ATOMIC STRUCTURE

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★ **Isotopes** – different atoms of same element which have same atomic number; but different mass number (same nuclear charge).
↓
$_1H^1$, $_1H^2$, $_1H^3$

★ **Isobars** – These are atoms of different element which have same mass number but different atomic Number
↓
$_6C^{14}$, $_7N^{14}$
→ [Diff nuclear charge)
→ [No. of nucleons same]

★ **Isotones / Isoneutronic** → same no. of neutrons [atoms]
eg – $_{19}K^{39}$, $_{20}Ca^{40}$

★ **Isodiaphers**: same value of (n−p) [atoms]
eg:- $_5B^{11}$, $_6C^{13}$, $_7N^{15}$, $_8O^{17}$

★ **Isosters** : 1) Molecules me
2) Same total no. of atoms
3) same total of e⁻
eg:-
1) CO_2, N_2O 2) $HClO$, OF_2

★ **Isoelectronic** – Ions / molecules / atoms have same no. of e⁻
eg :- [H_2O, NH_3], [Cl^-, Ar], [C_6H_6, $B_3N_3H_6$]

① Structure of Atom

a) **Thomson Model** - Acc to Thomson;
- atom is tvely charged particle.
- -ve charge present like seed in watermelon

b) **Rutherford Model** – [gold leaf experiment]

★ Why select gold foil – 1) Heavy metal
2) Thermally stable↑
3) Malleable ↑

★ Screen – ZnS

★ **Observation**:
- 1 comes back
- 99.1% undeflected
- few deflected at some angles.

N = No. of deflected α particle
θ = Angle of deflection

$$N \propto \frac{1}{\sin^4(\theta/2)}$$

★ **Result** :-
- Maxm part of atom = Hollow
- Nucleus is concentrated in a very small place
- Nucleus is rigid body.
  → Responsible for mass
- Other part → responsible for size / volume.
- Electron revolve around nucleus like in solar system.

• size of nucleus = fermi order = 1 fermi
size of atom = Angstron order = 1 A°

$$\frac{D_A}{D_N} = \frac{10^{-10}}{10^{-15}} = 10^{+5}$$

$$D_A = 10^5 D_N$$

$$R_A = 10^5 R_N$$

$$V_A = 10^{15} V_N$$
→ volume

$$R_N = R_0 (A)^{1/3}$$

A → mass number
R_N → Radius of nucleus
R_0 = 1.33 fermi

$$\frac{R_{N_1}}{R_{N_2}} = \left(\frac{A_1}{A_2}\right)^{1/3}$$

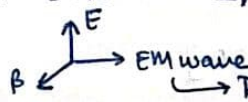
★ Density of nucleus = 10^{17} Kg/M³
→ fixed for all.
→ Doesnot depend on A.

★ **Demerits of Rutherford experiment**
- Cannot explain why revolving e⁻ does not collide into the nucleus (if field is attractive in nature) in spiral path.

Maxwell theory :- If a charge revolve in the presence of attractive field then it will emit energy in the form of EMW.
- Energy = decreasing so spectrum = continuous
But in real spectrum = discontinuous. (line spectrum)

Rutherford → Bohr's Model
↓
- EMW
- Plank's Quantum theory

★ **Electromagnetic waves (EMW)**
- It is the transfer of energy in the form of waves which travels with the speed of light.
- contain both EF and MF.
- Velocity = 3×10^8 m/s = speed of light
- Not require medium for propagation.
- Direction → ⊥r to both MF and EF both



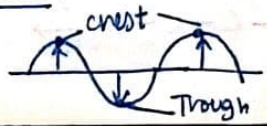
EM wave → pure energy wave
→ Do not have mass

γ rays	X rays	U.V rays	Visible rays	IR	Micro	Radio

V↑ E↑ λ↓ ⟶ λ↑ V↓ E↓

Parameter of EMW :-

1) **Amplitude** (A)
→ height of crest or depth of ~~crest~~ trough



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→ units → cm, Å

2) Wavelength (λ) → Dist b/w 2 nearest crest or 2 nearest troughs
→ Displacement in ⊥ wave
→ unit = cm, Å

3) frequency (ν): unit = s^{-1} or Hz
→ equal to number of waves passing a point in 1 sec.

$\nu = \frac{1}{T}$ 1 wave → T sec

4) Velocity (v) - Displacement in 1 sec

$v = \nu \times \lambda$

$v = \frac{c}{\lambda}$ ← Em wave

5) Wave Number ($\bar{\nu}$): unit = cm^{-1}

$\bar{\nu} = \frac{1}{\lambda}$ $\nu = c\bar{\nu}$

② PLANK'S QUANTUM THEORY

→ The radiant energy emitted or observed by a body is not continuous but discontinuous in the form of discrete packets of energy.
→ And these packets are k/a Quantum
→ In case of light radiant; Quantum is named as 'photon'.

$E \propto \nu$ $E = h\nu$

E: Energy of photon; ν: frequency of radiation; h: plank's constant

$E = \frac{hc}{\lambda}$ $E = n\frac{hc}{\lambda}$

$h = 6.6 \times 10^{-34}$ Js
ν = frequency of radiation.
λ = wavelength of radiation.
E = Energy of 1 photon

1 J = 1 kg m^2/s^2
1 erg = 1 g cm^2/s^2
1 J = 10^7 g cm^2/s^2

③ BOHR'S MODEL: Based on 2 theories

a) Quantum theory
b) classical law of physics.

→ This model is applicable for Hydrogen and hydrogen like species (single e⁻ specie) [Hydrogen like atom] eg: He^+, Li^{2+}, Na^{10}, H

$\frac{Kze^2}{r^2} = \frac{mv^2}{r}$ $mvr = \frac{nh}{2\pi}$ → energy conservation

m = mass of e⁻
v = speed of e⁻
Angular Momentum
r = radius of shell in which e⁻ is revolving
n = shell no. in which electron is revolving

→ e⁻ is associated with a fixed energy in a particular orbit and that is k/a stationary shell of that e⁻.

$mvr = \frac{nh}{2\pi}$ $mv_n r_n = \frac{nh}{2\pi}$ v, r → variable

→ Angular momentum is Quantised
↳ +ve integral multiple

④ Radius (r_n):

$r_n \propto \frac{n^2}{z}$ $r_n = \frac{n^2h^2}{4\pi^2 Kze^2 m}$ → radius of nth shell

$r_n = 0.529\left[\frac{n^2}{z}\right]$ Å

• for hydrogen atom; (z=1) $r_n = n^2(r_1)$
• for a particular single e⁻ species $\frac{r_1}{r_n} = \frac{1^2}{n^2}$

⑤ Velocity (v_n)

$v_n \propto \frac{z}{n}$ $v_n = \frac{2\pi Kze^2}{nh}$ → an e⁻ which is revolving in nth shell of a single e⁻ species

$v_n = 2.188 \times 10^8 \left(\frac{z}{n}\right)$ cm/s

• For a particular single e⁻ species

$\downarrow v_n \propto \frac{1}{n\uparrow}$ (z = fix)

⑥ Total Energy of electron (U)

$KE = \frac{1}{2}mv^2$ $PE = -\frac{kq_1q_2}{r}$

TE = KE + PE

$TE = -\frac{Kze^2}{r} + \frac{1}{2}mv^2$

$TE = -\frac{Kze^2}{2r}$

$-TE = KE = -PE \times 2$

$E_n = -13.6\left(\frac{z^2}{n^2}\right)$ eV/atom ← Main

⑦ Ionisation Energy / Ionisation Potential (IE/IP)
↳ Min^m energy which is required to eject an e⁻ from ground state

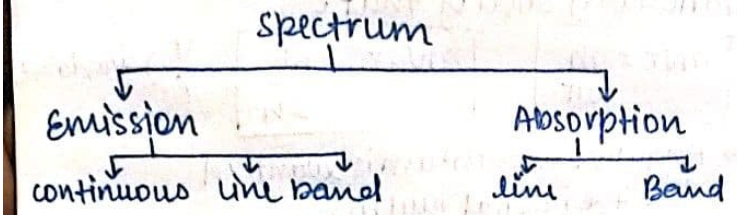
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⑧ SEPARATION ENERGY @supremedevotee

→ minimum amt of energy required to escape an e⁻ from excited state

⑨ SPECTRUM:

↳ when radiation is passed through a prism for the dispersion of the radiation, the pattern obtained is k/a spectrum.



★ Emission: radiation emitted from incandescence source
eg:- candle, sun, bulb etc

1) Line → by passing electrical discharge through a gas at low temp.
2) Band → by heating some substance at high temperature.
3) Continuous → prism se pass and pattern on screen

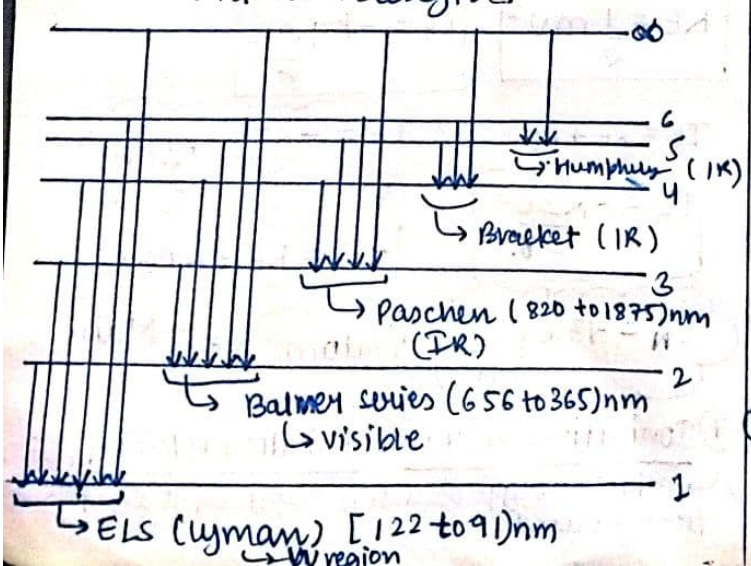
→ No 2 elements will have identical linespectrum.

★ Absorption: white light passed through a solution or vapours of chemical substance

White light through atomic gas = Line
White light through molecular gas = Band

⑩ Hydrogen linespectrum

↳ when hydrogen is subjected to electrical excitation at low pressure, then bluish light comes out, then these lines passed through spectroscope; then we obtain several spectral lines with Diff wavelength.



★ Lyman is the only series in which absorption and emission both are observed.

★ Every series: 1st line → ΔE_{min}
last line → ΔE_{max}

1st line → λ_{max} of that series
last line → λ_{min} of the series.
(member)

★ Total spectral lines ($\Delta n = n_2 - n_1$)

$$\text{Lines} = \frac{(\Delta n)(\Delta n + 1)}{2}$$

⑪ Rydberg formula:

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

Constant = 109700 /cm

$\frac{1}{R} = 912 \text{ Å}$

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

Demerits of Bohr Model

1) Not valid for multielectron species
2) Used ($mvr = \frac{nh}{2\pi}$); without any theoritical derivation.
3) Biggest drawback → used Quantum theory and classical laws simultaneously without any correction.
4) Was not able to explain fine line spectrum
5) Not explain; zeeman, stark effect
   ↓ Splitting in MF ↓ in EF
6) Has a contradiction with Heisenberg's uncertainity principle.

⑫ QUANTUM NUMBERS

↳ Exclusive identity of electron

country → city → Area → House
(n) → (l) → (m) → (s)

ⓐ Principal Quantum Number (n)

→ given by Bohr
→ gives name, size, energy of the shell to which e⁻ belongs

n=1 (K shell)
n=2 (L shell)
n=3 (M shell)
n=4 (N shell)

→ Angular momentum

★ max^m no. of e⁻ in a particular shell = $2n^2$

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(b) Azimuthal Quantum Number (l)

→ value of 'l' will be (0 to n-1)
→ represents shape of the ~~shell~~ subshell and orbital angular momentum.

- l=0 [s] → spherical
- l=1 [p] → dumb bell
- l=2 [d] → double dumb bell
- l=3 [f] → complicated

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Maxm No. of e⁻ = 4l+2
↳ in subshell

 # Orbital angular momentum

$L = \sqrt{l(l+1)}\,\frac{h}{2\pi}$

(c) Magnetic Quantum Number (m)

→ represents orientation of orbitals
→ orbitals are electron cloud
→ m = (−l to +l)
→ orbital = space of probability of finding electron

maxm no. of e⁻ in an orbital = 2

(d) Spin Quantum Number (s)

→ represents the direction of electron spin around its own axis.

- clockwise spin = ↑ or 1
- Anticlockwise spin = ↓ or ↓

$s = \pm 1/2$

 # Spin angular momentum

$SAM = \sqrt{s(s+1)}\,\frac{h}{2\pi}$

 # Magnetic Moment $= \sqrt{n(n+2)} = M$
n = no. of unpaired e⁻

(13) NODE – where the probability of finding an e⁻ is zero

$\psi = 0$

- **Nodal point**: Point where prob of e⁻ = 0
- **Nodal plane**: Plane at which prob of finding e⁻ = 0

↓ Nodal surface → same as above.

★ No. of Radial Nodes / Nodal surfaces = n−l−1

★ No. of angular nodes / or No. of nodal planes = l

Total No. of Nodes = n−1
→ Radial = n−l−1
→ Angular = l

(14) Filling of e⁻ in diff subshell :-

(2) Rules → Afbau Rule
→ (n+l) Rule

Afbau Rule
→ fill e⁻ in the decreasing order of stability or increasing order of energy

(n+l) Rule
→ (n+l) ↓ energy ↓ stability ↑ max

- **Exchange Energy** – Amt of energy released when an electron exchanges its position among degenerate orbitals
  ↓
  (same energy orbitals)

★ No. of exchanges ↑ EE ↑ Released E ↑ Stability ↑

★ **Hund's Rule** → All e⁻ so that maxm no. of unpaired e⁻ with same spin are obtained.
→ Also k/a maxm multiplicity Rule.

★ nth shell → outermost / ultimate shell
(n−1)th shell → Penultimate / core shell
(n−2)th shell → Prepenultimate shell

★ **Kernal** → if we remove the outermost shell then the remaining str is k/a kernal.

★ core → (n−1)th shell

(15) Heisenberg's Uncertainity Principle

↳ impossible to measure momentum and exact location of a moving particle like e⁻

$(\Delta p)(\Delta x) \geq h/4\pi$
$m(\Delta v)(\Delta x) \geq h/4\pi$
$(\Delta v)(\Delta x) \geq h/4\pi m$

ψ ↓ Amplitude of wave.

$(\Delta E)(\Delta t) \geq h/4\pi$

★ **Debroglie** $\lambda = \frac{h}{mv}$

$\frac{\lambda_1}{\lambda_2} = \frac{m_2 v_2}{m_1 v_1} = \frac{P_2}{P_1}$

ψ^2 = Probability density

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