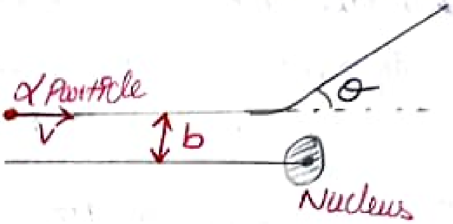
ATOMS

Rutherford Model

$$\text{Nucleus Size}^{\,R} = 10^{-15}$$
$$\text{Atom size} = 10^{-10}$$
10^5

Radioactive Source $= {}_{83}Bi^{214} \longrightarrow \alpha$ particle $= 5.5$ MeV

(1) Impact parameter (b)



$$b = \frac{Ze^2 \cot(\theta/2)}{4\pi\varepsilon_0 (\frac{1}{2}mu^2)}$$

$$b \propto \cot(\theta/2)$$

(2) Scattering Angle (θ)

(3) Distance of closest Approach (r_0)

$$KE_\alpha \longrightarrow PE_{system}$$

$$\frac{1}{2}mv^2 = \frac{1}{4\pi\varepsilon_0}\frac{2ze^2}{r_0}$$

$$r_0 = \frac{2Ze^2}{4\pi\varepsilon_0 (\frac{1}{2}mv^2)}$$

unit of mass = 1 amu

$1\,amu = 1.66 \times 10^{-27}\,kg$

$= \frac{{}_6C^{12}}{12}$

Properties	e^-	Proton	neutron
Absolute charge	$-1.6 \times 10^{-19}\,C$	$1.6 \times 10^{-19}\,C$	0
Relative Charge	-1	$+1$	0
Absolute Mass	$m_e = 9.1 \times 10^{-31}\,kg$	$m_p = 1.67 \times 10^{-27}\,kg$ $= 1.0073\,amu$	$m_n = 1.67 \times 10^{-27}\,kg$ $= 1.0087\,amu$
Relative mass (w.r.t H)	$\frac{1}{1837} \times m_H$	$\approx m_H$	$\approx m_H$
Specific charge by mass ratio. [$\frac{e}{m}$ ratio]	$\frac{e}{m} = \frac{1.6 \times 10^{-19}}{9.1 \times 10^{-31}}\,C/kg$ * Nature of Gas ✗ * Voltage ↑ ⇒ $\frac{e}{m}$ ↓	$\frac{e}{m} = \frac{1.6 \times 10^{-19}}{1.6 \times 10^{-27}}\,C/kg$ * Nature of Gas ✓ * Voltage ↑ ⇒ $\frac{e}{m}$ ↓	$\frac{e}{m} = 0$

$$m_m = \frac{m_r}{\sqrt{1 - (v/c)^2}}$$

★ Bohr's Atomic Model.

(1) Circular Orbit (or) Energy level (or) Stationary State Orbit (n)

(2) Revolving e^- $\Rightarrow$ $l = n\frac{h}{2\pi}$ $n = 1, 2, 3, \ldots$

(3) Transition $\rightarrow$ Energy release $\rightarrow$ Radiation (wave)

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

★ Radius

$$r_n = \frac{n^2 a_0}{Z}$$

★ TE of revolving e^-

$TE = PE + KE$ $\boxed{-TE = KE}$ $\boxed{TE = \frac{PE}{2}}$ $\boxed{KE = \frac{-PE}{2}}$

$$TE = -13.6\,\frac{Z^2}{n^2}\ eV/atom$$

$TE \propto \frac{1}{n^2}$

$$TE = -1312 \times \frac{Z^2}{n^2}\ KJ/mole$$

$$TE = -2.18 \times 10^{-18}\,\frac{Z^2}{n^2}\ J/atom$$

★ Velocity of e^-

$$V = 2.188 \times 10^{8}\left(\frac{Z}{n}\right)\ m/s$$

★ Time Period

$$T = 1.6 \times 10^{-15} \times \frac{n^3}{Z^2}\ sec$$

Photoelectric effect

→ Surface phenomenon

→ 1 Photon $\Rightarrow$ $1e^-$

$$h\nu_i = h\nu_0 + \frac{1}{2}mv^2$$

ν_0 → Threshold frequency.

⇒ Stopping Voltage

Opposing voltage $\Rightarrow$ electric work $= qV$ i.e $\boxed{W = eV}$

$KE = W = eV$

$$h\nu_i = h\nu_0 + eV$$

V → Stopping voltage / potential

Hydrogen Spectrum

$$\Delta E = h\nu = \frac{hc}{\lambda} = 13.6\, Z^2 \left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right) eV \Rightarrow$$

$13.6 \rightarrow eV$
$2.18 \times 10^{-18} \rightarrow J$

Wave number $\Rightarrow \frac{1}{\lambda} = \bar{\nu} = R Z^2 \left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)$ cm^{-1}

Reydberd constant
$R = 109677 cm^{-1}$

(1) Lyman Series $\Rightarrow$ $n = 1$ $\rightarrow$ UV
(2) Balmer Series $\Rightarrow$ $n = 2$ $\rightarrow$ visible reaching
(3) Paschen Series $\Rightarrow$ $n = 3$
(4) Bracket Series $\Rightarrow$ $n = 4$] Infrared
(5) Pfund Series $\Rightarrow$ $n = 5$

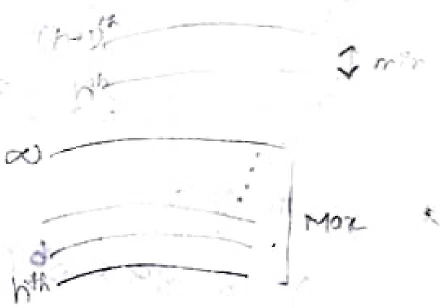
★ **Maximum Wavelength of a Series**

$\lambda_{max} \uparrow \Rightarrow E_{min} \downarrow \Rightarrow n_{min} \downarrow$

★ **Minimum Wavelength of a Series**

$\lambda_{min} \rightarrow E_{max} \rightarrow n_{max}$

$n = \infty$



$\Rightarrow$ Maximum number of Spectral lines produced from n_2 to n_1 State of simple atom.

$$= \frac{n(n+1)}{2} \quad \text{where } n = n_2 - n_1$$

De-Broglie hypothesis

(1) $\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mKE}} = \frac{h}{\sqrt{2mqV}}$

for e^-,
$\lambda = \frac{12.27}{\sqrt{V}}$ Å

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

$$E = \frac{19.87 \times 10^{-26}}{\lambda} J = \frac{1240}{\lambda \text{ (in nm)}} eV$$

(2) $n\lambda = 2\pi r_n$

$\boxed{\lambda = 2\pi n a_0}$

radius of n^{th} orbit
$r_n = n^2 a_0$

Heisenberg Uncertainty Principle

53.7×10^{-3}

$$\Delta x \times \Delta P \geq \frac{h}{4\pi} \qquad \frac{h}{4\pi} = 0.0527 \ kg\,m^2/s$$

Schrodinger Wave Equation

$e^- \rightarrow$ wave equation $\rightarrow \phi = A \sin \omega t$

solve

- Real value
  - $[\theta, \phi, r]$ Eigen func.
    - Radial wave func. $R(r)$
      - $\psi = 0$ → Radial Node $= n - l - 1$
        - ↳ within the Orbital
      - $\psi \neq 0$
    - Angular wave func. $(\theta\ \phi)$
      - $\psi \neq 0$
      - $\psi = 0$ → Angular Node $= l$
        - ↳ b/w the orbital
  - Eigen value
- Imaginary

Total node = $n - 1$

↳ <u>Solution</u>

$n \longrightarrow$ P. QN
$l \longrightarrow$ A. QN
$m \longrightarrow$ M. QN

* Spin QN → not solu. of schrodi. wave eq.

Principal QN. (n)	Azimuthal QN (l)	Magnetic QN. (m)
↳ number of shell / orbit $n = 1, 2, 3, \ldots$ • represent the size of atom and energy of e^-.	↳ represent the shape of the subshell and Orbital $l = 0$ to $(n-1)$	↳ represent the orientation of e^- cloud (orbital) in the subshell. i.e. direction of e^- density. $m = -l$ to $+l$

$l =$	0	1	2	3	4..
Subshell	s	p	d	f	g..

Shell (n) $\longrightarrow$ Subshell (l) $\longrightarrow$ Orbital (m)

eg: $l = 1 \longrightarrow$ p subshell

$m = -1, 0, 1$

P_x	P_y	P_z

$P_z \rightarrow m = 0$ $\qquad$ $P_x, P_y \rightarrow m = \pm 1$

No. of Orbital in a particular subshell $= 2l+1$

Max. no. of e^- in a particular Subshell $= 2(2l+1)$

★ $$\boxed{\text{Orbital Angular momentum of } e^- = \sqrt{l(l+1)}\left(\frac{h}{2\pi}\right)}$$

(4) Spin Quantum Numbers → represents spin states of e^-

$$S = \pm\frac{1}{2}$$

$$\boxed{\text{Spin Angular Momentum} = \sqrt{s(s+1)} \cdot \frac{h}{2\pi}}$$

★ Aufbau Principle

↳ e^- arrange in increasing order of energy level of subshell

$(n+l)$ ⇒ Rule

① Energy $\propto (n+l)$

② $E \propto n$

Same then

↳ Exception → half & fully filled stability

★ Pauli's Exclusion principle

↳ No 2 e^- can have same 4 QN.

★ Hund's Rule

↳ pairing of e^-