

CA02 – Structure of Atom & Molecules

→ Chemistry – CA02 · AFCAT General Awareness

AFCAT Level

★ High Priority

Atomic structure is the foundation of all chemistry – understanding what atoms are made of explains why elements behave the way they do. AFCAT tests subatomic particles (charge, mass, location), atomic models, isotopes and isobars, and basic bonding. Expect 1–2 questions from this chapter.

✦ **AFCAT Focus:** Neutrons = $A - Z$ (mass number minus atomic number); Bohr model explained hydrogen spectrum; isotopes = same Z , different A ; ionic bond = metal + non-metal (electron transfer); covalent bond = non-metal + non-metal (electron sharing); hydrogen bonding explains water's high boiling point.

PART 1 – SUBATOMIC PARTICLES

1. Three Subatomic Particles

FIG. 1 – ELECTRON, PROTON AND NEUTRON: DISCOVERER, CHARGE, MASS AND LOCATION

SUBATOMIC PARTICLES — The Building Blocks of Every Atom

Particle	Discoverer	Charge	Relative Mass	Location in atom
Electron e^- (e)	J.J. Thomson 1897	-1	$\approx 1/1836$ of proton ≈ 0	Orbitals / shells around nucleus
Proton p^+ (p)	Goldstein 1886	+1	1 amu	Inside the nucleus
Neutron n^0 (n)	Chadwick 1932	0	≈ 1 amu	Inside the nucleus


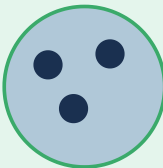
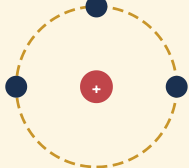

Atomic Number (Z) = Protons = Electrons (neutral atom) | Mass Number (A) = Protons + Neutrons | Neutrons = A - Z

PART 2 — ATOMIC MODELS

2. Four Atomic Models

FIG. 2 — EVOLUTION OF ATOMIC MODELS: EACH MODEL FIXED THE FLAW OF THE PREVIOUS

ATOMIC MODELS — How Each Model Improved Understanding

DALTON (1803)	THOMSON (1897)	RUTHERFORD (1911)	BOHR (1913)
Billiard Ball	Plum Pudding	Nuclear Model	Quantised Shells
 <p style="text-align: center;">Atom</p>	 <p style="text-align: center;">e^- in +ve sphere</p>	 <p style="text-align: center;">Electrons orbit nucleus</p>	 <p style="text-align: center;">Fixed orbits; no radiation</p>
<p>Atom = solid, indivisible sphere. Each element has unique atoms.</p> <hr/> <p>✓ First atomic theory (laws)</p> <hr/> <p>✗ Atom is actually divisible</p>	<p>Electrons embedded in a diffuse positive sphere.</p> <hr/> <p>✓ Explained charge neutrality</p> <hr/> <p>✗ Could not explain Rutherford scattering expt</p>	<p>Tiny positive nucleus; electrons orbit at large distances.</p> <hr/> <p>✓ Discovered nucleus</p> <hr/> <p>✗ Electrons should spiral into nucleus</p>	<p>Electrons in fixed energy shells (orbits). No radiation in orbit.</p> <hr/> <p>✓ Explained H spectrum ✓ Atomic stability</p> <hr/> <p>✗ Fails for multi-e^- atoms</p>

PART 3 — ISOTOPES, ISOBARS & BONDING

3. Isotopes, Isobars and Isotones

FIG. 3 – ISOTOPES VS ISOBARS VS ISOTONES: WHAT THEY SHARE, WHAT THEY DON'T

ISOTOPES vs ISOBARS vs ISOTONES			
Term	SAME	DIFFERENT	Example
ISOTOPES Same element	Atomic Number (Z)	Mass Number (A)	^1H , ^2H (D), ^3H (T) ^{12}C , ^{13}C , ^{14}C (Z=6)
ISOBARS Different elements	Mass Number (A)	Atomic Number (Z)	^{40}Ca and ^{40}Ar A=40; Z differs
ISOTONES Different elements	Neutron Count ($n = A - Z$ same)	Z and A both differ	^{14}C (8n) and ^{15}N (8n) both have 8 neutrons

4. Chemical Bonding & Hydrogen Bonding

► Ionic Bond

- ▶ Metal GIVES electrons to non-metal
- ▶ Forms ions: cation (+) and anion (-)
- ▶ Strong electrostatic attraction between ions
- ▶ High melting point; conducts when dissolved/melted
- ▶ Examples: NaCl, MgO, CaF₂, KCl, AlCl₃

► Covalent Bond

- ▶ Non-metal SHARES electrons with non-metal
- ▶ Single (H₂), Double (O₂), or Triple (N₂) bonds
- ▶ Low melting point; usually poor conductors
- ▶ Examples: H₂O, CO₂, CH₄, HCl, NH₃
- ▶ Polar covalent: electrons shared unequally (H₂O, HCl)

Hydrogen Bonding (AFCAT Favourite Question):

A hydrogen bond forms when H is covalently bonded to a highly electronegative atom (F,

O, or N) and is attracted to another F, O, or N nearby.

- **Why water has an unusually high boiling point** (100°C) compared to H₂S (-60°C):

Water molecules form strong hydrogen bonds with each other. More energy is needed to break them → higher boiling point.

- Other effects: high surface tension of water; DNA structure (holds two strands together); protein folding.
- **Strongest hydrogen bond:** H—F > H—O > H—N



AFCAT PYQs – Atomic Structure

Q1. Which atomic model successfully explained the hydrogen emission spectrum? AFCAT PYQ

- (a) Dalton's model (b) Thomson's model (c) Rutherford's model
(d) Bohr's model

✓ Answer: (d) Bohr's model

Bohr (1913) proposed that electrons exist in fixed, quantised energy orbits. When an electron jumps from a higher to a lower orbit, it emits a photon of specific energy (= specific colour/wavelength). This perfectly predicted the hydrogen spectrum (Balmer series in visible range). Rutherford's model had electrons spiralling and continuously emitting radiation – which contradicted the observed discrete line spectrum.

Q2. An atom has atomic number $Z = 17$ and mass number $A = 35$. Number of neutrons is: AFCAT PYQ

- (a) 17 (b) 35 (c) 18 (d) 52

✓ Answer: (c) 18

Neutrons = Mass number - Atomic number = $35 - 17 = 18$. This is Chlorine-35 (²⁵Cl). It has 17 protons, 18 neutrons, and (in a neutral atom) 17 electrons. The formula Neutrons = $A - Z$ is one of the most directly tested atomic structure calculations in AFCAT and CDS both.

Q3. Isotopes of an element have the same: AFCAT PYQ

- (a) Mass number (b) Atomic number (c) Number of neutrons (d) Atomic mass

✓ Answer: (b) Atomic number

Isotopes are atoms of the same element — same atomic number ($Z = \text{protons}$) but different mass numbers ($A = \text{protons} + \text{neutrons}$). They have identical chemical properties (same electrons, same bonding) but different physical properties (different masses). Example: ^{12}C (6 protons, 6 neutrons) and ^{14}C (6 protons, 8 neutrons).

Q4. Water has an anomalously high boiling point because of:

AFCAT PYQ

- (a) Ionic bonding (b) Metallic bonding (c) Hydrogen bonding
(d) Van der Waals forces

✓ Answer: (c) Hydrogen bonding

H_2O boils at 100°C while H_2S (heavier, similar structure) boils at -60°C . This anomaly is due to strong **hydrogen bonding** between water molecules — the highly electronegative O pulls electron density from H, leaving H partially positive and attracted to the O of neighbouring molecules. Extra energy is needed to break these bonds, raising the boiling point significantly.

🧠 Quick Memory Chart — CA02

🌀 Particles

- ♦ e^- : Thomson (1897), charge -1
- ♦ p^+ : Goldstein (1886), charge +1
- ♦ n^0 : Chadwick (1932), neutral
- ♦ $Z = \text{protons} = \text{electrons}$ (neutral)
- ♦ **Neutrons = $A - Z$**

🧪 Models

- ♦ Dalton: solid sphere (no subparticles)
- ♦ Thomson: plum pudding
- ♦ Rutherford: discovered nucleus (1911)
- ♦ Bohr: quantised orbits; H spectrum ✓
- ♦ Bohr fails for multi-electron atoms

📌 Bonding

- ♦ Ionic: metal+non-metal (e^- transfer)
- ♦ Covalent: non-metal+non-metal (sharing)
- ♦ H-bond: only with F, O, N
- ♦ H-bond: explains water's high BP
- ♦ Strongest H-bond: H—F

Practice Exercise

E1. An element has $Z=11$ (sodium). Its electron configuration is:

- (a) 2,8 (b) 2,8,1 (c) 2,9 (d) 3,8

E2. Which of these is an example of a covalent compound?

- (a) NaCl (b) MgO (c) H₂O (d) CaF₂

E3. Two atoms ¹²C and ¹⁴C are:

- (a) Isobars (b) Isotones (c) Isotopes (d) Isomers

E4. The maximum electrons in the 3rd shell ($n=3$) of an atom is:

- (a) 8 (b) 18 (c) 32 (d) 2

Answers:

E1 → (b) 2,8,1 [Shell 1=2, Shell 2=8, Shell 3=1; uses $2n^2$ rule: max in shell 1=2, shell 2=8] | E2 → (c) H₂O [O and H are both non-metals; they share electrons] | E3 → (c) Isotopes [same $Z=6$; different A (12 and 14)] | E4 → (b) 18 [$2n^2 = 2 \times 3^2 = 18$]

 **Mock Tests**

 **Subject Quiz**

 **Telegram**

This material is for personal AFCAT exam preparation only.

Unauthorised reproduction or distribution is prohibited.

All rights reserved · ODEA.Classes@gmail.com · OliveDefence.com