Week 8: Chemical Combinations II

Topic: Chemical Bonding – Part II

Focus Areas:

- **Strong bonds**: Electrovalent (Ionic), Covalent, Coordinate Covalent (Dative)
- **Weak bonds**: Hydrogen bonding, Van der Waals forces

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1. Lesson Objectives

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

- Define and explain the different types of strong chemical bonds.
- Describe how atoms achieve chemical bonding through different means.
- Identify examples of ionic, covalent, and coordinate covalent bonds.
- Distinguish between strong bonds and weak intermolecular forces.
- Explain the nature and significance of hydrogen bonding and Van der Waals forces.

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2. Introduction

Atoms combine chemically to attain stability, often to complete their outermost electron shells (duplet or octet rule). This combination leads to the formation of different types of bonds. These bonds can be **strong (intra-molecular)** or **weak (inter-molecular)** depending on the nature of interaction between the atoms or molecules.

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3. STRONG CHEMICAL BONDS

These are bonds that exist **within** molecules and involve the **sharing** or **transfer** of electrons.

A. Electrovalent Bond (Ionic Bond)

- **Definition**: A bond formed by the complete **transfer of electrons** from a metal to a non-metal.
- **Mechanism**:

    - A **metal** loses one or more electrons to become a **cation**.
    - A **non-metal** gains one or more electrons to become an **anion**.
    - The oppositely charged ions are then held together by **electrostatic attraction**.
- **Example**: Sodium Chloride (NaCl)
    - Na (2,8,1) loses 1 electron → Na^+
    - Cl (2,8,7) gains 1 electron → Cl^-
    - $Na^+ + Cl^- \rightarrow NaCl$
- **Characteristics of Ionic Compounds**:
    - Crystalline solids
    - High melting and boiling points
    - Conduct electricity when molten or dissolved
    - Soluble in water

B. Covalent Bond

- **Definition**: A bond formed by the **sharing of electrons** between two non-metals.
- **Types**:
    - **Single bond** – sharing 1 pair of electrons (e.g., H_2)
    - **Double bond** – sharing 2 pairs (e.g., O_2)
    - **Triple bond** – sharing 3 pairs (e.g., N_2)
- **Example**: Chlorine molecule (Cl_2)
    - Each Cl atom has 7 valence electrons.
    - They share 1 electron each → Cl—Cl
- **Characteristics**:
    - Low melting/boiling points
    - Often gases or liquids
    - Poor electrical conductors

- Soluble in non-polar solvents

C. Coordinate Covalent Bond (Dative Bond)

- **Definition**: A covalent bond in which **both electrons** come from **the same atom**.
- **How it works**: One atom with a lone pair donates electrons to another atom that needs them.
- **Example**: Formation of **Ammonium ion (NH_4^+)**
  - NH_3 has a lone pair on N
  - H^+ accepts the lone pair → NH_4^+
- **Importance**:
  - Seen in complex ions
  - Present in many biological molecules

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4. WEAK INTERMOLECULAR FORCES

These are **forces of attraction between molecules**, not within.

A. Hydrogen Bonding

- **Definition**: A special type of dipole-dipole attraction that occurs between a hydrogen atom bonded to **N, O, or F**, and another electronegative atom.
- **Example**: Water (H_2O)
  - Each water molecule can form hydrogen bonds with others:
    - H—O···H—O···H
- **Significance**:
  - Explains water's high boiling point
  - Stabilizes DNA (double helix)
  - Important in protein folding

B. Van der Waals Forces

- **Definition**: Weak forces arising from **temporary dipoles** in molecules.
- **Types**:
  - **London dispersion forces** – present in all molecules, especially non-polar ones.
  - **Dipole-dipole interactions** – present in polar molecules.
- **Examples**:
  - **Cl_2** molecules held together by London forces
  - Weak attractions in noble gases (e.g., Argon)
- **Significance**:
  - Affect physical properties (e.g., boiling points)
  - Important in molecular interactions in biology and chemistry

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5. Comparison Table

Feature	**Strong Bonds**	**Weak Bonds**
Types	Ionic, Covalent, Coordinate	Hydrogen bonds, Van der Waals
Strength	High	Low
Location	Inside molecules	Between molecules
Energy to break	High	Low
Example	NaCl, Cl_2, NH_4^+	Water H-bonding, Van der Waals in Cl_2

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6. Summary

- Chemical bonds are essential for the formation of compounds.
- Strong bonds (ionic, covalent, and coordinate) hold atoms together in molecules.
- Weak bonds (hydrogen and Van der Waals) hold molecules together and influence physical states and biological function.

- Recognizing the type of bond helps in predicting compound properties like solubility, melting point, and electrical conductivity.