Topic: Particulate Nature of Matter II

Subtopics Covered:

1. **Dalton's Atomic Theory**
2. **Atomic Structure**
3. **Constituents of Atoms: Protons, Neutrons, Electrons**
4. **Electron Arrangement (Electronic Configuration)**
5. **Atomic Number, Mass Number, and Isotopy**
6. **Relative Atomic Mass (Based on Carbon-12 Standard)**

Lesson Objectives:

By the end of the lesson, students should be able to:

- Explain **Dalton's Atomic Theory** and its relevance.
- Describe the **modern structure of the atom**.
- Identify and explain the roles of **protons, neutrons, and electrons**.
- Arrange electrons in shells following **electronic configuration rules**.
- Define and calculate **atomic number, mass number, and isotopic composition**.
- Calculate **relative atomic mass** using real-world examples.

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1. Dalton's Atomic Theory

Historical Background:

Before Dalton, scientists believed matter was continuous. Dalton introduced the concept of atoms as tiny, indivisible particles.

Postulates of Dalton's Atomic Theory:

1. **All matter is made up of tiny indivisible particles called atoms.**
2. **Atoms cannot be created, divided, or destroyed.**

(Modern science has modified this: atoms can be split in nuclear reactions.)

3. **Atoms of the same element are identical in mass and properties.**

(Today we know about isotopes, so this is partly outdated.)

4. **Atoms of different elements have different masses and properties.**
5. **Atoms combine in simple whole-number ratios to form compounds.**
6. **In chemical reactions, atoms are rearranged, not created or destroyed.**

Significance of Dalton's Theory:

- First **scientific model of the atom**.
- Foundation of **modern chemistry**.
- Explains **law of conservation of mass** and **law of definite proportions**.

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2. Atomic Structure

Modern View of the Atom:

Atoms are made up of **subatomic particles**:

Particle	Symbol	Charge	Location
Proton	p^+	+1	Inside nucleus
Neutron	n^0	0	Inside nucleus
Electron	e^-	-1	Orbiting nucleus

Atomic Model Summary:

- **Nucleus:**
  - Contains **protons** and **neutrons**.
  - Has most of the atom's **mass**.
  - Positively charged because of protons.

- **Electron Shells:**
    - **Electrons orbit** the nucleus in **energy levels**.
    - Electrons have **negligible mass** but determine **chemical properties**.

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3. Constituents of the Atom

Particle	Relative Mass	Charge	Role
Proton	1	+1	Determines atomic number and element identity
Neutron	1	0	Adds mass and provides stability
Electron	1/1840	-1	Involved in chemical reactions and bonding

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Examples:

Element	Protons	Neutrons	Electrons
Hydrogen (^{1}H)	1	0	1
Helium (^{4}He)	2	2	2
Carbon (^{12}C)	6	6	6
Oxygen (^{16}O)	8	8	8
Sodium (^{11}Na)	11	12	11

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4. Electron Arrangement (Electronic Configuration)

Rules for Filling Electron Shells:

- Shells are filled from **lower to higher energy levels**.
- Each shell has a **maximum capacity**:

Shell	Maximum Electrons
K (1st shell)	2

Shell	**Maximum Electrons**
L (2nd shell)	8
M (3rd shell)	18
N (4th shell)	32

Examples of Electron Configuration:

Element	**Atomic Number**	**Electron Arrangement**
Hydrogen	1	1
Helium	2	2
Lithium	3	2, 1
Carbon	6	2, 4
Oxygen	8	2, 6
Sodium	11	2, 8, 1
Chlorine	17	2, 8, 7
Calcium	20	2, 8, 8, 2

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5. Atomic Number, Mass Number, and Isotopy

A. Atomic Number (Z):

- The **number of protons** in an atom's nucleus.
- Determines the **identity** of the element.

B. Mass Number (A):

- The **total number of protons and neutrons** in the nucleus.

Formula:

Mass Number (A)=Number of Protons+Number of Neutrons\text{Mass Number (A)} = \text{Number of Protons} + \text{Number of Neutrons}Mass Number (A)=Number of Protons+Number of Neutrons

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Example:

For **Carbon-12:**

- Atomic Number (Z) = 6 (protons)
- Neutrons = 6
- Mass Number (A) = 6 + 6 = 12

C. Isotopy

Definition:

Isotopes are **atoms of the same element** with the **same atomic number (Z)** but **different mass numbers (A)** due to different numbers of **neutrons**.

Examples of Isotopes:

Element	Isotope	Protons	Neutrons	Mass Number
Carbon	^{12}C	6	6	12
	^{14}C	6	8	14
Hydrogen	^{1}H (Protium)	1	0	1
	^{2}H (Deuterium)	1	1	2
	^{3}H (Tritium)	1	2	3
Chlorine	^{35}Cl	17	18	35
	^{37}Cl	17	20	37

Uses of Isotopes:

Isotope	Use
Carbon-14	Carbon dating (archaeology)
Cobalt-60	Cancer treatment (radiotherapy)
Iodine-131	Thyroid diagnosis
Deuterium (^2H)	Used in heavy water (nuclear reactors)

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6. Relative Atomic Mass (RAM)

Definition:

The **Relative Atomic Mass (Ar)** of an element is the **average mass of its naturally occurring isotopes**, compared to **1/12 of Carbon-12**.

Formula for RAM:

RAM=(Isotope 1 mass×abundance)+(Isotope 2 mass×abundance)+…Total abundance\text{RAM} = \frac{(\text{Isotope 1 mass} \times \text{abundance}) + (\text{Isotope 2 mass} \times \text{abundance}) + \dots}{\text{Total abundance}}RAM=Total abundance(Isotope 1 mass×abundance)+(Isotope 2 mass×abundance)+…

Example 1: Chlorine

Isotope	Mass Number	Abundance (%)
Chlorine-35	35	75%
Chlorine-37	37	25%

Calculation:

RAM of Cl=(35×75)+(37×25)100=2625+925100=35.5\text{RAM of Cl} = \frac{(35 \times 75) + (37 \times 25)}{100} = \frac{2625 + 925}{100} = 35.5RAM of Cl=100(35×75)+(37×25)=1002625+925=35.5

So, the **Relative Atomic Mass of chlorine = 35.5**

Example 2: Magnesium

Isotope	Mass Number	Abundance (%)
Magnesium-24	24	79%
Magnesium-25	25	10%
Magnesium-26	26	11%

Calculation:

RAM of Mg=(24×79)+(25×10)+(26×11)100\text{RAM of Mg} = \frac{(24 \times 79) + (25 \times 10) + (26 \times 11)}{100}RAM of Mg=100(24×79)+(25×10)+(26×11) =1896+250+286100=2432100=24.32= \frac{1896 + 250 + 286}{100} = \frac{2432}{100} = 24.32=1001896+250+286=1002432=24.32

So, **RAM of magnesium = 24.32**

Summary Table of Key Concepts:

Concept	Meaning
Atom	Smallest unit of an element
Proton	Positive particle in nucleus
Neutron	Neutral particle in nucleus
Electron	Negative particle orbiting nucleus
Atomic Number (Z)	Number of protons
Mass Number (A)	Protons + Neutrons
Isotopes	Same element, different mass number
Relative Atomic Mass (Ar)	Average mass of isotopes

Conclusion:

The **particulate nature of matter** explains the structure of atoms, the arrangement of electrons, and how atomic properties influence chemical behavior.
Understanding **isotopes and atomic masses** helps in chemistry, biology, and physics.