2.1 Atoms and Molecules

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Syllabus

- Definition
- Postulates of Dalton's atomic theory
- Modern position of the theory
- Limitations of Dalton's atomic theory

Why do we study atoms and molecules?

Everything around us is made of matter. Matter is made up of very small particles called **atoms and molecules**. Understanding atoms and molecules helps us understand how substances are formed and how they react.

Atoms and Molecules

Atoms

An atom is the smallest fundamental unit of an element that shows the properties of that element. E.g., Cl represents the chlorine atom.

Or,

Atoms are the smallest units of an element that participate in chemical reactions.

Most atoms don't exist in a Free State in nature, except for noble gases.

Molecule

A molecule is the **smallest particle of an element or compound that exists independently.** It has all the properties of that element or compound.

E.g., CO_2 is a molecule of the compound Carbon dioxide. Cl_2 is a molecule of the element chlorine.

Homoatomic molecule: molecules containing atoms of the SAME element

Type	Examples
Monoatomic (1 atom)	He, Ne, Ar (noble gases)
Diatomic (2 atoms)	H_2, O_2, N_2, Cl_2, F_2, Br_2, I_2
Triatomic (3 atoms)	O_3 (ozone)
Tetra-atomic (4 atoms)	P_4 (phosphorus)
Octa-atomic (8 atoms)	S_8 (sulfur)

Mono = 1 | Di = 2 | Tri = 3 | Tetra = 4 | Octa = 8

Heteroatomic molecules — contain atoms of DIFFERENT elements:

- *Water: H_2O (2 hydrogen + 1 oxygen)*
- *Carbon dioxide: CO_2 (1 carbon + 2 oxygen)*
- *Sulfuric acid: H_2SO_4 (2 H + 1 S + 4 O)*

🧱 Think of it this way:
Atoms → building blocks
Molecules → groups of atoms joined together

⭐ Remember

Molecule of an element: contains atoms of the same element. Example: O_2

Molecule of a compound: contains atoms of different elements. Example: H_2O

Dalton's Atomic Theory

Long ago, a Greek thinker named Democritus said that matter is made of very small parts. He called these parts "atoms". But he had no scientific proof.

How Did the Ancient Greeks Predict The Atom?

In 1808, John Dalton gave the first scientific atomic theory based on the experimental findings available at that time.

The basic postulates of Dalton's atomic theory are:

1) **All matter is made up of very small particles called atoms. These small parts can't be broken down (indivisible).**
2) **Atoms cannot be made (created), destroyed, or changed into atoms of different elements.**
3) **All atoms of the same element are alike. They have the same size, mass, and properties.**
4) **Atoms of different elements are different. Their shape, size, and mass are different.**
5) **Atoms join in a simple whole-number ratio to form compound atoms (now called 'molecules').**

In light of modern experimental findings, we know these postulates are not precisely true in their original form. However, modern chemistry was founded on this atomic theory.

Limitations and Modern View of Dalton's Theory

Dalton's theory was a very important beginning. But later discoveries showed that some of his ideas were not completely correct.

Let's see what modern science tells us.

1. **An atom can be subdivided. It is a complex structure consisting of electrons, protons, and neutrons.**

2. **Atoms of the same element may not be alike. Atoms can have isotopes with the same atomic number but different atomic masses.** For example, the element chlorine has two isotopes: Cl-35 and Cl-37.

3. **Dalton said that atoms combine in simple whole-number ratios. Modern chemistry has shown that the ratios can sometimes be more complex than Dalton originally thought.**

Some familiar examples include: Soap ($C_{18}H_{35}O_2Na$; 18:35:2:1)

Cane sugar ($C_{12}H_{22}O_{11}$; 1.09:2:1)

4. **Instead of compound atoms, the term molecules is used. Molecules are the smallest particles with independent existence. The molecules of elements consist of the same type of atoms, but those of a compound consist of dissimilar atoms.**
For example, the molecule O_2 consists of the same type of atoms, whereas calcium carbonate ($CaCO_3$) consists of different atoms.

5. **Atoms can be altered. Certain radioactive elements occurring in nature change into atoms of another element by the emission of radiation.**
For example, a uranium atom changes into a thorium atom by emitting an alpha particle.

$$_{92}U^{238} \rightarrow {}_{90}Th^{234} + {}_{2}He^{4}$$

Summary

Dalton's idea	**Modern science**
Atom cannot be divided	Atom contains smaller particles
Atoms of the same element are alike	Isotopes have different masses
Atoms combine in simple ratios	Some ratios can be larger/less familiar
"Compound atom"	Molecule
Atoms cannot change into another element	Nuclear reactions can change elements

Important Questions

1. **Explain Dalton's atomic theory.** [4]
   Write down the postulates of Dalton's atomic theory.
2. **How is Dalton's atomic theory modified in light of Modern Knowledge?** **[5]**
   Discuss Dalton's atomic theory in the light of modern knowledge. [4]
   State the modifications made to Dalton's atomic theory. [4]
   Explain the modern position of Dalton's atomic theory.

Key Vocabulary Helper (महत्त्वपूर्ण शब्दकोश)

English Word	Nepali Meaning (नेपाली अर्थ)	Simple Explanation in Easy Words
Atom	परमाणु	smallest unit of an element
Molecule	अणु	smallest particle that can exist independently
Element	तत्त्व	A pure substance made of only ONE kind of atom (e.g., pure Gold, Oxygen).
Compound	यौगिक	A substance made of TWO or MORE different atoms (e.g., Water: H_2O).
Postulate	अवधारणा / बुँदा	Main statement or rule proposed in a scientific theory.
Limitation	सीमा / कमी-कमजोरी	Points where an old theory fails or needs correction.

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