FREE NOTES · NCERT + JEE/NEET LEVEL

Structure of Atom

Subatomic particles, Thomson aur Rutherford models, electromagnetic radiation, Planck ki quantum theory aur photoelectric effect, hydrogen spectrum, Bohr model, dual nature aur uncertainty principle, quantum numbers, orbitals aur electronic configuration.

01 Subatomic particles & purane models
02 Atomic number, mass number, isotopes
03 Electromagnetic radiation & Planck
04 Photoelectric effect
05 Bohr model & hydrogen spectrum
06 Dual nature & uncertainty principle
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01 Subatomic particles & purane models

Particle	Kisne khoja	Charge	Mass
Electron	J.J. Thomson (cathode rays); charge Millikan ne (oil drop)	-1.602×10^{-19} C	9.109×10^{-31} kg
Proton	Goldstein (canal rays)	$+1.602 \times 10^{-19}$ C	1.672×10^{-27} kg
Neutron	Chadwick (1932)	0	1.675×10^{-27} kg

Electron ka e/m = 1.758×10^{11} C/kg. Cathode rays cathode se anode seedhi line me chalti aur gas ya electrode pe depend nahi karti.

- **Thomson model:** plum pudding; positive gola jisme electrons ghuse hue. Scattering explain nahi kar paaya.
- **Rutherford ka α-scattering** (sone ki patli parat): zyada tar α seedhe nikal gaye (atom zyada tar khaali), kuch mude, ~20000 me 1 wapas aaya (chhota, ghana, positive **nucleus**).
- Kami: ghoomta electron energy chhod ke nucleus me gir jaana chahiye; stability aur line spectra explain nahi kar paaya.

02 Atomic number, mass number, isotopes

- Atomic number Z = protons; mass number A = protons + neutrons. Notation ${}^{A}_{Z}X$.
- **Isotopes:** same Z, alag A (^{1}H, ^{2}H, ^{3}H). **Isobars:** same A, alag Z (^{14}C, ^{14}N). **Isotones:** neutrons barabar.
- Isoelectronic: electrons barabar (Na^{+}, Mg^{2+}, F^{-}, Ne).

03 Electromagnetic radiation & Planck

$c = \nu\lambda$, wave number $\bar{\nu} = 1/\lambda$

$$E = h\nu = hc/\lambda$$

h = 6.626 × 10^{-34} J s. Energy packets me nikalti ya absorb hoti (**quanta**; light ke liye **photons**). Black body radiation sirf aise hi explain hua.

Spectrum order (λ badhta hua): γ < X < UV < visible (400–750 nm) < IR < microwave < radio.

04 Photoelectric effect

Kaafi zyada frequency ki light metal surface (jaise Cs, K) se electrons nikaal deti.

- **Threshold frequency ν_0** se kam pe electron nahi nikalte, light kitni bhi tez ho.
- Electrons ki kinetic energy frequency pe, electrons ki ginti intensity pe depend.
- Electron turant nikalta.

$$h\nu = h\nu_0 + \tfrac{1}{2} m_e v^2$$

$h\nu_0$ = work function W_0. Einstein ne photons se explain kiya. Light ka dual nature hai (wave aur particle).

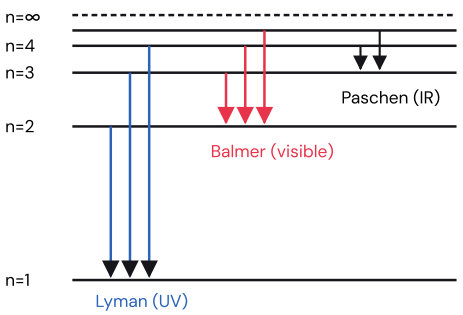
05 Bohr model & hydrogen spectrum

- Electrons fixed circular orbits (stationary states) me bina energy chhode ghoomte.
- Energy sirf orbits ke beech koodne pe li/chhodi jaati: $\Delta E = h\nu$.
- Angular momentum quantised: $mvr = nh/2\pi$.

$$E_n = -2.18 \times 10^{-18}\,(Z^2/n^2)\ \text{J}$$

$$r_n = 52.9\,(n^2/Z)\ \text{pm}$$

$$\bar{\nu} = 109677\,(1/n_1{}^2 - 1/n_2{}^2)\ \text{cm}^{-1}\ \text{(Rydberg)}$$



Hydrogen ki spectral series

Kamiyan: multi-electron atoms pe fail, Zeeman/Stark effect explain nahi, dual nature aur uncertainty ko nazarandaz karta.

Series	n_1	Region
Lyman	1	UV
Balmer	2	Visible
Paschen	3	IR
Brackett / Pfund	4 / 5	IR

Level n se ground tak spectral lines ki ginti: $n(n-1)/2$.

06 Dual nature & uncertainty principle

de Broglie: $\lambda = h/mv = h/p$

Heisenberg: $\Delta x \cdot \Delta p \geq h/4\pi$

Har chalte particle ka wave nature hota (electron microscope me electrons ke liye dikhta; badi cheezon ke liye na ke barabar). Exact position aur momentum ek saath nahi jaan sakte, isliye electrons ke fixed orbits ka matlab nahi ⇒ **orbitals** (probability wale region) ka idea.

07 Quantum numbers & orbitals

Quantum number	Values	Kya batata
Principal n	1, 2, 3 ...	Shell, size aur energy
Azimuthal l	0 se n − 1 (s, p, d, f)	Subshell, shape; angular nodes = l
Magnetic m_l	−l se +l	Orientation; 2l + 1 orbitals
Spin m_s	+½, −½	Electron ka spin

- Shapes: s gol, p dumb-bell (p_x, p_y, p_z), d double dumb-bell (5 orbitals; d_{z^2} alag).
- **Nodes:** radial = n − l − 1; angular = l; total = n − 1. 3p: 1 radial, 1 angular.
- Shell n me max electrons = $2n^2$; subshell me = 2(2l + 1).

08 Bharne ke rules & electronic configuration

- **Aufbau:** orbitals badhti energy ke order me bharo, **(n + l) rule** se; barabar ho to kam n pehle. Order: 1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p 6s 4f 5d 6p ...
- **Pauli exclusion:** do electrons ke chaaron quantum numbers same nahi ho sakte ⇒ ek orbital me max 2, ulte spin ke saath.
- **Hund's rule:** barabar energy wale orbitals me pehle har ek me ek electron (parallel spin), phir pairing.

EXCEPTIONS

Cr: [Ar] $3d^5$ $4s^1$; Cu: [Ar] $3d^{10}$ $4s^1$. Half-filled aur poore bhare subshells extra stable (symmetry aur exchange energy).

09 JEE Extra + Tricks

JEE LEVEL

- Radial nodes = n − l − 1; angular nodes = l; kul = n − 1.
- Spin-only magnetic moment μ = √(n(n + 2)) BM (n = unpaired): 1 → 1.73, 2 → 2.83, 3 → 3.87, 4 → 4.90, 5 → 5.92.
- Configuration ke apvaad: Cr = $[Ar]3d^5 4s^1$, Cu = $[Ar]3d^{10}4s^1$ (half-filled/full stability, exchange energy).
- Heisenberg: Δx·Δp ≥ h/4π; de Broglie λ = h/mv; V se accelerated electron: λ = 12.27/√V Å.
- H-like ke liye Bohr: $E_n = -13.6\ Z^2/n^2$ eV; $r_n = 0.529\ n^2/Z$ Å; n se 1 tak lines = n(n − 1)/2.
- Orbital energy order (n + l rule): kam n + l pehle; barabar ho to kam n pehle.

10 Solved numericals

Q1. λ = 500 nm wale photon ki energy?

$E = hc/\lambda = (6.626 \times 10^{-34} \times 3 \times 10^{8})/(500 \times 10^{-9})$ = **3.98×10^{-19} J**.

Q2. n = 1 se H ko ionise karne ki energy?

$0 - (-2.18 \times 10^{-18})$ = per atom **2.18×10^{-18} J** (13.6 eV).

Q3. 10 m/s pe 0.1 kg ki ball ka de Broglie λ?

$\lambda = 6.626 \times 10^{-34}/(0.1 \times 10)$ = **6.6×10^{-34} m** (itna chhota ki pata hi nahi chalta).

Q4. Na ke aakhri electron ke quantum numbers?

$3s^1$ ⇒ n = 3, l = 0, m = 0, s = +½.

11 Mistakes & practice

- Kehna ki tez light se photoelectrons zyada tez (KE frequency decide karti).
- 4s se pehle 3d bharna (n + l use karo).
- l = n likhna (max n − 1 hai).
- Radial aur angular nodes me confusion.

1. n = 3 me kitne orbitals?
2. H ki kaun si series visible?
3. 3s me radial nodes?
4. Cu ka configuration?
5. Same speed pe kiska de Broglie λ sabse zyada: e^-, p, α?

ANSWERS

1) 9 · 2) Balmer · 3) 2 · 4) [Ar] $3d^{10}$ $4s^1$ · 5) Electron (sabse kam mass)

12 Quick revision: exam se 5 minute pehle

MODELS

- Rutherford: nucleus, khaali jagah.
- Bohr: $E_n = -13.6\ Z^2/n^2$ eV.
- $r_n = 52.9\ n^2/Z$ pm.

LIGHT

- $E = h\nu = hc/\lambda$.
- $h\nu = W_o + KE$.
- Lyman UV, Balmer visible.

QUANTUM

- $\lambda = h/mv$.
- $\Delta x\ \Delta p \geq h/4\pi$.
- n, l (0…n−1), m (−l…+l), s (±½).

BHARNA

- Aufbau (n + l), Pauli, Hund.
- Cr $3d^5 4s^1$, Cu $3d^{10} 4s^1$.
- Nodes: n − l − 1 radial, l angular.

Koi doubt? padhaiadda.netlify.app pe AI Doubt Solver se poocho, ya is chapter ka mock test do.