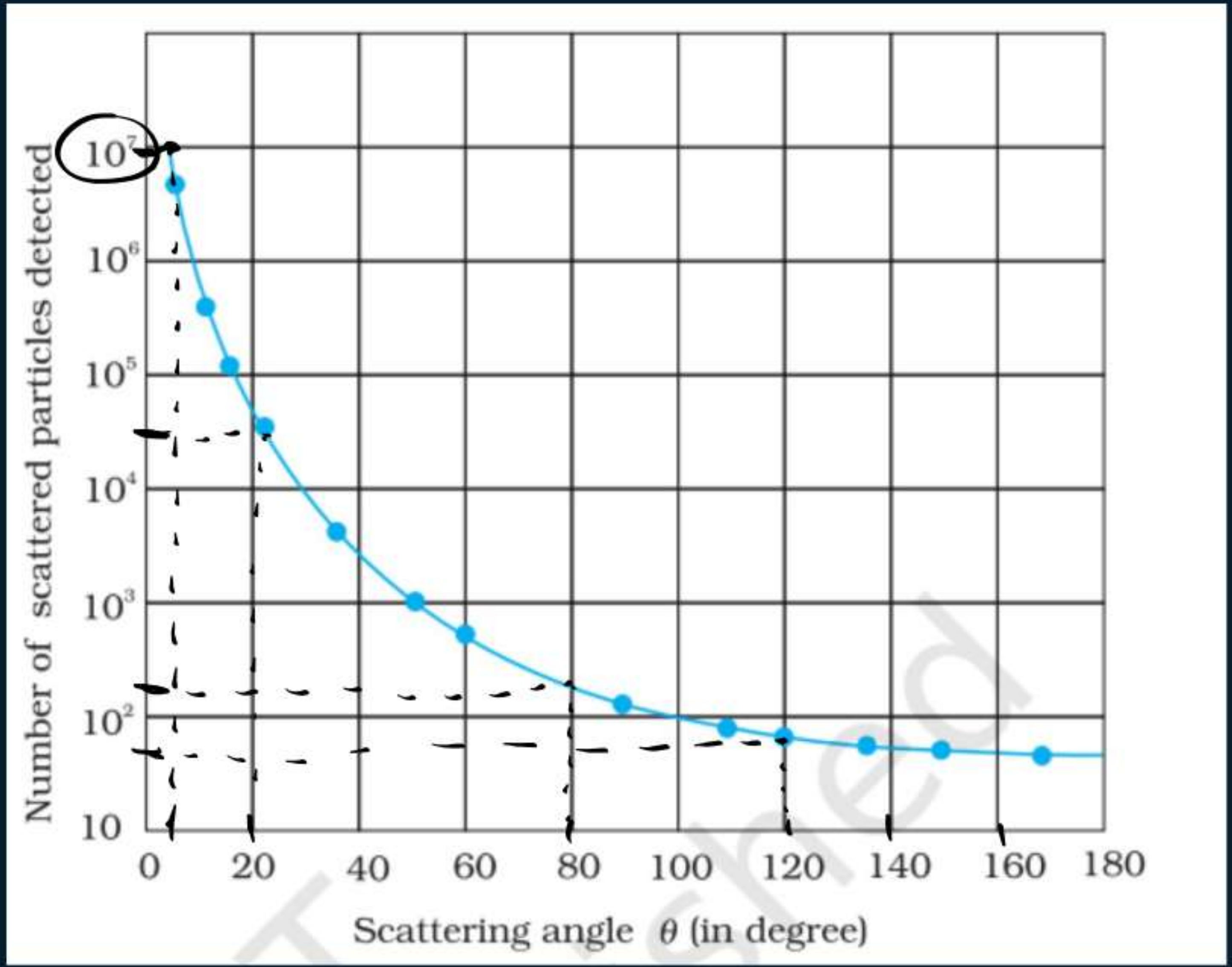
② Noble Metal



(zinc Sulphide) Coating

99 %

RUTHERFORD MODEL

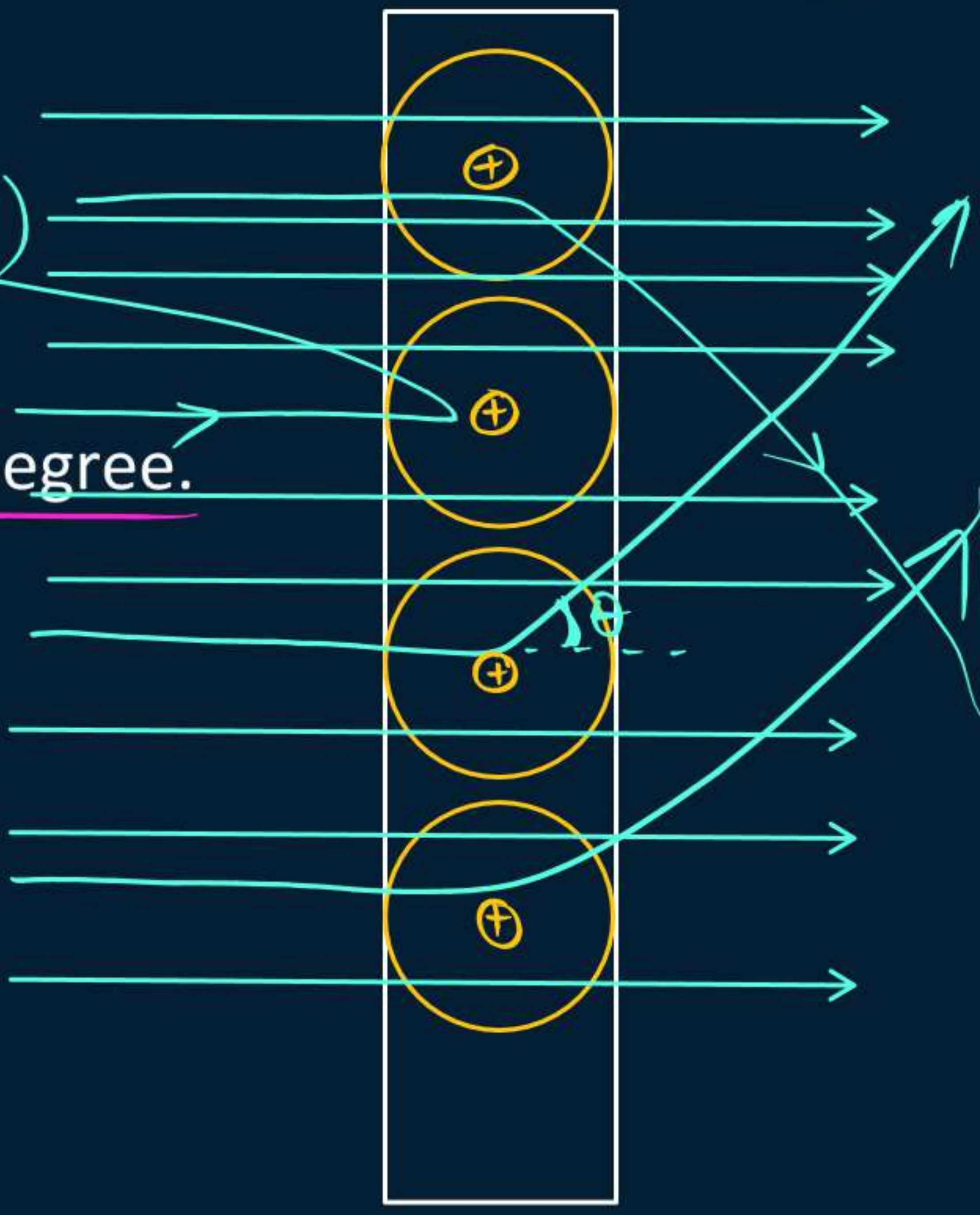


OBSERVATIONS

1. Most of the alpha particles pass undeviated. (straight)

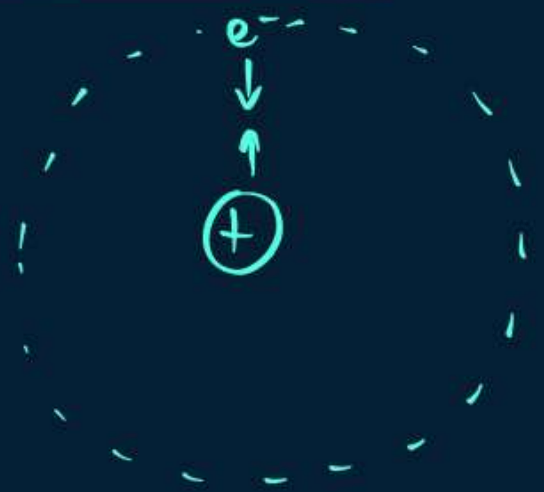
2. Only 0.14 % percent particles deviated by more than 1 degree.

3. 1 in 8000 particles deviated by more than 90 degrees.



CONCLUSION

1. Most of the space is empty in an atom because many particles pass undeviated.



2. There must be a strong positive charge at the centre.

   ⇒ It must be very dense.

3. Size of nucleus = → 10^{-15} m Size of an atom = → 10^{-12} m .... 10^{-10} m

4. There must be electrons in an atom to keep it electrically neutral. They revolve in circular orbit around the nucleus. The centripetal force is provided by electrostatic attraction between nucleus and an electron.

CLOSEST DISTANCE OF APPROACH

"r_0"

Y.K.B.

$q_1 \leftarrow r \rightarrow q_2$

$U = \frac{k q_1 q_2}{r}$

Using C.O.M.E. (Conservation of Mech. Energy)

$$TE_1 = TE_2$$

$$U_1 + K_1 = U_2 + K_2$$

$$0 + \frac{1}{2} m V_0^2 = \frac{k(+2e)(+Ze)}{r_0} + 0$$

$$\frac{1}{2} m V_0^2 = \frac{k 2 Z e^2}{r_0}$$

$$r_0 = \frac{k 2 Z e^2}{\frac{1}{2} m V_0^2}$$

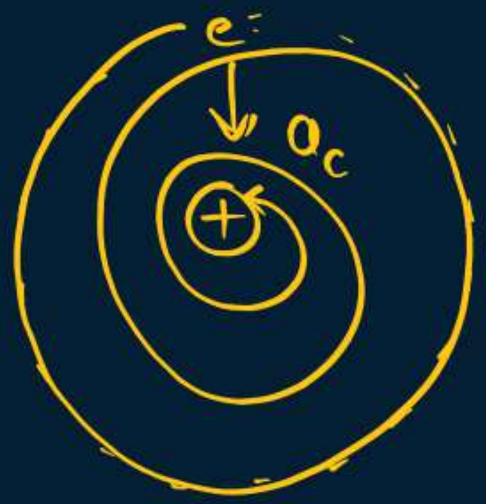
याद *

$$\boxed{r_0 = \frac{4 k Z e^2}{m V_0^2}}$$

Drawbacks of Rutherford :-

① Couldn't Explain the stability of Atom.

②



Circular Motion

↓

Accelerated Motion

↓

Accelerated charge
EM Waves produce

↓

e^- will collapse into Nucleus. ← Energy dissipation

BOHR'S POSTULATES

1. The electrons revolve around the nucleus in fixed orbits, but they do not radiate light while revolving.

2. Only those orbits exist for which angular momentum is quantized.

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

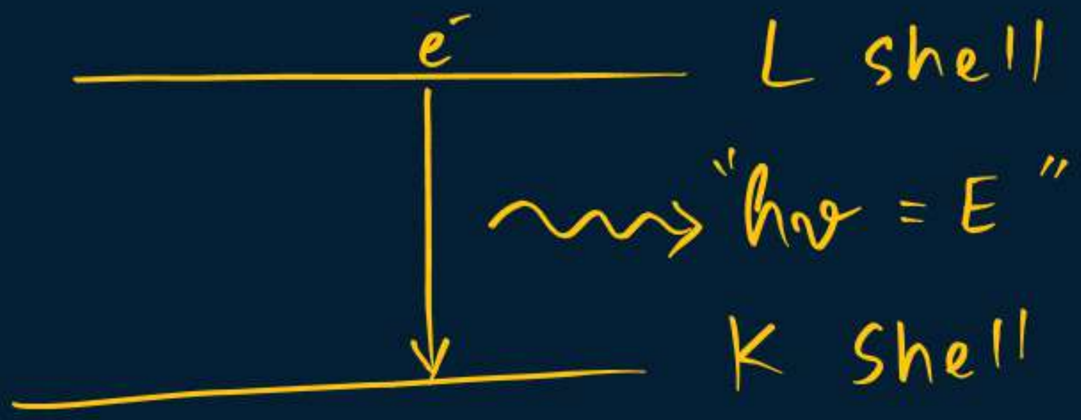
$n = 1$: K shell

$n = 2$: L

$n = 3$: M

⋮

3. The electrons emit energy or light when they jump from higher orbit to lower orbit.

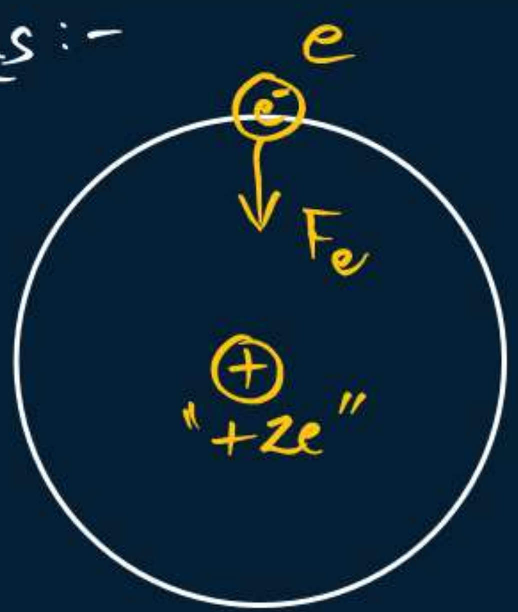


CALCULATION ON BOHR'S MODEL

Y.K.B.

$F_c = \frac{mv^2}{R}$

* radius :-



$F_c = F_{elec}$

$\frac{MV^2}{\cancel{r}} = \frac{K(+Ze)(e)}{r^{\cancel{2}}}$

$r = \frac{kZe^2}{MV^2}$

$r = \frac{kZe^2}{M\left(\frac{nh}{2\pi mr}\right)^2}$

$\cancel{r} = \frac{KZe^2\, 4\pi^2 m^{\cancel{2}} r^{\cancel{2}}}{\cancel{m}\, n^2 h^2}$

from Bohr's Postulate :-

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

$V = \frac{nh}{2\pi mr}$

$r = \frac{h^2 n^2}{KZe^2\, 4\pi^2 m}$

$r = \frac{h^2 n^2}{\frac{1}{\cancel{4\pi}\epsilon_0} Ze^2\, \cancel{4}\pi^2 m}$

$$r = \left(\frac{\epsilon_0 h^2}{e^2 \pi m}\right)\frac{n^2}{Z}$$

$$\boxed{r = 0.53 \times 10^{-10}\,\frac{n^2}{Z}\ m}$$

$$\boxed{r = 0.53\,\frac{n^2}{Z}\ A^0}$$

$$\boxed{r = r_0\,\frac{n^2}{Z}\ A^0}$$

$$r \propto \frac{n^2}{Z}$$

Spl. case :-

for H-atom

$(Z = 1\ ,\ n = 1)$

$$r = 0.53\,\frac{(1)^2}{1}$$

$$\boxed{r_0 = 0.53\ A^0} \rightarrow \text{Bohr Radius}$$

* Velocity :-

By Bohr's 2^{nd} postulate :-

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

$$V = \frac{nh}{2\pi mr}$$

$$V = \frac{nh}{2\pi m\left(r_0 \frac{n^2}{Z}\right)}$$

$$V = \frac{\cancel{n}\cancel{h}}{2\cancel{\pi}\cancel{m}\left[\frac{\epsilon_0 h^{\cancel{2}}}{e^2\cancel{\pi}\cancel{m}}\right]\frac{n^{\cancel{2}}}{Z}}$$

$$\boxed{V = \left(\frac{e^2}{2\epsilon_0 h}\right)\frac{Z}{n}}$$

$$V = 2.2\times10^6\ \frac{Z}{n}$$

$$\boxed{V = V_0\frac{Z}{n}}$$

$$V \propto \frac{Z}{n}$$

$$V_0 = 2.2\times10^6\ m/s$$

$$\boxed{V_0 = \frac{c}{137}}$$

e^- speed in an H-atom

* Time Period :-

$$S = \frac{D}{T}$$

$$T = \frac{D}{S}$$

$$= \frac{2\pi r}{V}$$

$$= \frac{2\pi r_0 \frac{n^2}{Z}}{V_0 \frac{Z}{n}}$$

$$T = \left(\frac{2\pi r_0}{V_0}\right)\frac{n^3}{Z^2}$$

$$\boxed{T = T_0 \frac{n^3}{Z^2}}$$

$$T \propto \frac{n^3}{Z^2}$$

* frequency :-

$$\boxed{\nu = \frac{1}{T}}$$

$$\frac{1}{T} = \frac{1}{T_0}\frac{Z^2}{n^3}$$

$$\nu = \nu_0 \frac{Z^2}{n^3}$$

$$\nu \propto \frac{Z^2}{n^3}$$

* Angular frequency :- $\omega = 2\pi\nu$

$$2\pi\nu = 2\pi\nu_0 \frac{Z^2}{n^3}$$

$$\omega = \omega_0 \frac{Z^2}{n^3}$$

$$\omega \propto Z^2/n^3$$

QUESTION

In terms of Bohr's radius a_0, the radius of the second Bohr orbit of a hydrogen atom is given by

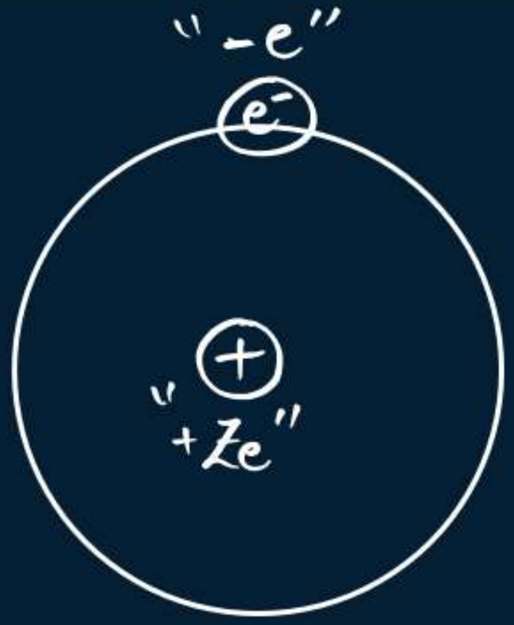
A. $2\,a_0$

B. $4\,a_0$

C. $6\,a_0$

D. $8\,a_0$

ENERGY IN AN ORBIT



$$F_c = F_{elec}$$

$$\frac{mv^2}{r} = \frac{k\,Ze\,e}{r^2}$$

$$mv^2 = \frac{kZe^2}{r}$$

finding Total Energy of an e^- :-

$$TE = U + K$$

$$= \frac{k(+Ze)(-e)}{r} + \frac{1}{2}mv^2$$

$$= -\frac{kZe^2}{r} + \frac{1}{2}\frac{kZe^2}{r}$$

$$= \frac{kZe^2}{r}\left(-1 + \frac{1}{2}\right)$$

$$\boxed{TE = -\frac{1}{2}\frac{kZe^2}{r}}$$

→ Whenever TE ⇒ -ve
shows Karza

$$TE = -\frac{1}{2}\frac{kZe^2}{r}$$

$$r = r_0 \frac{n^2}{Z}$$

$$TE = -\frac{1}{2}\frac{kZe^2}{r_0 \frac{n^2}{Z}}$$

$$TE = -\left(\frac{1}{2}\frac{ke^2}{r_0}\right)\frac{Z^2}{n^2}$$

$$\boxed{TE = -13.6\,\frac{Z^2}{n^2}}$$

H-atom $(Z = 1)$

for K-shell : $n = 1$

$$E_1 = -13.6\,\frac{(1)^2}{(1)^2}$$

$$E_1 = -13.6 \text{ e.V.}$$

L-shell : $n = 2$

$$E_2 = -13.6\,\frac{(1)^2}{(2)^2}$$

$$= -\frac{13.6}{4} \text{ e.V.}$$

M-shell : $E_3 = -\frac{13.6}{9}$ e.V.

N-shell : $E_4 = -\frac{13.6}{16}$ e.V.

RYDBERG'S FORMULA

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

Wave No.

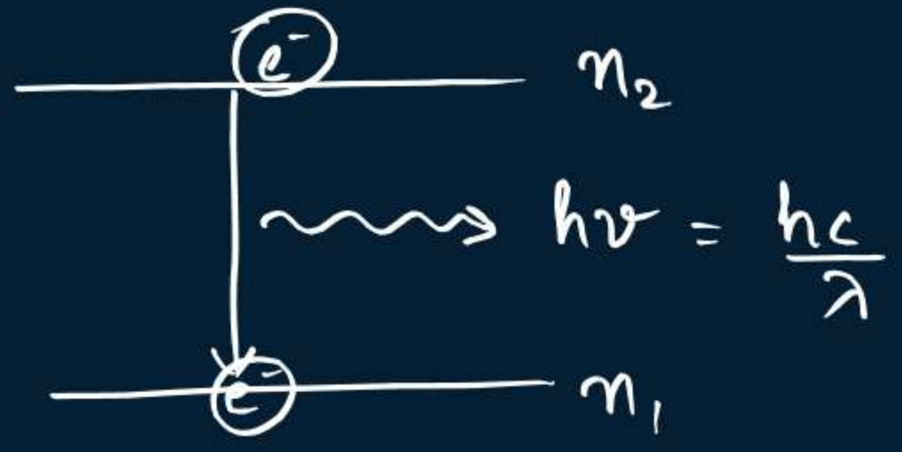
$$\boxed{\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)}$$

n_1: final orbit

n_2: initial orbit

Rydberg constant

$$\boxed{R = 1.01 \times 10^{7}\ m^{-1}}$$



DIFFERENT SERIES

Series

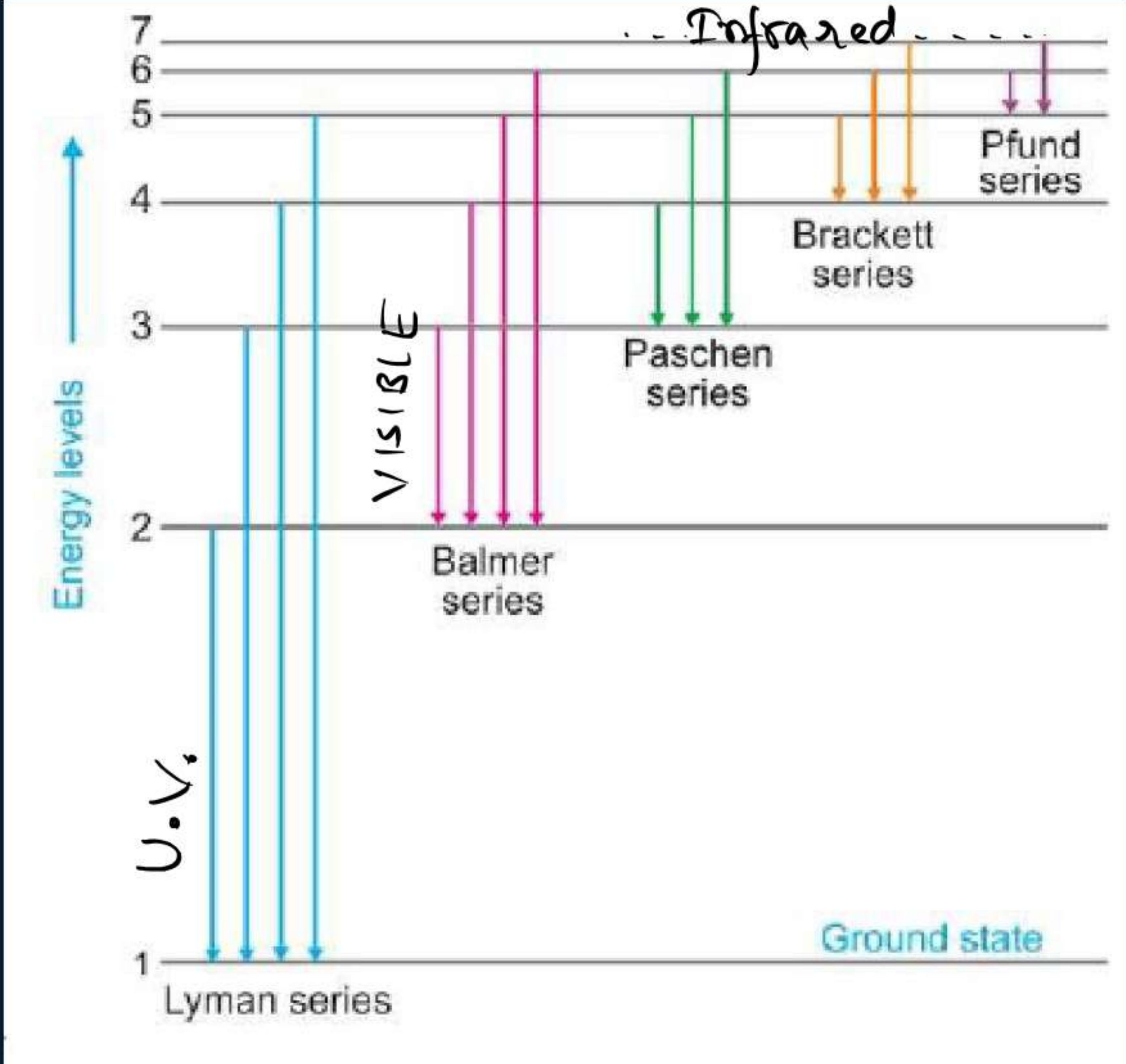
Lyman : $\frac{1}{\lambda} = R\left(\frac{1}{(1)^2} - \frac{1}{n_i^2}\right)$

Balmer : $\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n_i^2}\right)$

Paschen : $\frac{1}{\lambda} = R\left(\frac{1}{3^2} - \frac{1}{n_i^2}\right)$

Brackett : $\frac{1}{\lambda} = R\left(\frac{1}{4^2} - \frac{1}{n_i^2}\right)$

Pfund : $\frac{1}{\lambda} = R\left(\frac{1}{5^2} - \frac{1}{n_i^2}\right)$

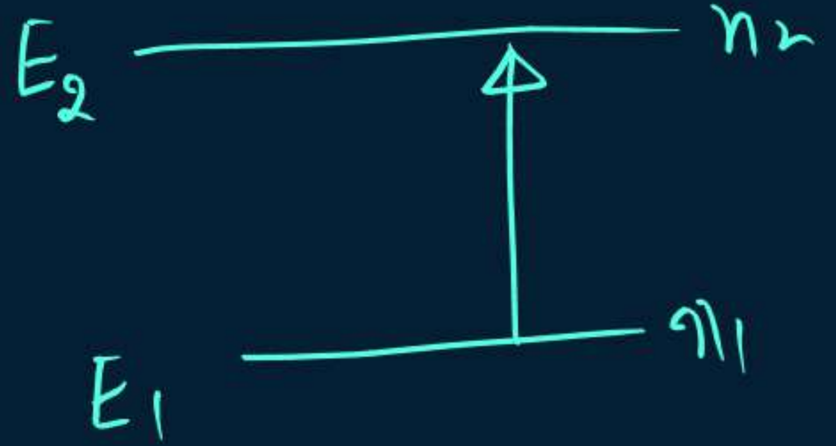


Hydrogen spectral series on a Bohr atom energy diagram.

Ionization Energy and Excitation Energy

Ionization Energy : It is the energy required to completely remove the electron from the atom.

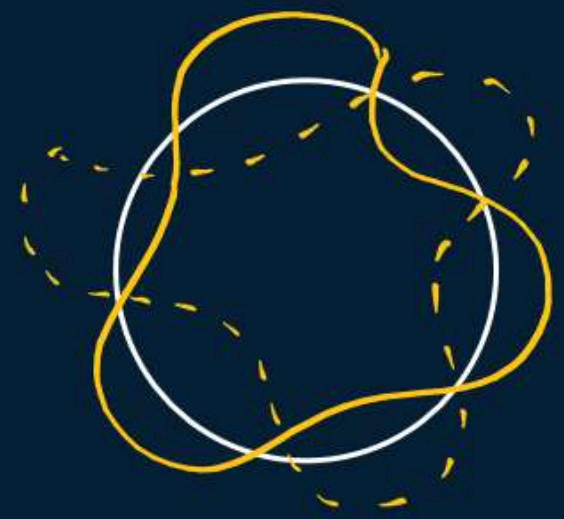
Excitation Energy : It is the energy required to move the electron from lower orbit to a higher orbit.



$$E_2 - E_1 = \Delta E = h\nu = \frac{hc}{\lambda}$$

* Bohr Quantization explained By De-Broglie Saahab :-

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



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

$$\boxed{L = \frac{nh}{2\pi}}$$

hence, Bohr's 2nd postulate was explained by De-broglie.

$$2\pi R = n\lambda$$

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

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

$$\frac{2\pi R}{n} = \frac{h}{mv}$$

* Failure of Bohr's Model :-

(1) It explained the atomic structure of H-atom only.

(2) e^- wave nature were not explained anywhere in this model.

(3) Why only circular orbits were told when elliptical orbits are also possible.

Homework

- Notes
- Revision
- Assignment