CN01 — Basic Concepts of Chemistry

📖 Chapter CN01 · NDA Class 11–12 Level

🎯 NDA Level : High Priority

Basic Concepts is the foundation of all chemistry. Questions on matter classification, laws of chemical combination, and mole concept appear consistently in NDA. Average students who can recognise elements vs compounds, apply the mole formula confidently, and recall the laws of conservation can solve most of these questions with straightforward calculation.

📌 **What to expect in NDA (based on 2022–2025 pattern):**
(1) Physical vs chemical changes; properties of states of matter;
(2) Elements, compounds, mixtures — classification and separation methods;
(3) Chemical symbols, formulae, and balancing equations;
(4) Laws of Chemical Combination — conservation of mass, constant proportions, multiple proportions;
(5) Mole concept — molar mass, Avogadro's number (6.022×10^{23}), stoichiometry calculations.

Topics at a Glance

① Matter & Its Changes
States, physical & chemical changes, properties

② Elements, Compounds & Mixtures
Classification, separation techniques

③ Symbols, Formulae & Equations
Valency, balancing, symbols of elements

④ Laws of Chemical Combination
Conservation, constant proportions, multiple proportions

⑤ Mole Concept
Atomic/molecular weight, molar mass,

Avogadro, stoichiometry

1. Matter and Its Changes

1.1 States of Matter — Solid, Liquid, Gas

Everything around us is matter — it has mass and occupies space

Matter exists in three physical states. The difference lies in the arrangement and energy of particles. Temperature and pressure determine the state of a given substance.

Property	Solid	Liquid	Gas
Shape	Definite	No definite (takes container shape)	No definite
Volume	Definite	Definite	No definite (fills container)
Particle arrangement	Closely packed, ordered	Close but disordered	Far apart, random
Intermolecular forces	Very strong	Moderate	Very weak
Compressibility	Negligible	Very low	High
Examples	Iron, ice, NaCl	Water, mercury, ethanol	O_2, CO_2, steam

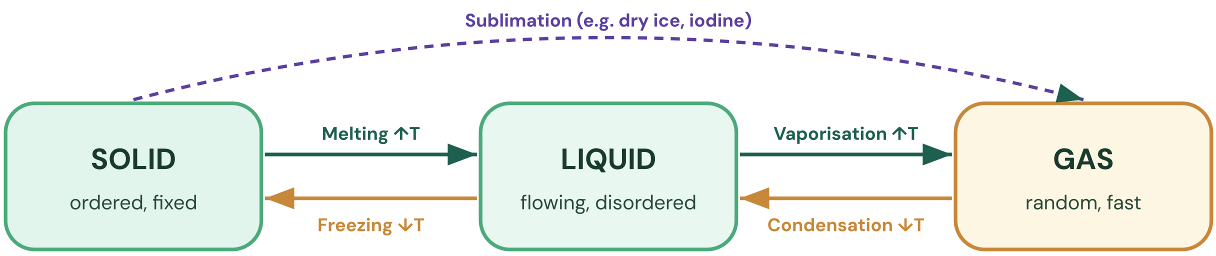

Fig. 1 — State changes and the names for each transition (heating = green arrows; cooling = orange arrows)

Physical Changes

- No new substance formed; original can be recovered
- Change of state: melting, boiling, freezing

Chemical Changes

- New substance(s) formed with different properties
- Generally irreversible (unless by another reaction)

- Dissolving sugar in water (physical, reversible)
- Cutting, shaping, stretching a material
- **Key test:** composition remains same

- Burning wood, rusting of iron, cooking food
- Signs: colour change, gas evolved, precipitate, heat/light
- **Key test:** chemical composition changes

2. Elements, Compounds, and Mixtures

2.1 Classification of Matter

Pure substances vs mixtures — the most-tested distinction in NDA Chemistry

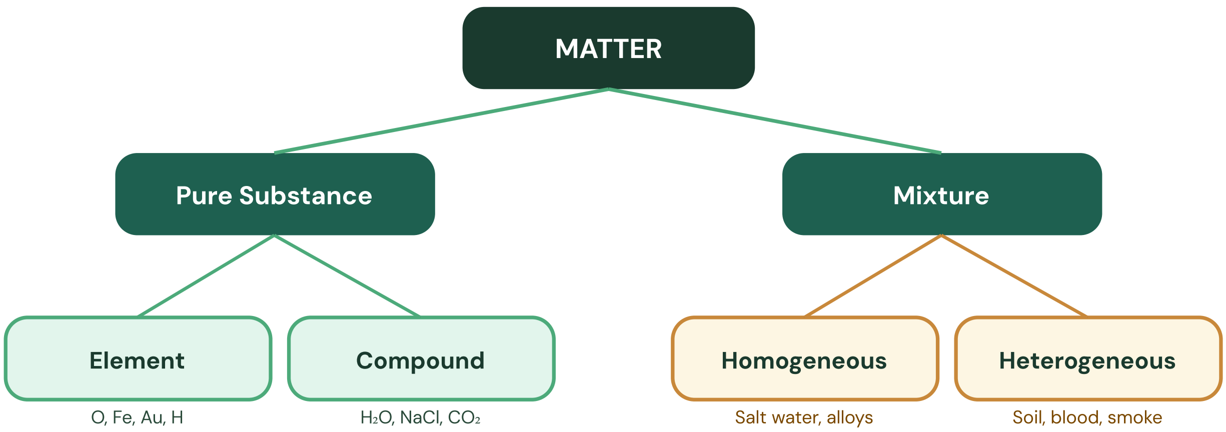

Fig. 2 — Classification of Matter: Pure substances vs Mixtures

⚛ Elements

- Made of only **one type of atom**
- Cannot be broken down by chemical means
- 118 known elements (92 natural)
- Examples: H, O, Fe, Au, Na, Cu, Cl
- Metals, non-metals, metalloids

🔬 Compounds

- Two or more elements **chemically combined**
- Fixed ratio by mass; can be broken by chemical methods
- Properties differ from constituent elements
- H_2O (H:O = 1:8 by mass); NaCl; CO_2; H_2SO_4

🔄 Mixtures

- Components **not chemically combined**; variable ratio
- Each component retains its own properties
- Separated by physical methods
- Homogeneous: uniform throughout (alloys, air, sea water)

- Na is soft metal + Cl_2 is toxic gas → NaCl is edible salt

- Heterogeneous: non-uniform (soil, smoke, blood)

📋 **Separation Methods (NDA-tested):**

Filtration — separates insoluble solid from liquid (sand from water)

Distillation — separates liquids of different boiling points (alcohol-water)

Crystallisation — purifies soluble solids (salt, sugar from impure solution)

Chromatography — separates dyes/pigments based on differential adsorption

Magnetic separation — iron filings from non-magnetic mixture

Centrifugation — cream from milk (different densities)

📝 TOPIC-WISE PYQ

Matter Classification & Changes — NDA Pattern Questions

Q1. Which of the following is a pure substance?

(a) Air (b) Sea water (c) Carbon dioxide (d) Steel

Answer: (c) Carbon dioxide (CO_2)

CO_2 is a compound — a pure substance with fixed composition (C:O = 3:8 by mass). Air is a homogeneous mixture of N_2, O_2, Ar etc. Sea water is a heterogeneous mixture. Steel is an alloy (mixture of iron, carbon, and other metals).

Q2. Rusting of iron is a —

(a) Physical change (b) Chemical change (c) Both physical and chemical (d) None of the above

Answer: (b) Chemical change

Rusting: $4Fe + 3O_2 + 6H_2O \rightarrow 4Fe(OH)_3$. A new substance (iron oxide/hydroxide) is formed. The composition changes permanently — this is irreversible without chemical treatment. Signals: change in colour and physical properties.

Q3. Which separation technique is used to separate cream from milk?

(a) Filtration (b) Distillation (c) Centrifugation (d) Sublimation

Answer: (c) Centrifugation
Centrifugation separates components of different densities by spinning at high speed. Cream (fat) is less dense than the aqueous part of milk; spinning makes the denser component settle outward. Used in dairies, blood banks, and laboratories.

3. Symbols, Chemical Formulae & Balancing Equations

3.1 Chemical Symbols and Common Elements

IUPAC symbols — many are from Latin names (must memorise)

Element	Symbol	Origin	Atomic No.	Valency
Sodium	**Na**	Natrium (Latin)	11	+1
Potassium	**K**	Kalium (Latin)	19	+1
Iron	**Fe**	Ferrum (Latin)	26	+2, +3
Copper	**Cu**	Cuprum (Latin)	29	+1, +2
Gold	**Au**	Aurum (Latin)	79	+1, +3
Silver	**Ag**	Argentum (Latin)	47	+1
Lead	**Pb**	Plumbum (Latin)	82	+2, +4
Mercury	**Hg**	Hydrargyrum	80	+1, +2
Tungsten	**W**	Wolfram (German)	74	+6
Tin	**Sn**	Stannum (Latin)	50	+2, +4

📌 **NDA Trap — Symbols from Latin:** Na, K, Fe, Cu, Au, Ag, Pb, Hg, W, Sn — these 10 non-obvious symbols appear repeatedly in NDA. The rest (C, H, O, N, Cl, Ca, Mg, Al, Si, P, S, Zn, Br, I) match the English name and are straightforward.

3.2 Valency, Chemical Formulae & Balancing Equations

Writing and balancing equations — a tested skill in NDA

Valency is the combining capacity of an element — the number of electrons it donates, accepts, or shares to form bonds. Chemical formulae are written using the cross-valency method.

📈 Common Valencies

- +1: Na, K, H, Li, Ag, NH_4^+
- +2: Ca, Mg, Fe^{2+}, Cu^{2+}, Zn, Pb^{2+}, Ba
- +3: Al, Fe^{3+}, Cr^{3+}
- −1: Cl, F, Br, I, OH^-, NO_3^-
- −2: O, S^{2-}, SO_4^{2-}, CO_3^{2-}
- −3: N^{3-}, PO_4^{3-}

📋 Writing Formulae (Cross Method)

- Aluminium sulfate: $Al^{3+} + SO_4^{2-} \rightarrow Al_2(SO_4)_3$
- Calcium chloride: $Ca^{2+} + Cl^- \rightarrow CaCl_2$
- Iron(III) oxide: $Fe^{3+} + O^{2-} \rightarrow Fe_2O_3$
- Magnesium nitrate: $Mg^{2+} + NO_3^- \rightarrow Mg(NO_3)_2$
- Sodium carbonate: $Na^+ + CO_3^{2-} \rightarrow Na_2CO_3$

🔧 **Balancing Equations — Hit & Trial Method (NDA approach):**

Step 1: Write unbalanced equation with correct formulae.

Step 2: Count atoms of each element on both sides.

Step 3: Add coefficients (whole numbers) to balance — never change subscripts.

Step 4: Verify: atoms equal on both sides; coefficients in lowest ratio.

Example: Burning of magnesium: $Mg + O_2 \rightarrow MgO$ (unbalanced)

→ **$2Mg + O_2 \rightarrow 2MgO$** (balanced: 2 Mg, 2 O on each side) ✓

📝 NDA-STYLE BALANCING EXAMPLES

1. **Electrolysis of water:** $2H_2O \rightarrow 2H_2 + O_2$
2. **Burning of methane:** $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
3. **Formation of ammonia (Haber):** $N_2 + 3H_2 \rightleftharpoons 2NH_3$
4. **Iron + steam:** $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$
5. **Photosynthesis:** $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

🧠 TRICKY QUESTIONS **Symbols, Formulae & Equations — Watch Out!**

Q. The chemical formula of rust is often stated as Fe_2O_3. What is its correct hydrated form?

Answer: $Fe_2O_3 \cdot xH_2O$ (hydrated iron(III) oxide)
Rust is not simply Fe_2O_3. The actual product is **hydrated iron(III) oxide**, $Fe_2O_3 \cdot xH_2O$, where x varies. This is why iron rusts faster in humid environments — water is a reactant, not just a medium. NDA sometimes tests whether students know rust is hydrated. Plain Fe_2O_3 is iron(III) oxide but *anhydrous*.

Q. While balancing $2H_2 + O_2 \rightarrow 2H_2O$, a student changed O_2 to O to balance oxygen. Is this correct?

Answer: No — Never change subscripts while balancing.
O_2 means two oxygen atoms bonded together — its molecular formula is fixed. Changing O_2 to O would describe a different substance (monatomic oxygen, which exists only in plasma). Balancing is *only* done by changing **coefficients** (the numbers in front of formulae). The correct balanced equation stays as $2H_2 + O_2 \rightarrow 2H_2O$.

4. Laws of Chemical Combination

4.1 The Three Fundamental Laws

Basis of quantitative chemistry — frequently tested in NDA statement-based MCQs

⚛ LAWS OF CHEMICAL COMBINATION — SUMMARY

LAW 1 — Conservation of Mass (Lavoisier, 1789):
"In any chemical reaction, total mass of reactants = total mass of products"
Example: $2H_2 + O_2 \rightarrow 2H_2O$
$4g\ H_2 + 32g\ O_2 = 36g\ H_2O$ ✓ (mass conserved)
KEY: This is the basis of stoichiometry — "matter is neither created nor

destroyed"

LAW 2 — Constant (Definite) Proportions (Proust, 1799):

"A compound always contains same elements in same ratio by mass, regardless of source"

Example: H_2O always has H:O = 1:8 by mass — whether from river, ocean or lab

KEY: If ratio changes → different compound (H_2O_2 has H:O = 1:16)

LAW 3 — Multiple Proportions (Dalton, 1803):

"When two elements form more than one compound, masses of one element that combine with fixed mass of the other are in simple whole number ratios"

Example: CO and CO_2 both contain C and O

Fix Carbon = 12g → O in CO = 16g; O in CO_2 = 32g → Ratio = 16:32 = 1:2 (simple!)

Gay-Lussac's Law (bonus): Gases combine in simple volume ratios at same T and P. H_2:O_2:H_2O = 2:1:2 by volume. Avogadro's Hypothesis extends this to explain molecular formulae.

📌 Law 1 — Conservation of Mass

- Proposed by **Lavoisier** (1789)
- Verified in open and closed systems
- Holds for all ordinary chemical reactions
- Does NOT hold for nuclear reactions (mass↔energy)
- NDA: "burning wood loses mass" — FALSE (gases escape)

📌 Law 2 — Constant Proportions

- Proposed by **Proust** (1799)
- Also called Law of Definite Proportions
- H_2O: H:O = 1:8 by mass — always
- CO_2: C:O = 3:8 by mass — always
- Source of sample does not matter

📌 Law 3 — Multiple Proportions

- Proposed by **Dalton** (1803)
- Only for pairs of compounds from same elements
- CO vs CO_2: O ratio = 1:2
- NO vs NO_2: O ratio = 1:2
- SO_2 vs SO_3: O ratio = 2:3

TOPIC-WISE PYQ **Laws of Chemical Combination — NDA Pattern Questions**

Q1. 5.6 g of iron reacts with sulphur to give 8.8 g of iron sulphide. What mass of sulphur is consumed?

(a) 2.2 g (b) 3.2 g (c) 4.4 g (d) 14.4 g

Answer: (b) 3.2 g
By **Law of Conservation of Mass**: mass of reactants = mass of products.
Mass of S = mass of product − mass of Fe = 8.8 − 5.6 = **3.2 g**

Q2. Carbon combines with oxygen to form CO and CO_2. If 12 g of carbon combines with 16 g oxygen in CO, how much oxygen combines with the same carbon in CO_2?

(a) 16 g (b) 24 g (c) 32 g (d) 48 g

Answer: (c) 32 g
Law of **Multiple Proportions**: the ratio of oxygen combining with fixed carbon must be a simple whole number ratio (1:2). If CO has 16 g O per 12 g C, then CO_2 must have 2 × 16 = **32 g** of O per 12 g C. Ratio = 16:32 = 1:2. ✓

Q3. Water obtained from a river and from electrolysis of acid always has the same ratio of H:O by mass. This illustrates:

(a) Law of Conservation of Mass (b) Law of Constant Proportions (c) Law of Multiple Proportions (d) Gay-Lussac's Law

Answer: (b) Law of Constant Proportions
Proust's law states that a compound always has the same fixed composition by mass regardless of its source or method of preparation. H_2O: H:O = 1:8 by mass — always, everywhere. This is distinct from Law 3 (multiple proportions), which deals with *different* compounds of the same elements.

TRICKY QUESTIONS **Laws of Chemical Combination — Conceptual Traps**

Q. When magnesium burns in air, the ash (MgO) appears lighter than the original magnesium strip. Does this violate the Law of Conservation of Mass?

Answer: No — the law is NOT violated.
The *apparent* decrease in mass is because students forget that oxygen from the **air** is a reactant: $2Mg + O_2 \rightarrow 2MgO$. The MgO formed is actually heavier than the original Mg. The ash may appear to scatter or some may rise as smoke — but if all products (including MgO smoke particles) are collected, total mass equals Mg + O_2 consumed. This is a classic NDA conceptual trap.

5. Mole Concept & Stoichiometry

5.1 Atomic Weight, Molecular Weight & Molar Mass

The bridge between atoms/molecules and measurable grams

Atoms are too tiny to count individually, so chemists use the **mole** as a counting unit — like a "dozen" for atoms. One mole = 6.022×10^{23} particles (Avogadro's number, N_A). The molar mass (in g/mol) numerically equals the atomic or molecular weight in amu.

MOLE CONCEPT — CORE FORMULAE

Avogadro's Number: $N_a = 6.022 \times 10^{23}\ mol^{-1}$

Number of moles: n = Given mass (g) / Molar mass (g/mol)

n = Number of particles / N_a

n = Volume at STP (L) / 22.4 L (for gases only, STP = 0°C, 1 atm)

Number of particles: $N = n \times N_a$

Mass from moles: Mass = n × Molar mass

Molecular mass: Sum of atomic masses of all atoms in the formula

Example: H_2SO_4 = 2(1) + 32 + 4(16) = 2 + 32 + 64 = 98 g/mol

Percentage composition:

% of element X = (mass of X in 1 mol of compound / molar mass) × 100

Example: % O in H_2O = (16/18) × 100 = 88.9%

At STP (Standard Temperature and Pressure): 1 mole of any gas occupies **22.4 litres**. This is called the molar volume. At SATP (25°C, 1 bar) it is 24.8 L — NDA uses 22.4 L unless stated otherwise.

🔮 Common Molar Masses (memorise)

- H = 1, C = 12, N = 14, O = 16, Na = 23
- Mg = 24, Al = 27, S = 32, Cl = 35.5, K = 39
- Ca = 40, Fe = 56, Cu = 63.5, Zn = 65
- H_2O = 18; CO_2 = 44; NaCl = 58.5
- NH_3 = 17; H_2SO_4 = 98; $CaCO_3$ = 100

⚛ Stoichiometry Approach

- Write balanced equation first
- Mole ratio from coefficients is the key
- Convert given quantity to moles → use ratio → convert to required unit
- $N_2 + 3H_2 \rightarrow 2NH_3$: 1 mol N_2 gives 2 mol NH_3
- Check: use limiting reagent if two reactants given

📝 TOPIC-WISE PYQ

Mole Concept — NDA Pattern Questions

Q1. How many molecules are present in 18 g of water?

(a) 6.022×10^{23} (b) 3.011×10^{23} (c) 12.044×10^{23} (d) 1.8×10^{23}

Answer: (a) 6.022×10^{23}

Molar mass of H_2O = 18 g/mol. 18 g of H_2O = 18/18 = **1 mole**.

Number of molecules = 1 × 6.022×10^{23} = **6.022×10^{23}**.

Q2. What volume (at STP) is occupied by 44 g of carbon dioxide?

(a) 11.2 L (b) 22.4 L (c) 44.8 L (d) 4.4 L

Answer: (b) 22.4 L

Molar mass of CO_2 = 12 + 16×2 = 44 g/mol. Moles = 44/44 = 1 mol.

At STP, 1 mol of any gas = **22.4 L**.

Q3. How many moles of H_2 are required to completely react with 1 mole of N_2 to form NH_3? ($N_2 + 3H_2 \rightarrow 2NH_3$)

(a) 1 mol (b) 2 mol (c) 3 mol (d) 6 mol

Answer: (c) 3 mol

The balanced equation $N_2 + 3H_2 \rightarrow 2NH_3$ shows the mole ratio directly: 1 mol N_2 reacts with **3 mol H_2** to give 2 mol NH_3. Mole ratios from balanced equations are the foundation of all stoichiometry — always write the balanced equation first.

Q4. The percentage by mass of oxygen in H_2SO_4 (molar mass = 98 g/mol) is approximately:

(a) 32.7% (b) 49.1% (c) 65.3% (d) 16%

Answer: (c) 65.3%

H_2SO_4: mass of O = 4 × 16 = 64 g/mol.

% O = (64/98) × 100 = **65.3%**.

For reference: % S = (32/98)×100 = 32.7%; % H = (2/98)×100 = 2.04%.

TRICKY QUESTIONS

Mole Concept — Classic NDA Calculation Traps

Q. 1 mole of N_2 and 1 mole of O_2 are mixed. Which statement is correct?
(a) Both have same number of molecules (b) Both have same mass (c) Both occupy same volume at STP (d) Both (a) and (c)

Answer: (d) Both (a) and (c)

1 mole of ANY substance contains the same number of particles = 6.022×10^{23}. ✓

1 mole of ANY gas at STP occupies 22.4 L. ✓

But masses differ: N_2 = 28 g/mol; O_2 = 32 g/mol. So (b) is FALSE.

This question tests whether students confuse moles (fixed count) with mass (element-specific).

Q. How many atoms are in 1 mole of CO_2?

Answer: 3 × 6.022 × 10^{23} = 18.066 × 10^{23} atoms

Common trap: students answer 6.022 × 10^{23} — that's the number of *molecules*. But each CO_2 molecule has **3 atoms** (1 C + 2 O). So total atoms = 3 × N_a. Always distinguish between molecules and atoms when moles are given.

📄 CN01 Formula & Fact Sheet — Quick Reference

⚛ Matter & Changes

- Physical change: no new substance, reversible
- Chemical change: new substance, mostly irreversible
- Solid → Liquid: Melting (↑T)
- Liquid → Gas: Vaporisation (↑T)
- Solid → Gas: Sublimation (e.g. dry ice, iodine, camphor)

🔄 Pure Substances vs Mixtures

- Element: one type of atom (e.g. H, O, Fe)
- Compound: fixed ratio, chemical combination (e.g. H_2O)
- Homogeneous mixture: uniform (air, alloys, sea water)
- Heterogeneous mixture: non-uniform (soil, blood, smoke)
- Separation: filtration, distillation, centrifugation, chromatography

⚡ Laws of Chemical Combination

- Conservation of Mass (Lavoisier): mass reactants = mass products
- Constant Proportions (Proust): fixed ratio by mass in compound
- Multiple Proportions (Dalton): simple whole number ratio of masses
- $CO:CO_2$ — oxygen ratio = 1:2 (for fixed mass of carbon)
- Exception: nuclear reactions violate mass conservation

🔮 Mole Concept Formulae

- $N_a = 6.022 \times 10^{23}\ mol^{-1}$
- n = mass / molar mass
- n = particles / N_a
- n = volume at STP / 22.4
- % composition = (mass of element / molar mass) × 100

🔋 Key Molar Masses (g/mol)

📌 Latin Symbol Traps

- H_2O = 18; CO_2 = 44; O_2 = 32; N_2 = 28
- NaCl = 58.5; NH_3 = 17; HCl = 36.5
- H_2SO_4 = 98; NaOH = 40; $CaCO_3$ = 100
- CH_4 = 16; $C_6H_{12}O_6$ (glucose) = 180
- $Ca(OH)_2$ = 74; Na_2CO_3 = 106

- Na (Natrium) = Sodium; K (Kalium) = Potassium
- Fe (Ferrum) = Iron; Cu (Cuprum) = Copper
- Au (Aurum) = Gold; Ag (Argentum) = Silver
- Pb (Plumbum) = Lead; Hg (Hydrargyrum) = Mercury
- W (Wolfram) = Tungsten; Sn (Stannum) = Tin

⚡ Quick Revision Booster — CN01 Basic Concepts

🔋 Matter Classification

- Pure substance = element OR compound (fixed composition)
- Mixture = variable composition, physical separation
- Air = homogeneous mixture (NOT a compound)
- Alloys = mixtures (not compounds)
- Diamond & graphite = both pure carbon (allotropes)

🔬 Physical vs Chemical

- Dissolving sugar = physical (solute recoverable)
- Burning = chemical (CO_2 + H_2O formed)
- Electrolysis of water = chemical ($H_2O \rightarrow H_2 + O_2$)
- Melting ice = physical (same H_2O molecules)
- Fermentation = chemical (new products formed)

📝 Law Shortcuts

- Lavoisier → Conservation (same total mass)
- Proust → Constant Proportions (same compound, same ratio)
- Dalton → Multiple Proportions (different compounds, whole ratios)
- Gay-Lussac → Gas volumes (simple ratios at same T, P)
- Avogadro → Equal volumes of gases = equal molecules at same T, P

🔮 Mole Shortcuts

- 18 g H_2O = 1 mol = 6.022×10^{23} molecules

📈 Balancing Tips

- Never change subscripts — only coefficients

🚨 Common Traps

- Air is a mixture — not a compound (cannot

- 22.4 L of any gas at STP = 1 mol
- 1 mol CO_2 contains 3 × N_a atoms (not 1 × N_a)
- Moles × molar mass = grams (always)
- Same moles → same number of molecules (different masses)

- Balance metals first, then non-metals, H and O last
- Reduce coefficients to lowest whole number ratio
- Fractions allowed temporarily — then multiply through
- Check both sides atom by atom before finalising

be expressed as formula)

- Rust is $Fe_2O_3 \cdot xH_2O$ — not just Fe_2O_3
- Burning magnesium: MgO is heavier than Mg (O added from air)
- 1 mole of N_2 has $2N_a$ atoms (diatomic!)
- $CaCO_3$ = 100 g/mol → simplest stoichiometry standard

📝 Mock Tests 🎯 Subject Quizzes ✈️ Telegram