ATOMIC STRUCTURE

Atomic number of an element →
Total no. of protons present in nucleus = Total no. of electrons present in atom.

Mass no. of an element = No. of protons + No. of neutrons

Mass number → A
Atomic number → Z
$^{A}_{Z}X$ → symbol of element

Atom → Smallest particle.
→ $e^{\ominus}$, proton and neutron

Electron → (Cathode rays experiment)
↳ J. J Thomson
- → Sealed glass tube
- → Vaccum pump -10^{-6} mm Hg
- → 10,000 Volt
- → Cathode (-ve) → Anode (+ve)

rays come out from cathode to anode

→ E.F. apply → Cathode rays deflected
→ Spin wheel rotates → mechanical effect.
→ Creates sharp shadow → moves in straight line.

Proton → (Anode Rays experiment)
↳ Rutherford
- → Perforated cathode
- → Red glow behind cathod
- → Seems ray coming from anode to cathode

↳ Voltage applied → $e^{\ominus}$ emitted from cathode and move anode.
→ $e^{\ominus}$ ionize gas → formed +ve ion
→ Observed rays moves from anode to cathode

* Nature of anode ray :— (e/m) ratio depends on → ① Nature of gas · 1.75×10^{11} C/Kg
② Material of electrode.

Neutron → Chadwick
→ Bombardment of α-particle

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

$m_e = 9.1 \times 10^{-31}$ Kg $= 9.1 \times 10^{-28}$ g
(e) $= 1.6 \times 10^{-19}$ C (-)
$m_p = 1.66 \times 10^{-27}$ Kg $= 1.66 \times 10^{-29}$ g $= 1$ amu
$m_p = 1837\, m_e$
(p) $= 1.6 \times 10^{-19}$ C (+)
$m_{(n)} = 1.675 \times 10^{-27}$ Kg $= 1.675 \times 10^{-24}$ g

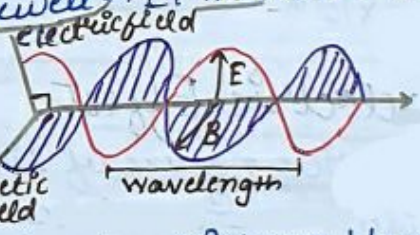
Thomson's atomic Model →
→ plum pudding model
→ explain neutrality of atom
→ Failed of explain stability of atom.

Rutherford Atomic Model :—
(α-particle scattering experiment)
→ Bombarded α-particle on thin gold foil.
→ Most α particle → Undeviated → empty par
→ few α particle → small angle deviated
→ -ve and +ve charge → Neutral.
→ Very few particles deviated back original path → becoz of nucleus
→ $R_{atom} = 10^{-10}$ m, $R_{nucleus} = 10^{-15}$ m

$R = R_0 (A)^{1/3}$ cm $R_0 = 1.33 \times 10^{-15}$ m

Drawbacks →
→ $e^{\ominus}$ revolves around the nucleus.
→ $e^{\ominus}$ continuosly changing direction
→ means accelerated motion
→ According to Maxwell → By acceleration ↓ Energy Released.
↳ So Ruterford failed to explain existence of atom

Electromagnetic Radiation (EMR)
Maxwell → EMR travels in waves



Wavelength → Distance b/w any two Trough and Crest.
S.I → Meter.
1 Å = 10^{-10} m, 1 nm = 10^{-9} m, 1 pm = 10^{-12} m, 1 fm = 10^{-15} m

Frequency → $f = \frac{c}{\lambda}$ Unit → sec^{-1} / Hz.
1 KHz = 10^3 Hz, 1 MHz = 10^6 Hz, 1 mHz = 10^{-3} Hz

Wavenumber → $\bar{\nu} = \frac{1}{\lambda}\, m^{-1}$

Velocity → 3×10^8 m/s

Amplitude → Height of crest and depth of trough.

DrawBack →

EMR cannot explain ① photo electric.
② Blackbody phenomena.

Plank's Quantum Theory

→ particle nature of light
→ Light energy transmitted → small packets (photon) ↓ Quanta

photon → $C = 3\times10^8 m/sec$
→ Speed and Wavelength → Change in medium.
→ frequency and medium → Remains Constant
→ Rest mass → Zero.

A/c to plank → $E = h\nu$ ★

$E = \frac{hc}{\lambda}$ $h = 6.62\times10^{-32}\ J\,sec^{-1}$.

$E = \frac{nhc}{\lambda}$ n = no of photon

Unit = Joule, Other Unit = eV ★
$1eV = 1.6\times10^{-19}\ J$, $hc = 1240\ eV\text{-}nm$
$hc = 12400\ eV - A^\circ$

Que) Calculate ① Wave number and ② Frequency of Yellow radiation having wavelength 5800 Å.

Sol.? → $\upsilon = \frac{1}{\lambda} = \frac{1}{5800\times10^{-10}} = 1.7\times10^{-6}\ m^{-1}$.

$\nu = \frac{c}{\lambda} = \frac{3\times10^8}{5800\times10^{-10}} = 5.1\times10^{14}$

Photoelectric Effect

→ Supports particle nature of light.
→ Light Incident → $e^\ominus$ are ejected out from metal surface
→ $e^\ominus$ → photoelectrons.

Photoelectric Current → Current flows due to motion of $e^\ominus$

Work function and Threshold energy → Minimum energy required to eject $e^\ominus$

Threshold Frequency → minimum frequency required to eject $e^\ominus$

$\phi = h\nu_0 = \frac{hc}{\lambda_0}$

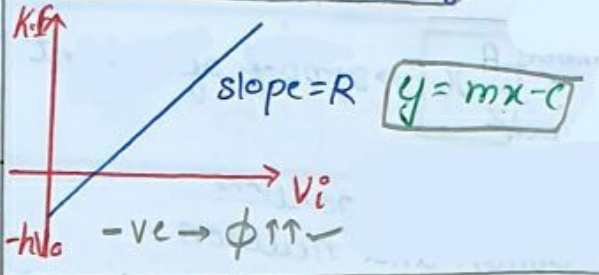
Photoelectric Equation →

(Conservation of energy)

$E_i = \phi + (K.E)_{max}$ ✓

$\frac{hc}{\lambda_i} = \frac{hc}{\lambda_0} + (K.E)_{max}$ ✓

$(K.E)_{max} = h\nu_i - h\nu_0$



Key Points →

→ For each incident photon → one photo $e^\ominus$ emitted.
→ No time gap.
→ Not all ejected photo electrons have $(K.E)_{max}$.
→ $E_i < \phi$ or $\nu_i < \nu_0$ → no photoelectron
→ $E_i \geq \phi$ or $\nu_i \geq \nu_0$ → photoelectric effect observed.

Stopping Potential (V_0) →

→ To stop moving charge → Reverse potential.
→ Reverse potential ↳ stop $e^\ominus$ $(K.E.)_{max}$.

$K.E._{max} = eV_0$
$E_i = \phi + eV_0$
$h\nu_i = h\nu_0 + eV_0$
$eV_0 = h\nu_i - h\nu_0$
$V_0 = \frac{h(\nu_i - \nu_0)}{e}$ ═

Black Body Radiation →

$T\uparrow\uparrow, \lambda\downarrow\downarrow$ ★

Bohr's Atomic Model →

→ Applicable for single $e^\ominus$ species.
e.g. – H, He^+, Li^{2+}, Be^{3+}.

Postulates →
→ atom is neutral
→ $e^\ominus$ revolves in circular path at constant radius. (Orbits or shells)

NEET SLAYER

→ Centripetal force = Electrostatic force of attraction.

$\frac{mv^2}{r} = \frac{Kq_1q_2}{r^2}$

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

→ angular momentum integral multiple of $h/2\pi$.

$mvr = \frac{nh}{2\pi}$ (Vimp) ★

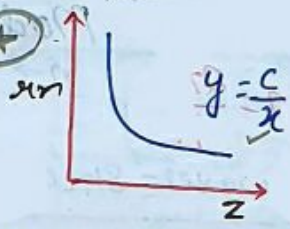
→ Stationary orbits

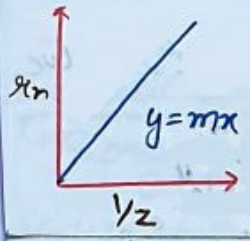
Radius of n^{th} Bohr's orbit →

$r_n = 0.529 \times \frac{n^2}{Z}$ Å

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

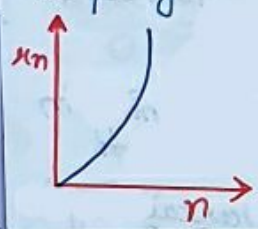
$\frac{r_1}{r_2} = \frac{n_1^2}{n_2^2}\frac{Z_2}{Z_1}$ ★

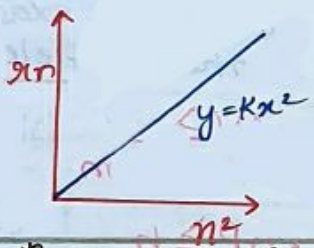




Keeping n Constant

Keeping Z Constant



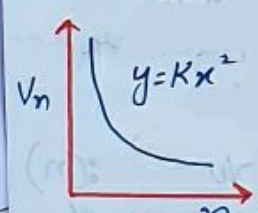


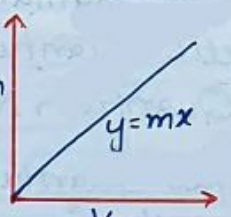
→ Velocity of n^{th} Bohr's Orbit →

$V_n = 2.188 \times 10^6 \times \frac{Z}{n}$ m/sec

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

$\frac{V_1}{V_2} = \frac{Z_2}{Z_1}\frac{n_2}{n_1}$





Keeping Z constant

Keeping n Constant

→ Time Period →

$T = 1.52 \times 10^{-16} \frac{n^3}{Z^2}$ sec

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

→ Frequency → $f \propto \frac{Z^2}{n^3}$

→ Energy of revolving electron.

Total Energy = −K.E = $\frac{P.E.}{2}$ ★

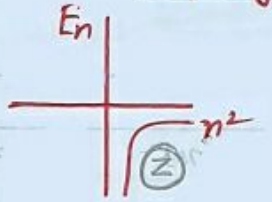
$E_n = -13.6 \times \frac{Z^2}{n^2}$ eV.

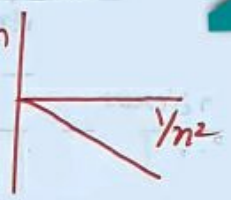
K.E. = $+13.6 \times \frac{Z^2}{n^2}$ eV

P.E. = $-27.2 \times \frac{Z^2}{n^2}$ eV

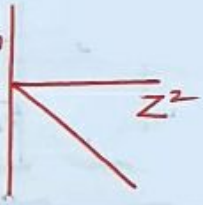
1eV = 1.602×10^{-19} J ★

Keeping Z constant





Keeping n Constant



Energy of Electron in n^{th} Bohr's atom

Energy Level	Energy
1	−13.6eV
2	−3.4eV
3	−1.51eV
4	−0.85eV
5	−0.54eV

Energy difference b/w 2 energy levels

$E_{n_2} - E_{n_1} = -13.6 \times Z^2 \left[\frac{1}{n_2^2} - \frac{1}{n_1^2}\right]$ eV/atom

Ionization Energy

→ energy required to send $e^\ominus$ to Infinity.

$\Delta E = I.E = 13.6 z^2$ eV.

$\Delta E = I.E = 13.6 z^2 \times 96$ KJ/mol

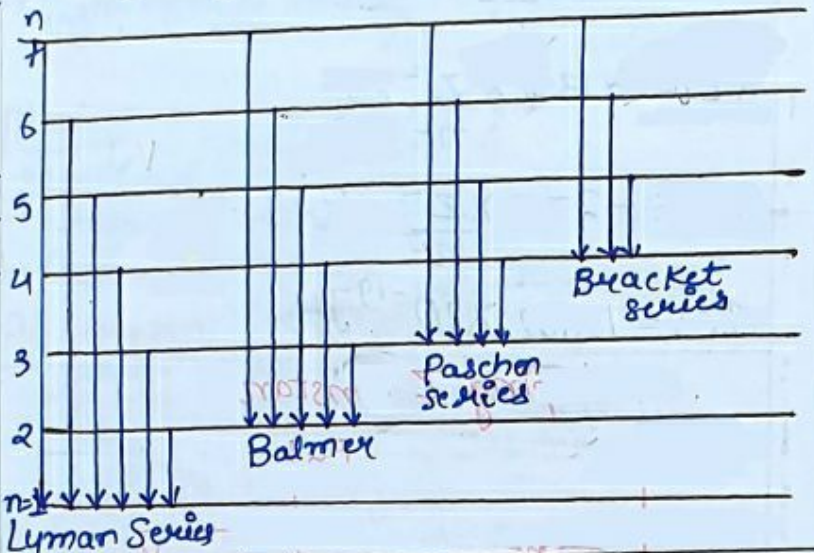
NEET SLAYER

Binding Energy

→ energy required to remove $e^{\ominus}$ from given energy shell.

B.E. = |Energy of n^{th} shell| = $13.6Z^2/n^2$ eV

Hydrogen Line Spectrum



Series	n_1	n_2	No. of lines	Region
Lyman	1	2,3,...∞	(n_2-1)	U.V
Balmer	2	3,4,5...∞	(n_2-2)	Visible
Paschen	3	4,5,6...∞	(n_2-3)	Infrared region
Bracket	4	5,6,7...∞	(n_2-4)	Infrared Region

Total no. of lines in Spectrum →

$$\frac{(n_2-n_1)(n_2-n_1+1)}{2}$$

Rydberg Formula

$$\bar{v} = \frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

↓ Rydberg Constant.

$$R = \frac{13.6}{hc}$$

$$\frac{1}{R} = 9.12 \times 10^{-6}\,cm = 9124\,\text{Å}$$

$$R = 1.0967 \times 10^5$$

Drawback of Bohr's Model →

→ applicable for single $e^{\ominus}$ species. ✓

→ Not explain stark effect and zeeman effect. ✓

De-Broglie Concept

If nature of light is both, particle and wave, then this dual behavior should be true for matter also.

$$\lambda \propto \frac{1}{p}$$ → momentum

$$\lambda \propto \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2m(K.E.)}}$$ = dual nature

$$\lambda_e = \sqrt{\frac{150}{v}}\,\text{Å} \text{ or } \frac{12.27}{\sqrt{v}}\,\text{Å}$$

↓ particle accelerated from rest.

Association of De-Broglie Concept with Bohr's Model →

$$n = \frac{2\pi r}{\lambda}$$

n → no. of waves

no. of waves = Shell in which $e^{\ominus}$ revolve

Heisenberg's Uncertainity Principle

↳ It is impossible to determine simultaneously exact position and momentum of electron

$$\Delta x \cdot \Delta v \geq \frac{h}{4\pi m}$$ Δp → Uncertainity in momentum

$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$$ Δv → Uncertainity in Velocity

Quantum Number →

→ Principal Quantum Number
→ Azimuthal Quantum Number
→ Magnetic Quantum Number
→ Spin Quantum Number

→ Principal Quantum Number: (n)
Determine the size and energy of orbital.

→ No. of orbitals present in n^{th} shell = n^2

→ No. of sub shell present in n^{th} shell = n

n	Subshell
1	s
2	s, p
3	s, p, d
4	s, p, d, f

Angular momentum of any orbit $= \frac{nh}{2\pi}$.

Angular momentum of revolving electon $\Rightarrow mvr = \frac{nh}{2\pi}$.

Azimuthal Quantum Number (l) →
Defines 3-D shape of orbital and no. of subshell in a shell

Value of $l = 0$ to $(n-1)$

$n = 1 \rightarrow l = 0 \rightarrow s$
$n = 2 \rightarrow l = 0, 1 \rightarrow p$
$n = 3 \rightarrow l = 0, 1, 2 \rightarrow d$

→ No. of orbital in subshell $= 2l+1$
→ Max. no of e^- in particular subshell $= 2 \times (2l+1)$
→ Orbital angular momentum $= \frac{h}{2\pi} \times \sqrt{l(l+1)}$

Magnetic Quantum Number : (m) →
↳ Represents shape and orientation of Orbital.

Value of $m = -l$ to $+l$ including 0.

Value of l	Value of m
0	0
1	-1, 0, -1
2	-2, -1, 0, +1, +2

Spin Quantum Number : (s) →
↳ Represent orientation of spin of electron.

→ Value of $s = +\frac{1}{2}$ and $-\frac{1}{2}$
→ Each orbital can accomodate 2 electron with opposite spin ⇅
→ Spin angular momentum of e^- $= \sqrt{s(s+1)} \cdot \frac{h}{2\pi}$ $= \sqrt{s(s-1)}\, h$

Rules for filling Orbitals

① Aufbau Principle →
↳ In ground state of atom, orbitals are filled in order of increasing energies.

$1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s$

Lowest $(n+l)$ valued orbital filled first.
→ At $(n+l) \rightarrow$ same $\rightarrow$ lowest value of n filled first.
→ Not valid for H atom.

② Pauli's Exclusion Principle →
↳ No 2 electrons in atom can have same set of 4 quantum numbers
→ Orbital can accomodate max. 2 electron with opposite spin.

③ Hund's Rule →
→ no pairing of $e^\ominus$ occur till orbital singly occupied.

Magnetic Moments →
$\mu = \sqrt{n(n+2)}$