🔷 3.1 Ancient Ideas About Matter

🧠 Indian & Greek philosophers long ago believed that matter is made of tiny invisible particles.

- Maharishi Kanad (India) called them "Parmanu" — he said if we keep dividing matter, we'll reach a stage where particles can't be divided further.
- Democritus (Greece) called these particles "atomos" (meaning indivisible).

🟩 These ideas were philosophical, not based on experiments.

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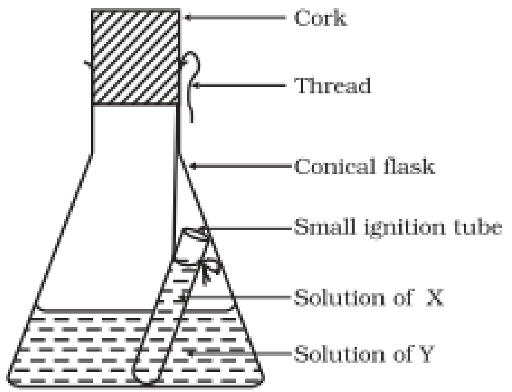
🔷 3.1.1 Law of Conservation of Mass

📘 Definition:
Mass can neither be created nor destroyed in a chemical reaction.
Total mass of reactants = Total mass of products

🧪 Activity 3.1:

- Prepare two solutions: X (e.g. barium chloride) and Y (e.g. sodium sulphate).
- Put solution Y in a flask, hang solution X in a test tube inside it without mixing.
- Weigh the setup → Then mix both and weigh again.

📍 Observation:
Weight remains the same before and after mixing → proves law of conservation of mass.



📷 *Fig. 3.1 – Reaction setup in conical flask*

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🔷 3.1.2 Law of Constant (Definite) Proportions

📘 Definition:
A given compound always contains its elements in a fixed ratio by mass, regardless of its source.

Examples:

- Water → H : O = 1 : 8 by mass
- Ammonia → N : H = 14 : 3 by mass

💡 Stated by Joseph Proust.

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🔷 3.1.3 Dalton's Atomic Theory

📘 **Definition:**
John Dalton's theory explained laws of chemical combinations using the idea of atoms.

🟩 **Postulates:**

1. All matter is made of tiny particles called atoms.
2. Atoms are indivisible and indestructible (not true now).
3. All atoms of a given element are identical.
4. Atoms of different elements have different masses.
5. Atoms combine in simple whole-number ratios.
6. In a compound, atoms are present in fixed ratios.

📷 Image – John Dalton

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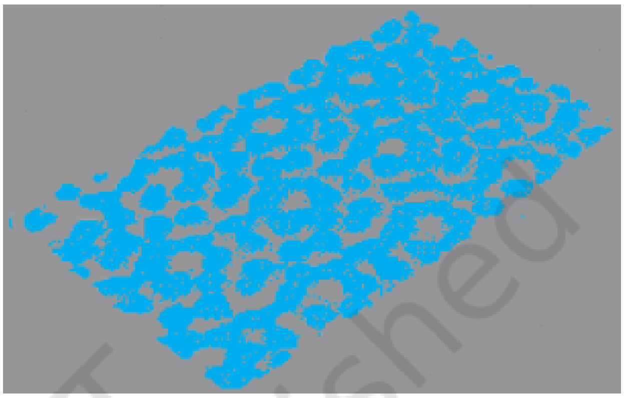
🔷 3.2 What is an Atom?

📘 **Definition:**
An atom is the smallest particle of an element that takes part in a chemical reaction.

💡 Atoms are extremely small — 1 nm = 1/1,000,000,000 m
Hydrogen atom radius ≈ 10^{-10} m



📷 Fig. 3.2 – Atomic sizes and comparison (e.g. ant, sand grain, atom)

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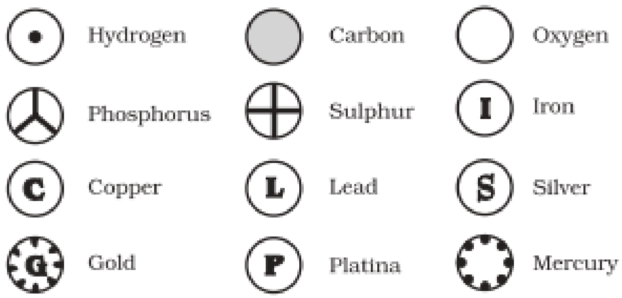
🔹 3.2.1 Modern Symbols of Elements

Dalton first used symbols to represent atoms.
Now, IUPAC assigns one- or two-letter symbols:

Examples:

- Hydrogen → H
- Chlorine → Cl
- Sodium → Na (from Latin “Natrium”)
- Iron → Fe (from “Ferrum”)



📷 Fig. 3.3 – Early Dalton symbols

📘 Table 3.1 – List of modern element symbols

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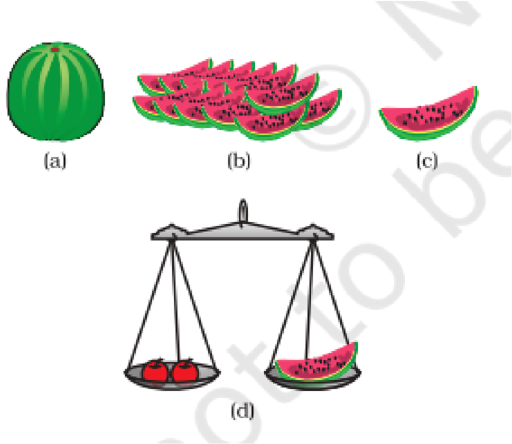
🔹 3.2.2 Atomic Mass

📘 **Definition:**
Atomic mass is the average mass of one atom of an element, compared to 1/12th the mass of one carbon-12 atom.

🧪 Example:
Carbon atom = 12 u, Oxygen = 16 u, Hydrogen = 1 u



📷 Fig. 3.4 – Watermelon analogy to explain 1/12 standard mass

📘 Table 3.2 – Atomic masses of common elements

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🔹 3.2.3 How Do Atoms Exist?

Atoms don't exist freely in most cases. They combine to form:

- Molecules (neutral group of atoms)
- Ions (charged atoms or groups)

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🔹 3.3 What is a Molecule?

📘 **Definition:**
A molecule is a group of two or more atoms chemically bonded together. It is the smallest unit that shows all the properties of a substance.

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🔹 3.3.1 Molecules of Elements

📘 **Atomicity:** Number of atoms in a molecule of an element.

Examples:

- Monoatomic → He, Ar
- Diatomic → O_2, N_2, H_2
- Tetraatomic → P_4
- Polyatomic → S_8

📘 Table 3.3 – Atomicity of elements

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🔹 3.3.2 Molecules of Compounds

📘 **Compounds:** Atoms of different elements combined chemically in fixed ratios.

Examples:

- Water (H_2O) → H : O = 2 : 1
- CO_2 → C : O = 1 : 2
- Ammonia (NH_3) → N : H = 1 : 3

📘 Table 3.4 – Compounds and combining mass ratio

🧪 Activity 3.2:
Use atomic masses and mass ratio to calculate number ratio in compounds
e.g. Water → H:O = 1:8 by mass → atomic masses = 1 & 16 → number ratio = 2:1

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🔹 3.3.3 Ions

📘 Ion: A charged particle (positive or negative)

- Cation → Positively charged ion (e.g., Na^+, Ca^{2+})
- Anion → Negatively charged ion (e.g., Cl^-, SO_4^{2-})

📘 Polyatomic ion: A group of atoms that carries a charge (e.g., NH_4^+, CO_3^{2-})

📘 Table 3.6 – Common ions and their valencies

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🔹 3.4 Writing Chemical Formulae

📘 **Chemical formula:** Short symbolic representation of a compound using symbols and subscripts.

🟩 Rules:

- Metal written first, then non-metal
- Cross-over method: Exchange valencies
- Use brackets for polyatomic ions (if more than one)

Examples:

1. HCl → Hydrogen chloride
2. H_2S → Hydrogen sulphide
3. $MgCl_2$ → Magnesium chloride
4. $Ca(OH)_2$ → Calcium hydroxide
5. Na_2CO_3 → Sodium carbonate
6. $(NH_4)_2SO_4$ → Ammonium sulphate
   📘 Table 3.5 – Examples of ionic compounds
   📘 Group Activity – Use placards to criss-cross valencies and write formulae

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🔷 3.5 Molecular Mass and Formula Unit Mass

📘 **Molecular Mass:**
Sum of atomic masses of all atoms in a molecule

Example:
Water (H_2O) → $2 \times 1 + 16 = 18$ u

📘 **Formula Unit Mass:**
Used for ionic compounds (which don’t form molecules), calculated like molecular mass

Example:
NaCl → $23 + 35.5 = 58.5$ u
$CaCl_2$ → $40 + 2 \times 35.5 = 111$ u