CHAPTER 4: CARBON AND ITS COMPOUNDS

1. Introduction

Carbon is one of the most important elements in nature. It forms the basis of all living organisms and a large number of compounds used in daily life such as food, fuels, medicines, and plastics.

Although carbon is present in very small amounts in the earth's crust (about 0.02%) and atmosphere (about 0.03% as carbon dioxide), it forms a vast number of compounds. This is due to its unique properties.

2. Bonding in Carbon – Covalent Bond

Why Carbon Forms Covalent Bonds ?

Carbon has 4 electrons in its outermost shell (valency = 4).
To achieve a stable noble gas configuration, it can:

- Gain 4 electrons (difficult due to instability)
- Lose 4 electrons (requires very high energy)

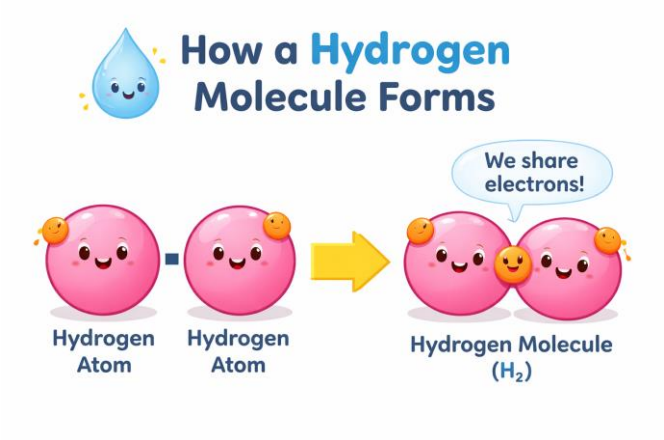
Therefore, carbon shares electrons with other atoms. This sharing leads to the formation of covalent bonds.

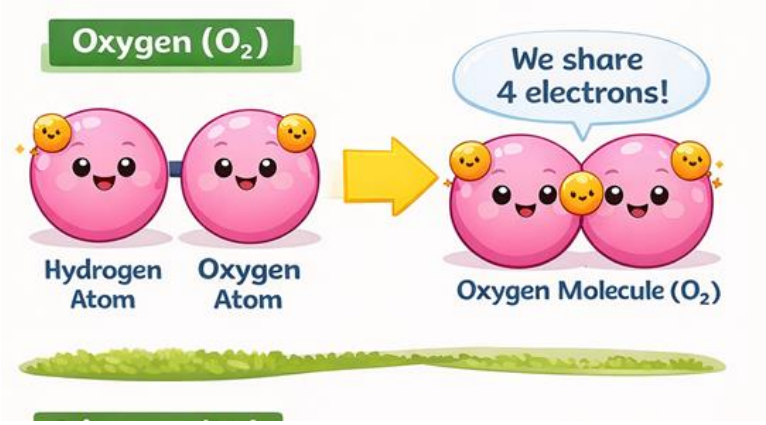
Covalent Bond

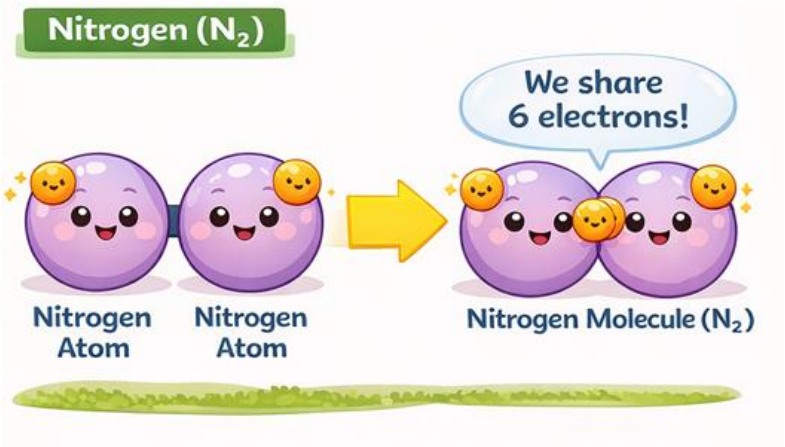
A covalent bond is formed by the sharing of one or more pairs of electrons between two atoms.

Examples:

- Hydrogen (H□): single bond

- 

- Oxygen (O□): double bond
- 

- Nitrogen (N□): triple bond
- 

Example: Methane (CH□)

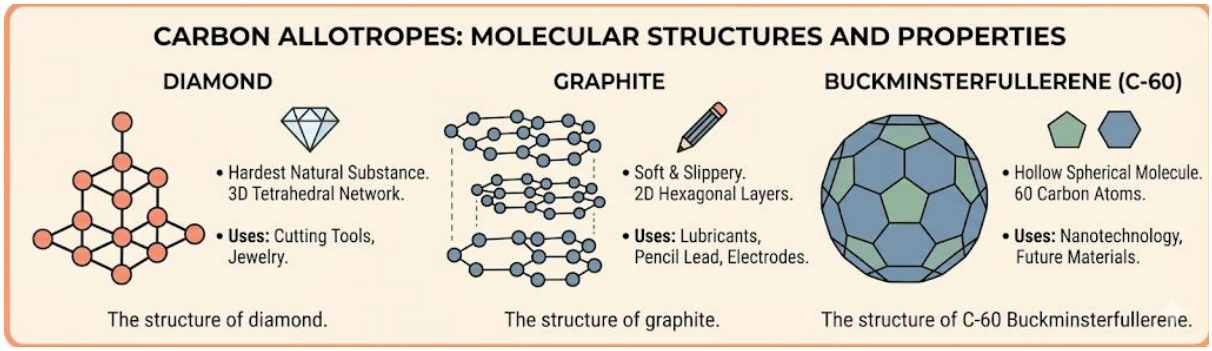
In methane, carbon shares its 4 electrons with 4 hydrogen atoms. Each bond is a single covalent bond, and all atoms achieve stable electronic configurations.

Properties of Covalent Compounds

- Low melting and boiling points
- Poor conductors of electricity
- Weak intermolecular forces
- Generally insoluble in water

3. Allotropes of Carbon

Carbon exists in different forms called allotropes.



Diamond

- Each carbon atom bonded to 4 other carbon atoms
- Hardest known substance
- Does not conduct electricity

Graphite

- Each carbon atom bonded to 3 other atoms
- Layered structure
- Good conductor of electricity
- Soft and slippery

Fullerene (C□□)

- Spherical structure resembling a football

4. Versatile Nature of Carbon

Carbon forms a large number of compounds due to two main properties:

(i) Catenation

The ability of carbon to form long chains with itself.

These chains can be:

- Straight
- Branched
- Ring-shaped

(ii) Tetravalency

Carbon forms four covalent bonds with:

- Hydrogen
- Oxygen
- Nitrogen
- Halogens

This allows formation of stable and complex compounds.

5. Hydrocarbons

Hydrocarbons are compounds containing only carbon and hydrogen.

(a) Saturated Hydrocarbons (Alkanes)

- Contain only single bonds
- General formula: C□H□□₊□
- Example: Methane (CH□), Ethane (C□H□)
- Less reactive

(b) Unsaturated Hydrocarbons

Alkenes

- Contain at least one double bond
- General formula: C□H□□
- Example: Ethene (C□H□)

Alkynes

- Contain at least one triple bond
- General formula: C□H□□₋□

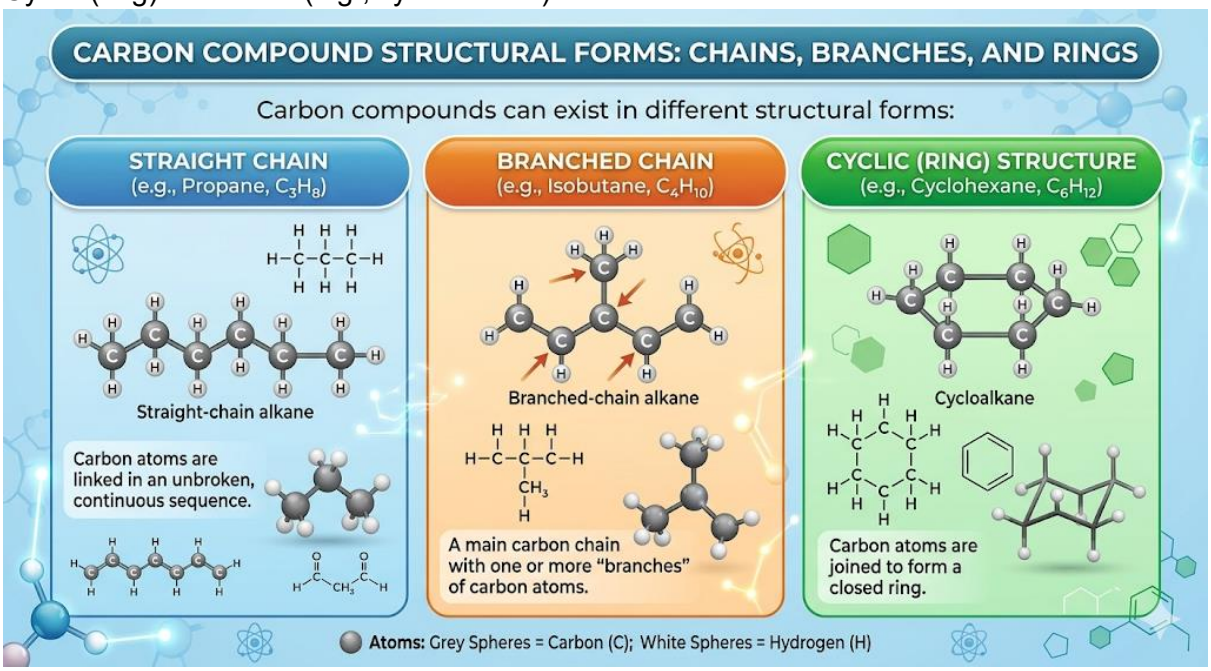
- Example: Ethyne (C□H□)

These are more reactive than saturated hydrocarbons.

6. Chains, Branches and Rings

Carbon compounds can exist in different structural forms:

- Straight chain (e.g., propane)
- Branched chain (e.g., isobutane)
- Cyclic (ring) structures (e.g., cyclohexane)



Structural Isomers

Compounds having the same molecular formula but different structures are called isomers.

Example: Butane (C□H□□) has two isomers.

7. Functional Groups

A functional group is an atom or group of atoms that replaces hydrogen in a hydrocarbon and determines the chemical properties of the compound.

Functional Group	Formula	Example
Alcohol	–OH	Ethanol
Aldehyde	–CHO	Ethanal
Ketone	–CO–	Propanone
Carboxylic acid	–COOH	Ethanoic acid
Halo (Cl/Br)	–Cl, –Br	Chloromethane

8. Homologous Series

A homologous series is a group of compounds having:

- Same functional group
- Similar chemical properties
- Consecutive members differ by –CH□ unit

Example:

CH□ → C□H□ → C□H□ → C□H□□

Characteristics

- Gradual change in physical properties (boiling point, melting point)
- Same chemical properties
- Regular increase in molecular mass

9. Nomenclature of Carbon Compounds

Steps for naming:

1. Count number of carbon atoms (meth, eth, prop, but, etc.)
2. Identify functional group
3. Add appropriate suffix or prefix

Examples

Formula	Name
CH□	Methane
C□H□OH	Ethanol
CH□COOH	Ethanoic acid
C□H□	Ethene

10. Chemical Properties of Carbon Compounds

(i) Combustion

Carbon and its compounds burn in oxygen to form carbon dioxide and water, releasing heat and light.

Example:
CH□ + O□ → CO□ + H□O + Heat

(ii) Oxidation

Addition of oxygen or removal of hydrogen.

Example:
Alcohol → Carboxylic acid

Oxidising agents:

- Alkaline KMnO□
- Acidified K□Cr□O□

(iii) Addition Reaction

Occurs in unsaturated hydrocarbons.

Example:
Ethene + Hydrogen → Ethane (in presence of Ni/Pd catalyst)

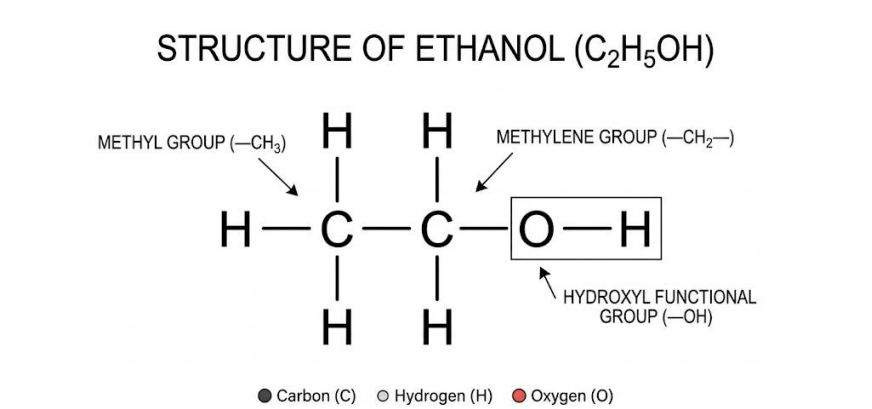
Used in hydrogenation of vegetable oils.

(iv) Substitution Reaction

Occurs in saturated hydrocarbons.

Example:
$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$ (in sunlight)

11. Ethanol (C_2H_5OH)



Simplified 2D structural diagram showing atom connections and functional groups.

Properties

- Colourless liquid
- Good solvent
- Miscible with water
- Used in medicines and alcoholic beverages

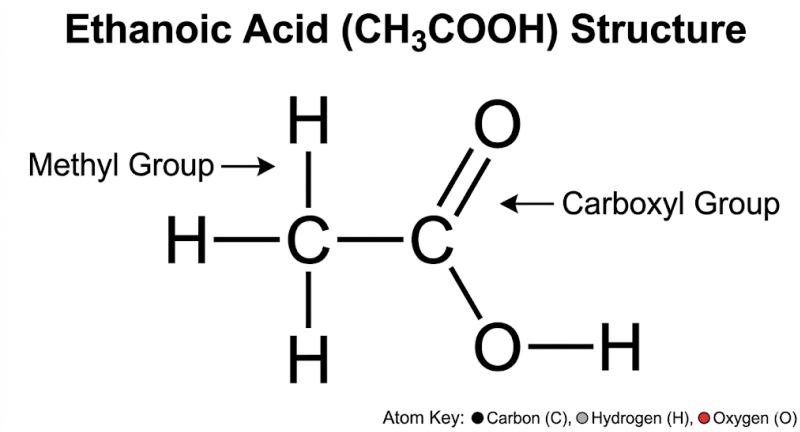
Reactions

1. With Sodium:
   Produces hydrogen gas
2. Dehydration:
   Ethanol → Ethene (in presence of concentrated H_2SO_4)

Effects

- Excess consumption is harmful
- Methanol is highly poisonous

12. Ethanoic Acid (CH_3COOH)



Properties

- Weak acid
- Known as acetic acid
- 5–8% solution is vinegar

Reactions

(i) Esterification

Acid + Alcohol → Ester (pleasant smell)

(ii) With Base

CH□COOH + NaOH → CH□COONa + H□O

(iii) With Carbonates

Produces CO□ gas

13. Soaps and Detergents

Soap

- Sodium or potassium salts of long-chain fatty acids
- Cleans by forming micelles

Micelle Formation

Soap molecules have:

- Hydrophilic (water-loving) head
- Hydrophobic (water-repelling) tail

These trap grease and dirt, allowing it to be washed away.

Hard Water Problem

- Soap reacts with Ca^{2+} and Mg^{2+} ions
- Forms insoluble scum
- Reduces cleaning efficiency

Detergents

- Do not form scum in hard water
- Work effectively in all types of water