

# Carbon and its Compounds - Class 10 Science Notes

## 1. Introduction to Carbon

### Unique Properties of Carbon

Carbon is a unique element that forms the basis of all living organisms and countless compounds. It has the atomic number 6 and electronic configuration 2,4.

### Why Carbon is Special?

1. **Tetravalency:** Carbon has 4 electrons in outermost shell
2. **Catenation:** Ability to form chains with other carbon atoms
3. **Small size:** Allows strong bonding
4. **Forms multiple bonds:** Single, double, and triple bonds

### Allotropes of Carbon

#### Crystalline Forms:

- **Diamond:** Each carbon bonded to 4 others in tetrahedral structure
- **Graphite:** Layered structure with each carbon bonded to 3 others
- **Fullerenes:** Spherical structures like  $C_{60}$  (Buckminsterfullerene)

#### Amorphous Forms:

- **Coal**
- **Charcoal**
- **Coke**
- **Carbon black**

## 2. Bonding in Carbon Compounds

### Covalent Bonding

Carbon forms covalent bonds by sharing electrons since:

- Gaining 4 electrons ( $C^{4-}$ ) would require enormous energy
- Losing 4 electrons ( $C^{4+}$ ) would require enormous energy
- Sharing electrons is energetically favorable

### Types of Covalent Bonds

1. **Single bond (C-C):** One pair of electrons shared

2. **Double bond (C=C):** Two pairs of electrons shared
3. **Triple bond (C≡C):** Three pairs of electrons shared

## Versatile Nature of Carbon

- **Chain formation:** Long chains of carbon atoms
- **Branched chains:** Carbon chains with side branches
- **Ring formation:** Closed chains forming rings
- **Multiple bonding:** Double and triple bonds possible

## 3. Saturated and Unsaturated Carbon Compounds

### Saturated Compounds (Alkanes)

- Contain only single bonds between carbon atoms
- General formula:  $C_nH_{2n+2}$
- Also called paraffins
- Examples: Methane ( $CH_4$ ), Ethane ( $C_2H_6$ ), Propane ( $C_3H_8$ )

### Unsaturated Compounds

#### Alkenes (One double bond)

- General formula:  $C_nH_{2n}$
- Examples: Ethene ( $C_2H_4$ ), Propene ( $C_3H_6$ )

#### Alkynes (One triple bond)

- General formula:  $C_nH_{2n-2}$
- Examples: Ethyne ( $C_2H_2$ ), Propyne ( $C_3H_4$ )

## 4. Homologous Series

### Definition

A series of carbon compounds with the same functional group, similar chemical properties, and successive members differing by  $CH_2$  unit.

### Characteristics of Homologous Series

1. Same general formula
2. Same functional group
3. Similar chemical properties
4. Gradual change in physical properties

5. Successive members differ by  $\text{CH}_2$  (14 amu)
6. Same method of preparation

## Examples of Homologous Series

### Alkanes ( $\text{C}_n\text{H}_{2n+2}$ )

- Methane:  $\text{CH}_4$
- Ethane:  $\text{C}_2\text{H}_6$
- Propane:  $\text{C}_3\text{H}_8$
- Butane:  $\text{C}_4\text{H}_{10}$
- Pentane:  $\text{C}_5\text{H}_{12}$

### Alkenes ( $\text{C}_n\text{H}_{2n}$ )

- Ethene:  $\text{C}_2\text{H}_4$
- Propene:  $\text{C}_3\text{H}_6$
- Butene:  $\text{C}_4\text{H}_8$

### Alcohols ( $\text{C}_n\text{H}_{2n+1}\text{OH}$ )

- Methanol:  $\text{CH}_3\text{OH}$
- Ethanol:  $\text{C}_2\text{H}_5\text{OH}$
- Propanol:  $\text{C}_3\text{H}_7\text{OH}$

## 5. Nomenclature of Carbon Compounds

### IUPAC Rules for Naming

1. **Identify longest carbon chain:** This gives the base name
2. **Number the carbon atoms:** Start from the end nearest to functional group
3. **Identify and name substituents:** Branches attached to main chain
4. **Name functional groups:** Use appropriate suffix or prefix

### Word Roots for Carbon Chains

- 1 Carbon: Meth-
- 2 Carbons: Eth-
- 3 Carbons: Prop-
- 4 Carbons: But-
- 5 Carbons: Pent-
- 6 Carbons: Hex-

## Suffixes for Different Compounds

- Alkanes: -ane
- Alkenes: -ene
- Alkynes: -yne
- Alcohols: -ol
- Aldehydes: -al
- Ketones: -one
- Carboxylic acids: -oic acid

## 6. Functional Groups

### Definition

An atom or group of atoms that determines the chemical properties of a compound.

### Important Functional Groups

| Functional Group | Formula        | Suffix    | Example          |
|------------------|----------------|-----------|------------------|
| Alcohol          | -OH            | -ol       | Ethanol          |
| Aldehyde         | -CHO           | -al       | Ethanal          |
| Ketone           | >C=O           | -one      | Propanone        |
| Carboxylic acid  | -COOH          | -oic acid | Ethanoic acid    |
| Ester            | -COO-          | -oate     | Methyl ethanoate |
| Halogen          | -X (F,Cl,Br,I) | halo-     | Chloroethane     |

## 7. Important Carbon Compounds

### 1. Ethanol (C<sub>2</sub>H<sub>5</sub>OH)

#### Physical Properties

- Colorless liquid
- Pleasant smell
- Boiling point: 78°C
- Soluble in water
- Neutral to litmus

#### Chemical Properties

**Combustion:**  $\text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O} + \text{Heat}$

**Oxidation:**  $\text{C}_2\text{H}_5\text{OH} + [\text{O}] \rightarrow \text{CH}_3\text{COOH} + \text{H}_2\text{O}$  (using oxidizing agents)

**Reaction with sodium:**  $2\text{C}_2\text{H}_5\text{OH} + 2\text{Na} \rightarrow 2\text{C}_2\text{H}_5\text{ONa} + \text{H}_2$

### Uses of Ethanol

- In alcoholic beverages
- As antiseptic in medicines
- As solvent for medicines, perfumes
- As fuel (gasohol)

### Harmful Effects

- Addiction and health problems
- Affects nervous system
- Causes liver damage

## 2. Ethanoic Acid ( $\text{CH}_3\text{COOH}$ ) - Acetic Acid

### Physical Properties

- Colorless liquid
- Pungent smell
- Boiling point:  $118^\circ\text{C}$
- Miscible with water
- Freezing point:  $17^\circ\text{C}$  (glacial acetic acid)

### Chemical Properties

**Reaction with metals:**  $2\text{CH}_3\text{COOH} + \text{Mg} \rightarrow (\text{CH}_3\text{COO})_2\text{Mg} + \text{H}_2$

**Reaction with bases:**  $\text{CH}_3\text{COOH} + \text{NaOH} \rightarrow \text{CH}_3\text{COONa} + \text{H}_2\text{O}$

**Reaction with carbonates:**  $2\text{CH}_3\text{COOH} + \text{Na}_2\text{CO}_3 \rightarrow 2\text{CH}_3\text{COONa} + \text{H}_2\text{O} + \text{CO}_2$

**Esterification:**  $\text{CH}_3\text{COOH} + \text{C}_2\text{H}_5\text{OH} \rightleftharpoons \text{CH}_3\text{COOC}_2\text{H}_5 + \text{H}_2\text{O}$

### Uses of Ethanoic Acid

- In vinegar (5-8% solution)
- In manufacture of esters
- As food preservative
- In textile industry

### 3. Soaps and Detergents

#### Soaps

**Preparation:** Fat/Oil + NaOH → Soap + Glycerol (Saponification reaction)

**Example:**  $\text{C}_{17}\text{H}_{35}\text{COONa}$  (Sodium stearate - a soap)

#### Structure of Soap

- **Hydrophilic head:**  $-\text{COONa}^+$  (water-loving)
- **Hydrophobic tail:** Long carbon chain (water-hating)

#### Cleaning Action of Soap

1. Soap molecules form micelles in water
2. Hydrophobic tails trap dirt and oil
3. Hydrophilic heads remain in water
4. Dirt is washed away with water

#### Disadvantages of Soaps

- Don't work well in hard water
- Form insoluble precipitates with  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  ions
- Not effective in acidic conditions

#### Detergents

- Synthetic cleaning agents
- Work well in hard water
- More effective than soaps
- Examples: Sodium lauryl sulfate

#### Advantages of Detergents

- Effective in hard water
- Work in acidic conditions
- Better cleaning action
- Don't form precipitates

## 8. Chemical Reactions of Carbon Compounds

### 1. Combustion Reactions

**Complete combustion:**  $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} + \text{Heat}$

**Incomplete combustion:**  $2\text{CH}_4 + 3\text{O}_2 \rightarrow 2\text{CO} + 4\text{H}_2\text{O} + \text{Heat}$

### 2. Oxidation Reactions

**Oxidation of alcohols:**

- Primary alcohol  $\rightarrow$  Aldehyde  $\rightarrow$  Carboxylic acid
- Secondary alcohol  $\rightarrow$  Ketone

### 3. Addition Reactions

**Hydrogenation:**  $\text{C}_2\text{H}_4 + \text{H}_2 \rightarrow \text{C}_2\text{H}_6$  (Ni catalyst)

**Addition of water:**  $\text{C}_2\text{H}_4 + \text{H}_2\text{O} \rightarrow \text{C}_2\text{H}_5\text{OH}$  (in presence of acid)

### 4. Substitution Reactions

**Halogenation of alkanes:**  $\text{CH}_4 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{HCl}$  (in presence of sunlight)

## 9. Life Processes and Carbon Compounds

### Photosynthesis

$6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$  (in presence of sunlight and chlorophyll)

### Respiration

$\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{ATP energy}$

### Importance of Carbon Compounds in Life

- **Carbohydrates:** Energy source (glucose, starch)
- **Proteins:** Body building (amino acids)
- **Fats:** Energy storage and insulation
- **Nucleic acids:** Genetic information (DNA, RNA)

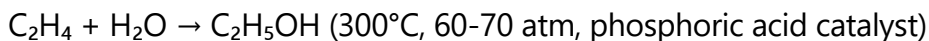
## 10. Important Industrial Processes

### 1. Manufacture of Ethanol

**From sugarcane (Fermentation)**

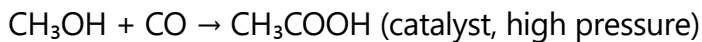
$\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2\text{C}_2\text{H}_5\text{OH} + 2\text{CO}_2$  (yeast enzyme)

### **From ethene (Industrial method)**

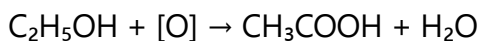


## **2. Manufacture of Ethanoic Acid**

### **From methanol**



### **Oxidation of ethanol**



## **3. Cracking of Hydrocarbons**

Long chain hydrocarbons → Short chain hydrocarbons  
(High temperature and pressure)

## **11. Environmental Impact**

### **Greenhouse Effect**

- $\text{CO}_2$  from combustion of fossil fuels
- Traps heat in atmosphere
- Causes global warming

### **Air Pollution**

- Incomplete combustion produces CO (toxic)
- Burning of fossil fuels releases pollutants
- Formation of smog in cities

### **Solutions**

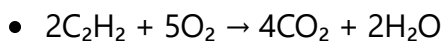
- Use of renewable energy
- Efficient combustion
- Catalytic converters in vehicles
- Alternative fuels (ethanol, biodiesel)

## **12. Key Chemical Equations**

### **Combustion Reactions**

- $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$
- $\text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O}$





## Oxidation Reactions

- $\text{C}_2\text{H}_5\text{OH} + [\text{O}] \rightarrow \text{CH}_3\text{COOH} + \text{H}_2\text{O}$
- $\text{C}_2\text{H}_5\text{OH} + [\text{O}] \rightarrow \text{CH}_3\text{CHO} + \text{H}_2\text{O}$

## Addition Reactions

- $\text{C}_2\text{H}_4 + \text{H}_2 \rightarrow \text{C}_2\text{H}_6$  (Ni catalyst)
- $\text{C}_2\text{H}_4 + \text{Br}_2 \rightarrow \text{C}_2\text{H}_4\text{Br}_2$
- $\text{C}_2\text{H}_4 + \text{HCl} \rightarrow \text{C}_2\text{H}_5\text{Cl}$

## Substitution Reactions

- $\text{CH}_4 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{HCl}$
- $\text{C}_2\text{H}_6 + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{HCl}$

## Esterification

- $\text{CH}_3\text{COOH} + \text{C}_2\text{H}_5\text{OH} \rightleftharpoons \text{CH}_3\text{COOC}_2\text{H}_5 + \text{H}_2\text{O}$

## Saponification

- $\text{Fat} + 3\text{NaOH} \rightarrow 3\text{Soap} + \text{Glycerol}$

# 13. Structural Formulas

## Alkanes

- **Methane:**  $\text{H}-\text{C}-\text{H}$  (with H above and below C)
- **Ethane:**  $\text{H}_3\text{C}-\text{CH}_3$
- **Propane:**  $\text{H}_3\text{C}-\text{CH}_2-\text{CH}_3$

## Alkenes

- **Ethene:**  $\text{H}_2\text{C}=\text{CH}_2$
- **Propene:**  $\text{H}_3\text{C}-\text{CH}=\text{CH}_2$

## Functional Groups

- **Alcohol:**  $\text{R}-\text{OH}$
- **Aldehyde:**  $\text{R}-\text{CHO}$
- **Ketone:**  $\text{R}-\text{CO}-\text{R}'$
- **Carboxylic acid:**  $\text{R}-\text{COOH}$

## 14. Tests for Carbon Compounds

### Test for Unsaturation

- **Bromine water test:** Unsaturated compounds decolorize orange bromine water
- **Potassium permanganate test:** Decolorizes purple  $\text{KMnO}_4$  solution

### Test for Alcohols

- **Sodium test:** Alcohols liberate hydrogen gas with sodium metal
- $2\text{ROH} + 2\text{Na} \rightarrow 2\text{RONa} + \text{H}_2$

### Test for Carboxylic Acids

- **Litmus test:** Turn blue litmus red
- **Sodium carbonate test:** Liberate  $\text{CO}_2$  gas
- $2\text{RCOOH} + \text{Na}_2\text{CO}_3 \rightarrow 2\text{RCOONa} + \text{H}_2\text{O} + \text{CO}_2$

## 15. Important Points to Remember

1. **Carbon** shows tetravalency and catenation
2. **Homologous series** members have similar properties
3. **Functional groups** determine chemical behavior
4. **Saturated compounds** have only single bonds
5. **Unsaturated compounds** have double or triple bonds
6. **IUPAC naming** follows systematic rules
7. **Ethanol** is neutral but ethanoic acid is acidic
8. **Soaps** don't work in hard water, detergents do
9. **Addition reactions** occur with unsaturated compounds
10. **Substitution reactions** occur with saturated compounds

## 16. Real-life Applications

### Fuels

- **Natural gas:** Mainly methane
- **LPG:** Butane and propane
- **Petrol:** Mixture of hydrocarbons
- **Ethanol:** Biofuel additive

## Plastics

- **Polyethene:** From ethene
- **PVC:** From chloroethene
- **Polystyrene:** From styrene

## Medicines

- **Ethanol:** Antiseptic
- **Ethanoic acid:** In aspirin synthesis
- **Various organic compounds:** Drug molecules

## Food Industry

- **Ethanoic acid:** Vinegar
- **Ethanol:** In food flavoring
- **Esters:** Artificial flavors and fragrances

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*These comprehensive notes cover all essential topics in Carbon and its Compounds for Class 10 Science. Focus on understanding functional groups, chemical reactions, and nomenclature for better exam preparation.*