Structure of Atom

① Atomic number (z) — Tells about $e^{\ominus}$ or No. of P

② Mass number (A) — Tells about No. of n+p in a nucleus.

Represent = $^{A}_{Z}X$ No. of neutrons = A−Z

③ Isobars — same atomic number but diff mass number.

④ Isobars — same mass number but diff atomic number.

⑤ Istones — A & Z = diff but same no. of neutrons.

⑥ Isoelectronic — species having same no. of electrons.

⑦ Isodiaphers — A & Z = diff but same $\underbrace{n-p}_{\text{Isotopic number}}$.

⑧ Isosters — species have same no. of atoms and electrons.

• Electromagnetic waves / Nature of light ⟶ Plancks quantum Theory.

① Energy transmitted from one body to another body in the form of waves move with speed of light.

② This waves consist of both EF and MF, which is perpendicular to each other called EMR.

③ EMR or Radiant energy — Don't required medium, can travel in vaccum also.

④ Radiant energy can transfer without medium coming through waves called EMR.

Waves / Radiation

↓ Mechanical (medium required) ↓ Sound waves

↓ Non-Mechanical (medium not required) ↓ EMR

- Characteristics of waves:

① Wave length (λ): Distance b/w two crest or Trough.

② Frequency (ν): The no. of waves which passed through a point in 1 sec.

③ Wave number ($\bar{\nu}$): The no. of waves spread in a unit length

④ Amplitude: The height of crest or depth of Trough.

• Electromagnetic spectrum:

- The arrangement of various EM values with same velocity called EMS. — Incre. order of wavelength / Decr. order of frequency

Ⓛ → Wavelength value Increases → Ⓡ

Cosmic Rays	γ rays	X Rays	UV rays	Visible rays	IR Rays	Micro waves	Radio Waves	T.V waves

VIBGYOR

Ⓛ → E, ν, $\bar{\nu}$ values also decreases → Ⓡ

- Black Body – Perfect absorber and perfect emitter.

• Plank's Quantum theory:

① Black Body emitted or absorbed EMR or Radiant energy

a) discontinuosly.

b) In the form of small packets called quanta.

c) which is propagated in the form of waves.

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Note: If energy source is light → called photon.

② Energy of each small pocket [quantum] ∝ frequency.

$$E \propto \nu$$

$$E = h\nu$$ n = No. of quanta / photons.

$$E = nh\nu$$ n = No. of small energy packets.

So energy emitted or absorbed from one body to another is integral multiple of $h\nu$

i.e $E_{ab/emi} = h\nu, 2h\nu, 3h\nu, 4h\nu \ldots\ldots$

- Notes: (Acording to NCERT)

① Absorption or emission of Radiation due to oscillation or vibration of charge particles in the walls of black body.

② $E, \nu, \bar{\nu}$ and λ values are changed / different for different EMR.

③ Plank suggest that atoms and molecules emit/ab radiation discontinuously in a small packets [quanta].

Note: wavelength of emitted radiation depends on its temp.

Instensity = No. of photons / Quanta.

- At a given temp,

① Intensity of emitted radiation increases with increase wavelength, Reached maximum level and then decreases.

② If temp increases, maxima of curve shifts to lower wavelength side.

$$\frac{E_1}{E_2} = \frac{\nu_1}{\nu_2} = \frac{\bar{\nu}_1}{\bar{\nu}_2} = \frac{\lambda_2}{\lambda_1}$$

$$\boxed{E = h\nu} \longrightarrow \boxed{E = \frac{hc}{\lambda}} \longrightarrow \boxed{E = hc\bar{\nu}}$$

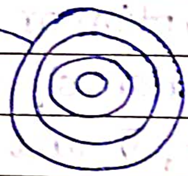
$$\left[\nu = \frac{c}{\lambda}\right] \qquad \left[\bar{\nu} = \frac{1}{\lambda}\right]$$

$$E \propto \nu \qquad E \propto \frac{1}{\lambda} \qquad E \propto \bar{\nu}$$

	E/K.E/T.E	h	λ	$\bar{\nu}$	c
SI	J	6.62×10^{-34} J	m	m^{-1}	3×10^{8} m/sec
CGS	Erg	6.62×10^{-27} erg	cm	cm^{-1}	3×10^{10} cm/sec

- **Bohr's atomic model :**

① orbits / shells / main energy level / stationary level.



$n = 1$ / $n = K$ $\longrightarrow$ 1st shell

$n = 2$ / $n = L$ $\longrightarrow$ 2nd shell

$n = 3$ / $n = M$ $\longrightarrow$ 3rd shell.

$\Delta E = E_2 - E_1 = nh\nu \longrightarrow$ Energy photon / packet / quanta

② Angular momentum $(mvr) = \frac{nh}{2\pi}$

AM of electrons in 1st shell $= \frac{1h}{2\pi}$ or $\frac{0.5h}{\pi}$

$\frac{h}{2\pi}$ / $\frac{0.5h}{2\pi}$

2nd shell $= \frac{2h}{2\pi}$ or $\frac{1h}{\pi}$

3rd shell $= \frac{3h}{2\pi}$ or $\frac{1.5h}{\pi}$

4th shell $= \frac{4h}{2\pi}$ or $\frac{2h}{\pi}$

③ Radius of an orbit: $r_n = \frac{n^2h^2}{4\pi^2 me^2}$

- $r_n = 0.529 \times \frac{n^2}{Z} A^o$

- $r_n = 5.29 \times \frac{n^2}{Z} nm$

$$\boxed{r_n = 0.53 \times \frac{n^2}{Z} A^o}$$

④ Energy of an electron: $T.E = KE + PE$

$E_n = -\frac{2\pi^2 me^4}{n^2h^2}$ $KE = \frac{e^2}{2r}$ $PE = \frac{-e^2}{r}$ $TE = \frac{-e^2}{2r}$

$KE = -TE$ $m = 9.1 \times 10^{-31}$ kg

$PE = 2TE$ $h = 6.62 \times 10^{-34}$ J

★ ① $E_n = -\frac{2.18 \times 10^{-18}}{n^2} \times Z^2$ J/atom

② $E_n = -\frac{2.18 \times 10^{-11}}{n^2} \times Z^2$ erg/atom

③ $E_n = \frac{-1312}{n^2} \times Z^2$ KJ/mole.

★ ④ $E_n = \frac{-13.6}{n^2} \times Z^2$ eV/atom.

⑤ $E_n = \frac{-313.6}{n^2} \times Z^2$ kcal/mole.

- Energy difference Between two shells

$$\Delta E = 2 \times 10^{-18} \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] Z^2 J$$

$$\Delta E = 13.6 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] Z^2 eV$$

① $n = 1$	-13.6 eV	④ $n = 4$	-0.85 eV
② $n = 2$	-3.4 eV	⑤ $n = 5$	-0.53 eV
③ $n = 3$	-1.51 eV	⑥ $n = 6$	-0.38 eV.

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- Hydrogen spectrum :

① H_2 gas kept in a discharge tube apply high voltage 10,000 V and low temp and pressure (0.01 atm).
② Radiation coming (energy released)
③ Some energy used to become H_2 molecules to H-atoms.
④ Remaining energy absorbed by electrons in H.

- Note :

① All electrons can't absorb same energy.
② electrons absorb energy and jump to diff excited states but at excited state electrons are unstable so they return to ground state in a single step or multiple steps.

series	Region	n_1		
Lyman	UV	1	1st line	— H_α
Balmer	visible	2	2nd line	— H_β
Paschen	Near IR	3	3rd line	— H_γ
Brackett	IR	4	4th line	— H_δ
Pfund	Far IR	5	∞th line	— Limiting line of series.

- Rydberg's eq : $\bar{\nu} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] z^2$

$R = 109678\ cm^{-1}$
$R = 1.1 \times 10^5\ cm^{-1}$
$R = 1.1 \times 10^7\ m^{-1}$

- Trick : No. of spectral lines : $\varepsilon n = \varepsilon n_2 - n_1$

- λ longest = λ maxi = λ High $\Rightarrow$ E mini ν mini $\bar{\nu}$ mini
λ shortest = λ mini = λ Low $\Rightarrow$ E max ν max $\bar{\nu}$ max

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- Maximum energy — Minimum energy

Maximum energy	Minimum energy
$n_1 = 1 \longrightarrow n_2 = \infty$	$n_1 = 1 \longrightarrow n_2 = 2$
$n_2 = 2 \longrightarrow n_2 = \infty$	$n_1 = 2 \longrightarrow n_2 = 3$
$n_1 = 3 \longrightarrow n_2 = \infty$	$n_1 = 3 \longrightarrow n_2 = 4$

- Notes :-

① P.q.n $\longrightarrow$ AM of an $e^{\ominus}$ $mvr = nh/2\pi$
A.q.n $\longrightarrow$ AM of an orbital $mvr = \sqrt{l(l+1)}\,\frac{h}{2\pi}$

② Maximum no. of electrons in a shell $= 2n^2$

③ $l = 0 \longrightarrow$ s-subshell (spherically symmetrical)
$l = 1 \longrightarrow$ p-subshell (Dumb-bell)
$l = 2 \longrightarrow$ d-subshell (Double dumb-bell)
$l = 3 \longrightarrow$ f-subshell (complex)

④ no. of subshells in a shell $= n$. $n \rightarrow$ size of orbit

⑤ l values from 0 to $(n-1)$ $l \rightarrow$ shape of subshell
$n = 1 \longrightarrow l = 0 \longrightarrow$ 1s
$n = 2 \longrightarrow l = 0, 1 \longrightarrow$ 2s, 2p
$n = 3 \longrightarrow l = 0, 1, 2 \longrightarrow$ 3s, 3p, 3d.
$n = 4 \longrightarrow l = 0, 1, 2, 3 \longrightarrow$ 4s, 4p, 4d, 4f

⑥ No. of orbitals in a subshell $= (2l+1)$ —— $s = 1\ (2e^{\ominus})$
$p = 3\ (6e^{\ominus})$
$d = 5\ (10e^{\ominus})$
$f = 7\ (14e^{\ominus})$

⑦ No of orbitals in a shell $= n^2$.

⑧ m values $= -l$ ---- 0 ---- $+l$
$l = 0 \rightarrow m = 0$
$l = 1 \rightarrow m = -1, 0, +1$
$l = 2 \rightarrow m = -2, -1, 0, +1, +2$
$l = 3 \rightarrow m = -3, -2, -1, 0, +1, +2, +3$

$s(l=0) \rightarrow m = 0$
$p(l=1) \rightarrow$ P_x P_y P_z
-1 $+1$ 0

$d(l=2) \longrightarrow$ $d_{x^2-y^2}$ d_{z^2}
$+2$ 0

$d(l=2) \rightarrow$ d_{xy} d_{yz} d_{zx}
-2 -1 $+1$

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- Trick: 1s ⟶ 2s

2p 3s ⟶ 3p 4s

3d 4p 5s ⟶ 4d 5p 6s

4f 5d 6p 7s ⟶ 5f 6d 7p 8s

I. AfBau – electrons must enter into lower energy – Higher energy.

- Energy of orbitals calculate by $(n+l)$ value.

① Lower $(n+l)$ value – lower energy

② Higher $(n+l)$ value – Higher energy

③ If $(n+l)$ value is same — Lower n value — Lower energy

Higher n value — Higher energy.

II. Hund's rule: In de-generated orbitals, orbitals first filled with single $e^{\ominus}$ with same spin and then pairing will takes place.

III. Pauli's Exclusion principle: Each orbital filled with 2 electrons with opposite spin. These $2e^{\ominus}$ have different 4 quantum number.

- According to hund's rule, Half-filled or Full-filled degenerated orbitals are stable.

p^3/p^6 d^5/d^{10} f^7/f^{14}

- According to A, H, P rules, anamalous E.C of Cr and Cu

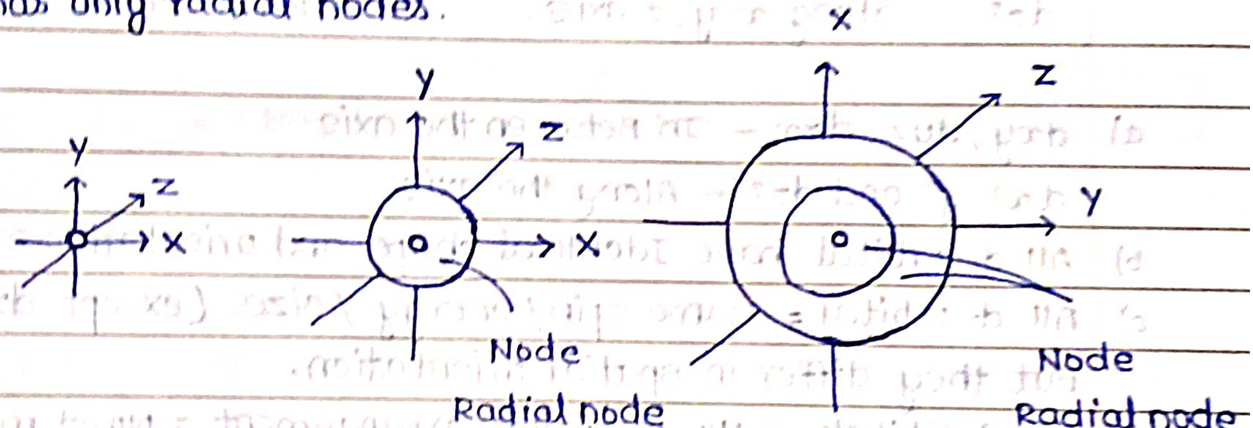
Cr [Z = 24] ⟶ (Ar) $4s^1 3d^5$

Cu [Z = 29] ⟶ (Ar) $4s^1 3d^{10}$

- Orbital - where maximum propobility of finding electrons (95%)
  Node - The point where P.F $e^{\ominus} = 0$ $[n-1]$
  Spherical / Radial node : The spherical space around nucleus where P.F. $e^{\ominus} = 0$ $[n-l-1]$.
  Angular node / nodal plane : The plane where P.F $e^{\ominus} = 0$ $[l]$

- s - orbital

① For s-orbitals $l = 0$ $n = 1, 2, 3, 4, \ldots$ $m = 0$
② s-orbital = spherically symmetrical and non-directional
③ P.F $e^{\ominus}$ symmetrically distributed along x, y, z - axis.
④ It has only radial nodes.



- P- orbital :

① For p-orbital $l = 1$, $n = 2, 3, 4 \ldots$ $m = -1, 0, +1$
② P- orbital = dumb-bell shape / Directional nature.
③

Orbital	Maximum $e^{\ominus}$ density	Nodal plane
P_x	x - axis	yz
P_y	y - axis	xz
P_z	z - axis	xy

④ $2P_x$, $2P_y$, $2P_z$ orbitals ⟶ same shape, same size, same energy, same spin } differ in spatial arrangement.
⑤ No. of orbitals = No. of spatial arrangement = no. of m values = 3

- d-orbitals:

1. For d-orbitals $l = 2$ $n = 3, 4, 5$ $m = -2, -1, 0, +1, +2$
2. Each d-subshell having 5 degenerated orbitals.
3. Each d-orbital = 4 lobes / double dumb-bell except dz^2

Orbital	Maximum PF electrons	Nodal planes
dxy	45° to x and y axis	xy, yz
dyz	45° to y and z axis.	xy, xz
dxz	45° to x and z axis	xy, zy
dx^2-y^2	Along x and y axis	xz, yz
dz^2	along x, y, z axis.	No nodal plane

a) dxy, dyz, dzx – In Between the axis
dx^2-y^2 and dz^2 – Along the axis.

b) All d-orbital have Identical shape and orientation except dz^2

c) All d-orbital = same spin / energy / size (except dz^2)
But they differ in spatial orientation.

d) No. of orbitals = No. of spatial arrangement = No. of m values = 5

- De-Broglie's wave nature concept:

1. Like EMR, All micro or macroscopic particles also having dual nature
2. Means just like photons ⟶ microscopic particle also having wave and particle nature.
3. The wave associated with particle called De-Broglie's wave or matter waves.
4. Every object in motion have wave nature — observed / seen in microscopic particles
— Not seen in macroscopic particles

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⑤ Any moving matter particles has λ and P $\rightarrow$ $\lambda = \frac{h}{P}$

$\downarrow P = mv$

$\lambda de \propto \frac{1}{m \text{ and } v} \longleftarrow \lambda de = \frac{h}{mv}$

- $\lambda = \frac{h}{P}$ $\quad \lambda = \frac{h}{mv}$ $\quad$ • $V = \sqrt{\frac{2KE}{m}}$

$\frac{\lambda_1}{\lambda_2} = \frac{m_2 V_2}{m_1 V_1}$ $\quad \lambda = \frac{h}{\sqrt{2m K\cdot E}}$

$\lambda \propto \frac{1}{\sqrt{KE}}$ $\quad \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{m_2 \cdot KE_2}{m_1 \cdot KE_1}}$

- $\lambda = \frac{h}{\sqrt{2meV}}$

(I) For $e^{\ominus}$ = $\lambda = \frac{12.26}{\sqrt{V}}$ A°

(II) For p = $\lambda = \frac{0.286}{\sqrt{V}}$ A°

(III) For α = $\lambda = \frac{0.101}{\sqrt{V}}$ A°

- Constructive Interference

$2\pi r = n\lambda$

Destructive Interference

$2\pi r \neq n\lambda$

- No. of waves made by the $e^{\ominus}$ in a shell = n.

- Heisenberg Uncertainty principle:

① It is impossible to determine both position and momentum of $e^{\ominus}$ simultaneously and accurately.

② H.U.P — Rules out existance of definite path / Trajectories of $e^{\ominus}$ and other similar particles.

③ H.U.P — Only meant for microscopic particles like $e^{\ominus}$, p, n, α..

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$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi} \qquad \frac{h}{4\pi} = 0.52 \times 10^{-34} \, J$$
$$0.52 \times 10^{-27} \, erg$$

$$\Delta x \cdot \Delta P = \frac{h}{4\pi}$$

$$\Delta x \cdot m \Delta V = \frac{h}{4\pi} \rightarrow \frac{\Delta x_1 \cdot m_1 \Delta V_1}{\Delta x_2 \cdot m_2 \Delta V_2} = \frac{1}{1}$$

$$\frac{\Delta x_1}{\Delta x_2} = \frac{m_2 \Delta V_2}{m_1 \Delta V_1}$$

$$\frac{\Delta V_1}{\Delta V_2} = \frac{m_2 \Delta x_2}{m_1 \Delta x_1}$$

① Δx = Uncertainty in position
Δx = radius x error / accuracy.

② ΔV = Uncertainty in velocity
ΔV = Actual velocity x error / accuracy

• Note : $\Delta x \cdot \Delta P = \frac{h}{4\pi}$

If $\Delta x = \Delta P$

$$(\Delta x)^2 = \frac{h}{4\pi}$$

$$\Delta x = \sqrt{\frac{h}{4\pi}}$$

$$\Delta x = \frac{1}{2}\sqrt{\frac{h}{\pi}}$$

$$\Delta P = \frac{1}{2}\sqrt{\frac{h}{\pi}}$$

$$(\Delta P)^2 = \frac{h}{4\pi}$$

$$(m\Delta V)^2 = \frac{h}{4\pi}$$

$$\Delta V^2 = \frac{h}{4\pi m^2}$$

$$\Delta V = \sqrt{\frac{h}{4 \cdot m^2 \cdot \pi}}$$

$$\Delta V = \frac{1}{2m}\sqrt{\frac{h}{\pi}}$$