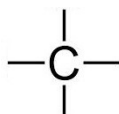


## Carbon and its Compounds

### Bonding in Carbon

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- Carbon atom has four electrons in its outermost shell.
- It requires four electrons to achieve the stable, 8 electron, inert gas configuration.
- Carbon atoms can achieve the inert gas electron arrangement only by sharing their electrons. Hence, carbon always forms covalent bonds.
- The valency of carbon is four since one carbon requires 4 electrons to achieve the nearest inert gas configuration. Thus, we can say that carbon is tetravalent.
- The four valencies of carbon are usually represented by drawing four short lines around the symbol of carbon (C).



### Allotropes of Carbon

- The various physical forms in which an element can exist are called the allotropes of that element.
- Carbon has three allotropes:
  - Diamond
  - Graphite
  - Buckminster fullerene

#### Diamond

- In diamond, each carbon atom is bonded to four other carbon atoms, forming a three dimensional structure.
- The rigid structure of diamond makes it a very hard substance.
- It is a non-conductor of electricity since there are no free electrons in a diamond crystal.
- It can be synthesized by subjecting pure carbon to a very high pressure and temperature.

#### Graphite

- In graphite, each carbon atom is bonded to three other carbon atoms in the same plane, giving a hexagonal array.
- One of the bonds is a double bond and thus the valency of carbon is satisfied.
- Graphite structure is formed by the hexagonal arrays being placed in layers, one above another.
- Graphite is smooth and slippery.
- It is a very good conductor of electricity due to the presence of free electrons.

#### Fullerene

- It is an allotrope of carbon containing clusters of 60 carbon atoms joined together to form spherical molecules.
- There are 60 carbon atoms in a molecule of buckminsterfullerene, so its formula is C<sub>60</sub>.
- The allotrope was named buckminsterfullerene after the American architect Buckminster Fuller.

## Versatile Nature of Carbon

The two characteristic properties of the element carbon which leads to the formation of a very large number of organic compounds are:

- i. **Catenation:** The property of the element carbon due to which its atoms can join one another to form long carbon chains is called catenation.

### Types of Chains

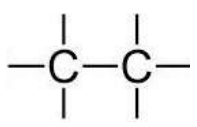
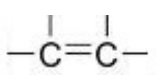
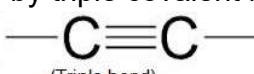
- Straight chain of carbon atoms
- Branched chain of carbon atoms
- Closed or ring chain of carbon atoms

- ii. **Tetravalency:** Carbon has a valency of four. So, it is capable of bonding with four other atoms of carbon or atoms of some other monovalent element.

Compounds of carbon are formed with oxygen, nitrogen, hydrogen, sulphur, chlorine and many other elements, giving rise to compounds with specific properties which depend on the elements other than the carbon present in the molecule.

## Classification of Hydrocarbons

### Comparison of Saturated and Unsaturated Hydrocarbons

Saturated hydrocarbons	Unsaturated hydrocarbons
1. All the four valencies of each carbon atom are satisfied by forming single covalent bonds with carbon and with hydrogen atoms.	1. The valencies of at least two carbon atoms are not fully satisfied by hydrogen atoms.
2. Carbon atoms are joined by a single covalent bond.  (Single bond)	2. Carbon atoms are joined by double covalent bonds.  (Double bond) or by triple covalent bonds.  (Triple bond)
3. They are less reactive due to the non-availability of electrons in the single covalent bond, and therefore, they undergo substitution reaction.	3. They are more reactive due to the presence of electrons in the double or triple bond and therefore undergo addition reaction.

## Cyclic Hydrocarbons

- Hydrocarbons in which the carbon atoms are arranged in the form of a ring are called cyclic hydrocarbons.
- Cyclic hydrocarbons may be saturated or unsaturated.

Saturated cyclic hydrocarbon	Unsaturated cyclic hydrocarbon
<ul style="list-style-type: none"> <li>Cyclohexane is an example of a saturated cyclic hydrocarbon.</li> <li>Formula: <math>C_6H_{12}</math></li> <li>Cyclohexane contains 6 carbon atoms arranged in a hexagonal ring, with each carbon atom attached to 2 hydrogen atoms.</li> </ul>	<ul style="list-style-type: none"> <li>Benzene is an example of an unsaturated cyclic hydrocarbon.</li> <li>Formula: <math>C_6H_6</math></li> <li>Benzene is made up of 6 carbon atoms and 6 hydrogen atoms.</li> </ul>

## Functional Groups

- Functional group:** An atom or a group of atoms present in the molecules, which determines the characteristics property of the organic compounds, is called the functional group.

Functional group	General formulae	Organic compound	Suffix	Examples with common & IUPAC name
Halide-X (F, Cl, Br, I)	R-X	Haloalkanes	-ane	$CH_3Cl$ Common name: Methyl chloride IUPAC name: Chloromethane
Hydroxyl-OH	R-OH	Alcohols	-ol	$C_2H_5OH$ Common name : Ethyl alcohol IUPAC name: Ethanol
Aldehyde-CHO	$\begin{array}{c} H \\ \diagup \\ R - C = O \end{array}$	Aldehydes	-al	$CH_3CHO$ Common name: Acetaldehyde IUPAC name: Ethanal
Carboxyl- COOH	$\begin{array}{c} O \\    \\ R - C - O - H \end{array}$	Carboxylic acids	-oic acid	$CH_3CH_2COOH$ Common name: Propionic acid IUPAC name: Propanoic acid
Keto $\begin{array}{c} O \\    \\ - C - \end{array}$	$\begin{array}{c} O \\    \\ R - C - R' \end{array}$	Ketones	-one	$CH_3COC_2H_5$ Common name: Diethyl ketone IUPAC name: Pentanone
Ethers $\begin{array}{c}   &   \\ - C & - O - C - \\   &   \end{array}$	R-O-R'	Ethers	-oxy	$CH_3 - O - C_2H_5$ Common name: Ethyl methyl ether IUPAC name: Methoxy ethane

## Homologous Series

It is a group of organic compounds having a similar structure and chemical properties in which the successive compounds differ by a  $-\text{CH}_2$  group.

### Characteristics of a Homologous Series

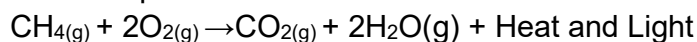
- Each member of the series differs from the preceding one by the addition of a  $-\text{CH}_2$  group and by 14 a.m.u.
- All members of a homologous series have the same general formula.
- The physical properties of the members show a gradation in properties as their molecular mass increases.
- All members of a homologous series can be prepared by the same general method of preparation.

## Chemical Properties of Carbon Compounds

### Combustion

- The process of burning a carbon compound in air to give carbon dioxide, water, heat and light is known as combustion.

For example:



### Oxidation

- Carbon compounds can be oxidised.
- Alcohols on oxidation are converted to carboxylic acids.
- Alkaline  $\text{KMnO}_4$  or acidified  $\text{K}_2\text{Cr}_2\text{O}_7$  are used as oxidising agents.

### Addition Reaction

- This reaction occurs only in unsaturated compounds, where there are double or triple bonds.
- The addition of hydrogen to an unsaturated hydrocarbon to obtain a saturated hydrocarbon is called hydrogenation.
- The process of hydrogenation is used in industries to prepare vegetable ghee (or vanaspati ghee) from vegetable oils.

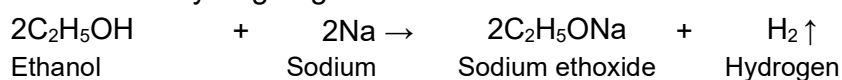
### Substitution Reaction

- The reaction in which one or more hydrogen atoms of a hydrocarbon are replaced by atoms of other elements is called a substitution reaction.
- Substitution reactions are a characteristic property of saturated hydrocarbons.

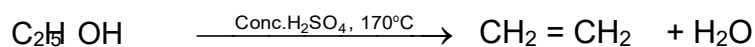
## Some Important Carbon Compounds – Ethanol & Ethanoic Acid

### Properties of Alcohols

- **Reaction with Sodium:** Sodium reacts steadily with ethanol to form sodium ethoxide along with the evolution of hydrogen gas.



- **Dehydration:** Ethanol, on heating with excess of conc.  $\text{H}_2\text{SO}_4$  at  $170^\circ\text{C}$  gets dehydrated to form ethene.

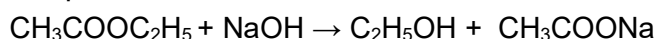


## Properties of Ethanoic acid

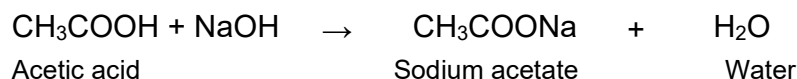
- **Esterification:** Ethanoic acid reacts with alcohols in the presence of a little conc. sulphuric acid to form esters.



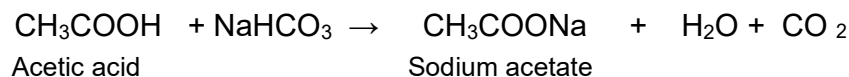
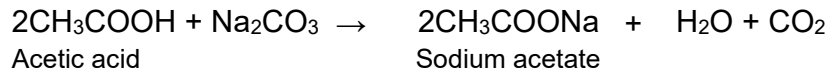
The ester, on treating with a base such as  $\text{NaOH}$  is converted back to alcohol and sodium salt of carboxylic acid. This reaction is known as saponification because it is used in the manufacture of soap.



- **Reaction with a base:** Ethanoic acid reacts with a base such as sodium hydroxide to form a salt and water.



- **Reaction with Carbonates & bicarbonates:** Acetic acid reacts with carbonates and bicarbonates to form salt, water and carbon dioxide.



## Soaps & Detergents

- Soaps are cleansing agents capable of reacting with water and dislodging the unwanted particles from clothes or skin.
- The molecules of soap are sodium or potassium salts of long chain carboxylic acids.
- A soap molecule has a tadpole shaped structure.
- At one end (long non-polar end) of the soap molecule is a hydrocarbon chain which is insoluble in water but soluble in oil.
- At the other end (short polar end) of the soap molecule, there is a carboxylate ion which is hydrophilic i.e. water soluble but insoluble in oil.

