Chapter 4
Carbon and It's Compounds

Carbon is an element with the symbol "C" and atomic number 6. It's a non-metal with the unique ability to form a large number of compounds.

Covalent Bond: A covalent bond is formed by the mutual sharing of electron pairs between two atoms in a molecule.

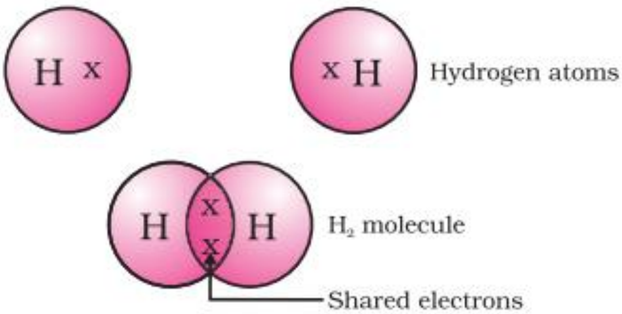
Covalent Bonding in Carbon Compounds

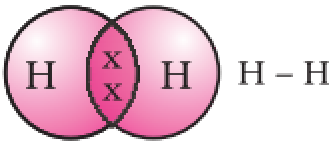
Carbon has an atomic number of 6 and an electronic configuration of 2, 4. It needs to gain or lose four electrons to attain a noble gas configuration. But carbon cannot form ionic bonds because:

- It could gain four electrons forming C^{4-} anion. But it would be difficult for the nucleus with six protons to hold on to ten electrons, that is, four extra electrons.
- It could lose four electrons forming C^{4+} cations. But it would require a large amount of energy to remove four electrons leaving behind a carbon cation with six protons in its nucleus holding on to just two electrons

Carbon overcomes this by **sharing** its valence electrons with other carbon atoms or atoms of other elements, forming **covalent bonds**.

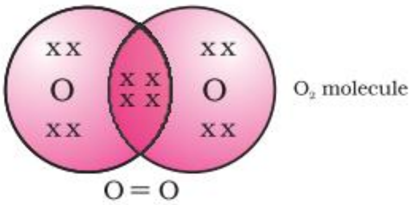
Formation of Hydrogen Molecule (Single Bond)





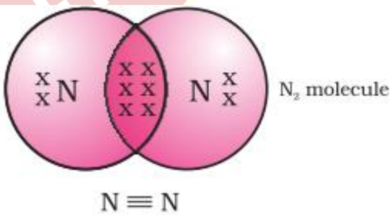
- Hydrogen (H) has an atomic number of 1, with one electron in its K shell.
- Two hydrogen atoms share their electrons to form a molecule of hydrogen (H_2).

Formation of Oxygen Molecule (Double Bond)



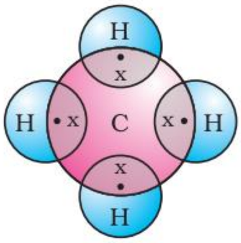
- Oxygen (O) has an atomic number of 8 and needs two more electrons to complete its octet.
- Each oxygen atom shares two electrons with another oxygen atom, creating a **double bond** between them.

Formation of Nitrogen Molecule (Triple Bond)



- Nitrogen (N) has an atomic number of 7 and needs three more electrons to complete its octet.
- Each nitrogen atom contributes three electrons, resulting in a **triple bond** between them.

Formation of Methane (CH_4)



- Methane is formed by carbon (C) and hydrogen (H) atoms.
- Carbon forms four single bonds with four hydrogen atoms in a tetrahedral structure.

Allotropes of Carbon

Allotropes are different forms of an element with the same **chemical properties** but different physical properties. Carbon has three common allotropes: Diamond, Graphite, and Fullerene.

Diamond

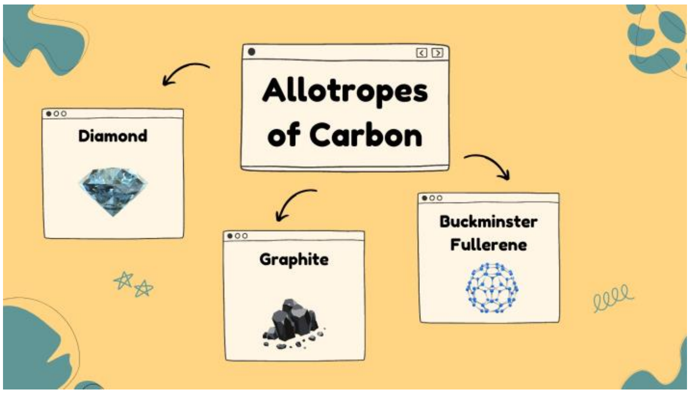
- Each carbon atom in diamond is bonded to four other carbon atoms, forming a rigid tetrahedral structure.
- Hardest substance known.
- High melting point.
- Poor conductor of electricity.

Graphite

- In graphite, each carbon atom is bonded to three other carbon atoms in the same plane, forming hexagonal rings.
- Good conductor of electricity.
- Uses: Dry lubricant, pencil lead.

Fullerene

- C_{60}, known as Buckminsterfullerene, consists of carbon atoms arranged in the shape of a football.
- Consists of 60 carbon atoms arranged in 12 pentagons and 20 hexagons.



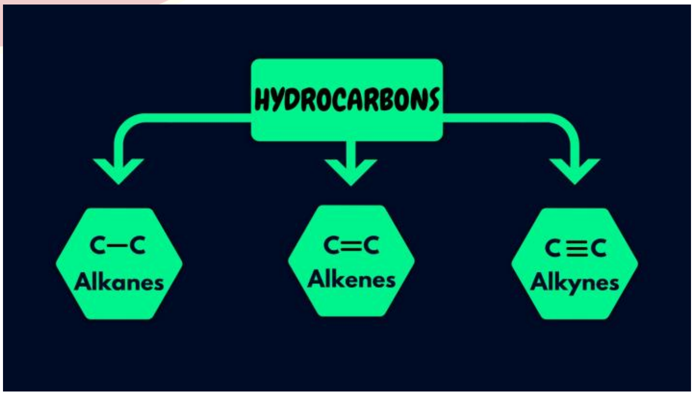
Versatile Nature of Carbon

Carbon can form a variety of compounds due to two key properties:

- **Catenation**: The ability to form covalent bonds with other carbon atoms, leading to large molecules.
- **Tetravalent Nature**: Carbon can bond with four other atoms of carbon or mono-valent elements.

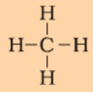
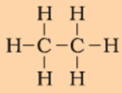
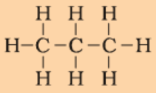
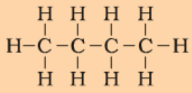
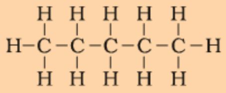
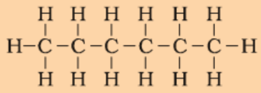
Hydrocarbons

- Compounds of carbon and hydrogen are known as hydrocarbons.
- Examples: Methane (CH_4), Ethane (C_2H_6), etc.
- **Saturated** hydrocarbons (alkanes) have all carbon-carbon **single** bonds.
- **Unsaturated** hydrocarbons include alkenes (carbon-carbon **double** bond) and alkynes (carbon-carbon **triple** bond).

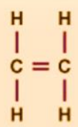
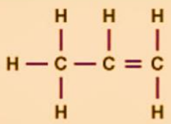
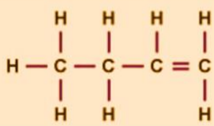
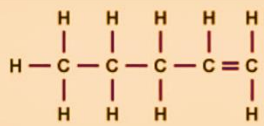
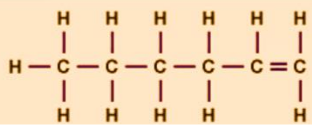


1. **Alkanes:** Hydrocarbons in which carbon atoms are linked to each other by a single bond.
   General Formula: C_nH_{2n+2}
   where n is the no. of carbon atoms

Examples:

Methane	CH_4	
Ethane	C_2H_6	
Propane	C_3H_8	
Butane	C_4H_{10}	
Pentane	C_5H_{12}	
Hexane	C_6H_{14}	

2. **Alkenes:** Hydrocarbons in which carbon atoms are linked to each other by a double bond.
   General Formula: C_nH_{2n}

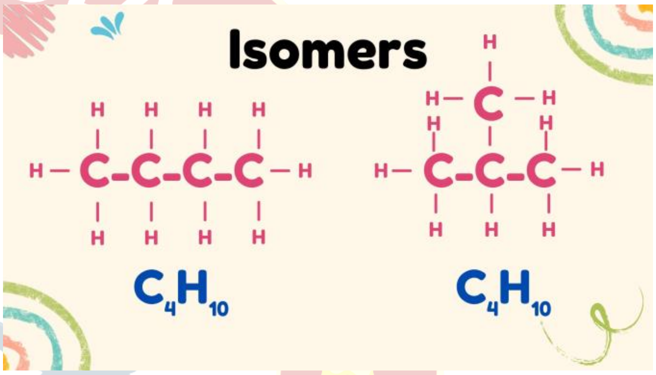
Ethene	C_2H_4	
Propene	C_3H_6	
Butene	C_4H_8	
Pentene	C_5H_{10}	
Hexene	C_6H_{12}	

3. **Alkynes:** Hydrocarbons in which carbon atoms are linked to each other by a triple bond.
   General Formula: C_nH_{2n-2}

Examples:

Ethyne	C_2H_2	$HC \equiv CH$
Propyne	C_3H_4	CH_3- $C \equiv CH$
Butyne	C_4H_6	CH_3 -H_2C -C $\equiv CH$
Pentyne	C_5H_8	CH_3-CH_2-CH_2-$C \equiv CH$

Structural Isomers: Isomers are compounds with the same molecular formula but different structures.



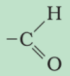
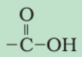
Homologous Series: A series of organic compounds with the same *functional group* and chemical properties.

- Successive members differ by CH_2 unit or 14 mass units.
- All compounds in a homologous series have same functional group and show similar chemical properties.

Functional Groups

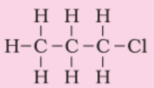
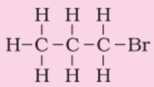
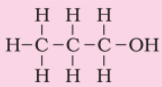
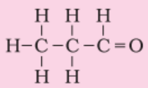
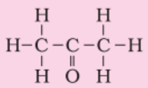
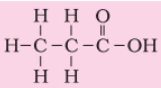
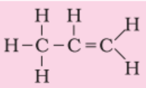
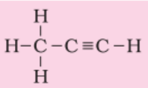
It is a **group of atoms** in a compound which determines chemical properties of a compound.

- The functional group is attached to the carbon chain through by replacing one hydrogen atom or atoms.
- Some important functional groups are **halogens, alcohols, aldehydes, ketones and carboxylic acids.**

Hetero atom	Class of compounds	Formula of functional group
Cl/Br	Halo- (Chloro/bromo) alkane	—Cl, —Br (substitutes for hydrogen atom)
Oxygen	1. Alcohol	—OH
	2. Aldehyde	
	3. Ketone	
	4. Carboxylic acid	

Nomenclature of Carbon Compounds

1. Identify the number of carbon atoms in the compound.
2. Indicate the functional group with a prefix or suffix.
3. If a suffix is added, remove the final 'e' from the name (e.g., ethane to ethanol).

Class of compounds	Prefix/Suffix	Example	
1. Halo alkane	Prefix-chloro, bromo, etc.		Chloropropane
			Bromopropane
2. Alcohol	Suffix - ol		Propanol
3. Aldehyde	Suffix - al		Propanal
4. Ketone	Suffix - one		Propanone
5. Carboxylic acid	Suffix - oic acid		Propanoic acid
6. Alkenes	Suffix - ene		Propene
7. Alkynes	Suffix - yne		Propyne

Chemical Properties of Carbon Compounds

1. Combustion: Carbon compounds burn in air to produce carbon dioxide and water, releasing heat and light.
2. Oxidation: Alcohols can be oxidized to carboxylic acids.
3. Addition Reaction: Hydrogen is added to unsaturated hydrocarbons.
4. Substitution Reaction: Hydrogen in saturated hydrocarbons can be replaced.

Chemical Properties of Carbon Compounds

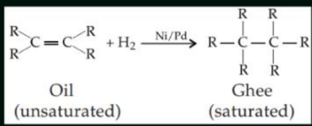
Combustion: The complete combustion of carbon compounds in the air gives carbon dioxide water, heat and light.

CH4 + O2 → CO2 + H2O + heat and light

Oxidation: Oxidation of ethanol in presence of oxidizing agents gives ethanoic acid.

$$CH_3-CH_2OH \xrightarrow[\text{Or acidified } K_2Cr_2O_7 + \text{Heat}]{\text{Alkaline } KMnO_4 + \text{Heat}} CH_3COOH$$

Addition Reaction: Addition of hydrogen gas with unsaturated hydrocarbon in the presence of catalysts such as nickel or platinum or palladium are known as addition(hydrogenation) reaction.



Substitution Reaction: Replacement of one or more hydrogen atom by another atom or group of the atom.

$$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl \text{ (in the presence of sunlight)}$$

*Bromine water test

SOME IMPORTANT CARBON COMPOUNDS – ETHANOL AND ETHANOIC ACID

Ethanol (CH3CH2—OH): Commonly known as alcohol.

- It is colourless, inflammable liquid.
- It is soluble with water in all proportions.
- It is neutral & has no effect on the litmus paper

Uses: antiseptic, fuel, medicines, etc.

Reaction with Sodium(Na) Metal:

$$CH_3CH_2OH + Na \longrightarrow CH_3CH_2O^-Na^+ + H_2$$

Dehydration of Ethanol:

$$CH_3-CH_2OH \xrightarrow[H_2SO_4]{\text{Hot Conc.}} CH_2 = CH_2 + H_2O$$

Ethanoic Acid (CH3COOH): Common name -Acetic acid. 5-8% of ethanoic acid in water is called Vinegar. Freezes in cold climate so named as glacial acetic acid.

- It is a colourless, pungent-smelling liquid.
- Soluble with water in all proportions.
- Turns blue litmus to red.

Uses: dyes, vinegar, perfume etc.

Esterification: The reaction of carboxylic acid with alcohol to form an ester.

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow[H_2SO_4]{\text{conc.}} \underset{\text{Ethyl ethanoate}}{CH_3COOCH_2CH_3} + H_2O$$

Saponification: Reaction of esters with sodium hydroxide, gives alcohol and sodium salt of carboxylic acid (soap).

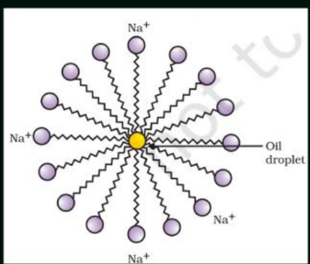
$$CH_3COOC_2H_5 \xrightarrow{NaOH} C_2H_5OH + CH_3COONa$$

Reaction with base: $NaOH + CH_3COOH \rightarrow CH_3COONa + H_2O$

Reaction with carbonates and hydrogencarbonates

$$2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + H_2O + CO_2$$
$$CH_3COOH + NaHCO_3 \rightarrow CH_3COONa + H_2O + CO_2$$

Cleansing action of soaps



The dirt - insoluble.
Therefore it cannot be removed by only washing with water.
When soap is dissolved in water, its hydrophobic ends attach themselves to the dirt and remove it from the cloth.
Then, the molecules of soap arrange themselves in micelles form and trap the dirt at the centre of the cluster.
These micelles remain suspended in the water.
Hence, the dust particles are easily rinsed away by water.

Soap: Sodium or potassium salts of long chain fatty acids is called Soap.

Detergents are generally sodium salts of long chain sulphonic acids.

Hard and Soft Water: Water that does not produce lather with soap readily is called hard water and which produces lather with soap is called soft water.
Hardness of water is due to the presence of chlorides/sulphate salt of calcium and magnesium

S. No.	Soap	Detergents
1.	Soaps are sodium salts of long chain carboxylic acids.	Detergents are sodium salt of long chain sulphonic acids.
2.	The ionic group in soap is $COONa^+$	The ionic groups in detergents is SO_3^-, Na^+
3.	Soaps are not useful when water is hard.	Detergent can be used for washing purpose even when water is hard.
4.	Soaps are biodegradable.	Some of the detergents are non-biodegradable.
5.	Soaps have relatively weak cleansing action.	Detergents have strong cleansing action.