ATOMS

Rutherford Model

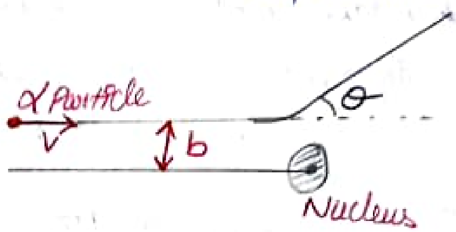
Nucleus Size $\xrightarrow{R}$ = 10^{-15}

Atom size = 10^{-10}

10^5

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

(1) Impact parameter (b)



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

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

(2) Scattering Angle (θ)

(3) Distance of closest Approach (r_0)

$KE_\alpha \longrightarrow PE_{system}$

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

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

unit of mass = 1 amu

1 amu = 1.66×10^{-27} Kg

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

Properties	e^-	Proton	neutron
Absolute charge	-1.6×10^{-19} C	1.6×10^{-19} C	0
Relative Charge	-1	$+1$	0
Absolute Mass	m_e = 9.1×10^{-31} kg	$m_p = 1.67\times10^{-27}$ kg $= 1.0073$ amu	$m_n = 1.67\times10^{-27}$ 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] $m_m = \frac{m_r}{\sqrt{1-(v/c)^2}}$	$\frac{e}{m} = \frac{1.6\times10^{-19}}{9.1\times10^{-31}}$ C/Kg * Nature of Gas ✗ * Voltage ↑ ⇒ $\frac{e}{m}$ ↓	$\frac{e}{m} = \frac{1.6\times10^{-19}}{1.6\times10^{-27}}$ C/Kg * Nature of Gas ✓ * Voltage ↑ ⇒ $\frac{e}{m}$ ↓	$\frac{e}{m} = 0$

★ Bohr's Atomic Model.

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

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

(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^-

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

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

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

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

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

★ Velocity of e^-

$$V = 2.188 \times 10^6 \left(\frac{Z}{n}\right) \text{ m/s}$$

★ Time Period

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

Photoelectric effect $\rightarrow$ Surface phenomenon

$\rightarrow$ 1 Photon $\Rightarrow$ $1e^-$

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

$\rightarrow$ Threshold frequency.

$\Rightarrow$ Stopping Voltage

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

$KE = W = eV$

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

$\rightarrow$ 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

(3) Paschen Series $\Rightarrow$ $n = 3$

(4) Bracket series $\Rightarrow$ $n = 4$

(5) Pfund Series $\Rightarrow$ $n = 5$

$\left.\right]$ Infra red (n = 3, 4, 5)

reaching n^{th} level

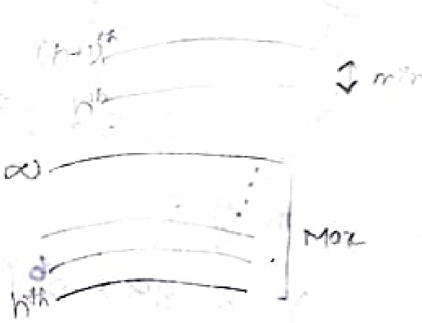
★ Maximum Wavelength of a Series

$\hookrightarrow \lambda\uparrow_{max} \Rightarrow E\downarrow_{min} \Rightarrow n\downarrow_{min}$

★ Minimum Wavelength of a Series

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

$n = \infty$



$\Rightarrow$ 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^-,

$$\lambda = \frac{12.27}{\sqrt{V}} \text{Å}$$

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

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

(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

$\Delta x \times \Delta P \geq \frac{h}{4\pi}$ $\qquad$ $\frac{h}{4\pi} = 0.0527 \ kg\,m^2/s$ $\quad 52.7 \times 10^{-3}$

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 $= n - \ell - 1$
          - within the orbital
      - $\psi \neq 0$
    - Angular wave func. $(\theta \ \phi)$
      - $\psi \neq 0$
      - $\psi = 0$
        - Angular Node $= \ell$
          - b/w the orbital
  - Eigen value
- Imaginary

Total node = $n-1$

Solution

$n \longrightarrow$ P. QN

$\ell \longrightarrow$ 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 $\ell = 0$ to $(n-1)$ $\ell =$: 0, 1, 2, 3, 4.. Subshell : s, p, d, f, g..	represent the orientation of e^- cloud (orbital) in the subshell. i.e. direction of e^- density. $m = -\ell$ to $+\ell$
Shell (n) →	Subshell (ℓ) →	Orbital (m)

eg: $\ell = 1 \longrightarrow$ P subshell

$m = -1, \ 0, \ 1$

$P_x \quad P_y \quad P_z$

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

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 ∝ (n+l)
  2. E ∝ 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^-