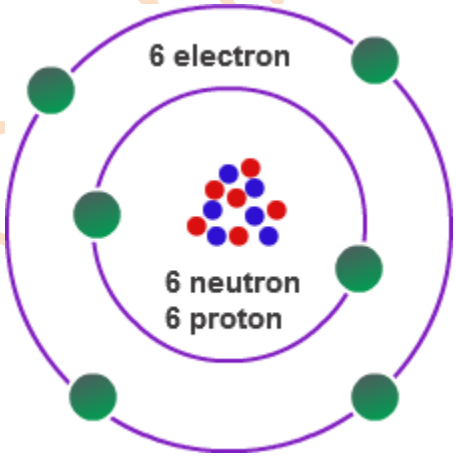
Carbon Compounds

Introduction

- A compound is a substance formed when two or more elements are chemically joined.
- The compounds are classified into the following two groups:
    1. Organic Compounds
        - Organic compounds are compounds obtained directly or indirectly from animals as well as plants.
        - E.g. Carbohydrate, Proteins, Fats, etc.
    2. Inorganic Compounds
        - Compounds derived from minerals, not living organisms, are called inorganic compounds.
        - E.g. Fe, Na, Cl, Mg, etc.
- It was said that only nature could produce organic compounds, but in 1820, scientist Friedrich Wöhler developed urea from an inorganic compound called ammonium cyanate in a laboratory.
- In 1845, Acetic Acid was produced in a laboratory by Hermann Kolbe.
- This changed the definition of organic compound after some time. In the definition, it is said that carbon compounds are called organic compounds. This is because carbon is the main component in organic compounds.

Carbon

- Carbon has 6 protons, 6 neutrons and 6 electrons.



- The outermost orbitals of a carbon have 4 electrons, which share with the electrons of another element.
- The bond formed by sharing with another atom is called covalent bond.
- Carbon molecules form different compounds by forming covalent bonds.
- E.g. CH_4

Hydrocarbons

- All carbon compounds having carbon and hydrogen are known as hydrocarbons.
- There are two main types of carbon compounds:

Saturated Hydrocarbon	Unsaturated Hydrocarbon
Formation: naturally + artificially	Formation: artificially
$C-C$ & $C-H$ (Single bond)	$C=C$ / $C\equiv C$ & $C-H$
A. Alkane group Formula: C_nH_{2n+2}	B. Alkene group for $C=C$ Formula: C_nH_{2n} C. Alkyne group for $C\equiv C$ Formula: C_nH_{2n-2}

Saturated Hydrocarbon

- In a hydrocarbon molecule in which all the carbon atoms are connected to another carbon atom by a single bond. They are the simplest class of hydrocarbons. They are called saturated because each carbon atom is bonded to as many hydrogen atoms as possible.
- The group of hydrocarbons that are produced naturally as well as synthetically is known as Alkane.

A. Alkane group

Formula: C_nH_{2n+2}

E.g.

$$n=1 \text{ --> } CH_4 - Methane$$

$$n=2 \text{ --> } C_2H_6 - Ethane$$

$$n=3 \text{ --> } C_3H_8 - Propane$$

$$n=4 \text{ --> } C_4H_{10} - Butane$$

$$n=5 \text{ --> } C_5H_{12} - Pentane$$

Methane CH_4

Found

- ➔ Methane is found naturally as well as synthetically.
- ➔ Natural Gas contains 97-98% methane.
- ➔ Methane is found naturally in swamps, paddy fields and biogas. Archaebacteria that produce methane in this area
- ➔ Methane is synthetically produced from Sodium Acetate, Soda lime, Aluminium Carbide.

Properties

- ➔ It is in a gaseous state.
- ➔ Methane is colourless.
- ➔ Dissolves to some extent in water.
- ➔ Is flammable and generates heat.

Usage

- ➔ Used as fuel.
- ➔ It is used for the production of acetylene.

Unsaturated Hydrocarbon

- Not found naturally.
- These are only artificially created in the laboratory.
- When double or triple bonds are formed in carbon-carbon, the compound is called unsaturated hydrocarbon.
- Unsaturated Hydrocarbon falls into two groups:

B. Alkene group

- Alkene can only be prepared artificially. It is not found naturally.
- The compound in Alkene should have at least one Carbon-Carbon double bond.
  Formula: C_nH_{2n}

E.g.

$$n = 2 \; --> \; C_2H_4 \; - Ethene/Ethylene$$

$$n = 3 \; --> \; C_3H_6 \; - \; Propene$$

$$n = 4 \; --> \; C_4H_8 \; - Butene$$

Ethylene C_2H_4

Found

- ➔ Ethylene is produced in the laboratory with the help of alcohol.

Properties

- ➔ It is in a gaseous state.
- ➔ It is colourless.
- ➔ Does not dissolve in water
- ➔ It is flammable.
- ➔ More active than methane

Usage

- ➔ For the manufacture of polythene
- ➔ To ripen the fruits

C. Alkyne group

- This is Unsaturated Hydrocarbon.

- Can only be created artificially.
- Carbon - Carbon has a triple bond.
  Formula: C_nH_{2n-2}

  E.g.

$$n = 2 \; --> \; C_2H_2 \; - \; Acetylene$$

$$n = 3 \; --> \; C_3H_4 \; - Propyne$$

$$n = 4 \; --> \; C_4H_6 \; - Butyne$$

Acetylene C_2H_2

Found

- ➔ Can only be created artificially.
- ➔ Acetylene is produced from coal, limestone and water.
- ➔ Acetylene can be produced from methane.

Properties

- ➔ It is in a gaseous state.
- ➔ Is colourless.
- ➔ Does not dissolve in water.
- ➔ Is flammable.
- ➔ Methane is more active than ethylene

Usage

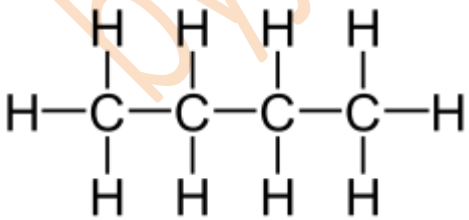
- ➔ Used in welding work.

Structural types of hydrocarbons

A. Aliphatic Hydrocarbon

Structure: Plain and simple

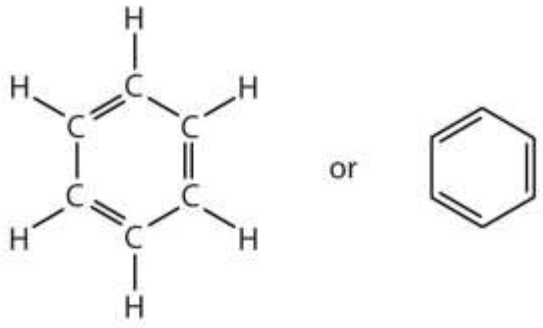
E.g. Alkane, Alkene, Alkyne, etc.



B. Aromatic Hydrocarbon

Structure: Ring

E.g. Benzene, Methylbenzene, Naphthalene, etc.



Carbon Compounds Containing Functional Groups

A. Alcohol

Functional Unit: $\boldsymbol{Aliphatic\ Hydrocarbon\ -\ OH}$

E.g. Methanol, Ethanol, 1-propanol, etc.

➔ If hydrogen is removed from aliphatic hydrocarbon and the OH group is added, the newly formed compound is alcohol.

1. CH_3OH(Methanol or Methyl Alcohol)
   - This is called Wood Grain Alcohol.
   - It is toxic.
   - Usage:
     - In the dry cleaner.
     - In the fragrant air
     - Methyl alcohol is added to make it unfit for drinking.
2. C_2H_5OH(Ethyl Alcohol)
   - It is used in fuel. E.g. E15 is gasoline with 15% ethanol content.
   - Ethyl Alcohol is an important component of drinking alcohol.
     - Bear - 8%, Wine - 15%, Whiskey - 45%, Vodka - 40%, Desi - 48%

B. Phenol

Functional Unit: $\boldsymbol{Aromatic\ Hydrocarbon\ -\ OH}$

Eg. Benzyl alcohol - C_6H_5OH

- Both Phenol and Alcohol have the -OH group, but phenol is acidic and alcohol is Neutral.
- Usage:
  - Dettol is an antiseptic phenol.
  - for the manufacture of Aspirin drugs.
  - 2, 4- D is a herbicide phenol.
  - Phenols are used in the manufacture of carbaldehyde.

C. Ether

Functional Unit: $-\boldsymbol{O}-\boldsymbol{R}\ \boldsymbol{or}\ -\boldsymbol{O}-\boldsymbol{CH_3}$

Eg. Methoxy Ether $CH3-\boldsymbol{O}-\boldsymbol{CH_3}$

- An ether is an organic compound that contains two alkyl or aryl groups by an oxygen atom.
- Usage:
  - To anesthetize. Nitrous Oxide is used in conjunction with Ether. Earlier Chloroform was used for anaesthesia, but since it is toxic, Ether is used.
  - The mixture of Ether and Ethyl Alcohol is called Natalite (used as a substitute for petrol)

D. Aldehyde

Functional Unit: $\boldsymbol{R}-\boldsymbol{CHO}$

Eg. Formaldehyde - CH_2O (methanol), Acetaldehyde - CH_3CHO (ethanal), etc.

E. Ketone

Functional Unit: $R-\boldsymbol{CO}-\boldsymbol{R}$

Eg. Acetone CH_3COCH_3

F. Carboxylic Acid

Functional Unit: $\boldsymbol{R}-\boldsymbol{CO}-\boldsymbol{OH}$

Eg. Acetic acid (CH_3COOH), Formic acid ($HCOOH$), etc.

G. Esters

Functional Unit: $\boldsymbol{R}-\boldsymbol{CO}-\boldsymbol{OR}$

Eg. Butyl Acetate -$CH_3COOC_4H_{10}$

H. Amides

Functional Unit: $\boldsymbol{R}-\boldsymbol{CO}-\boldsymbol{NH_2}$

Eg. Acetamide - $CH_3CO\boldsymbol{NH_2}$

Allotropes of Carbon

- When the same elements form different substances by combining in different ways, then those substances are allotropes of those elements.

A. Graphite

- ➔ It has 3 Carbons attached to one Carbon.
- ➔ Shape: Graphite is hexagonal in shape.
- ➔ Graphite is composed of layers.
- ➔ The bond between the two layers of graphite is very weak, so the graphite is soft.
- ➔ The structure of graphite is 2D.

- ➔ Graphite has a free electron, so graphite can conduct electricity.
- ➔ Usage: in pencil, as electrode, etc.

B. Diamond

- ➔ Diamond consists of 4 Carbons attached to one Carbon.
- ➔ Shape - Square
- ➔ The structure of a diamond is Network or 3D.
- ➔ It is harder than graphite.
- ➔ There are no free Electron, so the current cannot flow.
- ➔ Uses: for cutting glass, as or in jewellery, etc.

C. Fullerene (C-60) - Buckminsterfullerene

- ➔ C60 is a molecule consisting of 60 carbon atoms, composed of 12 pentagons and 20 hexagons.
- ➔ 3 Carbons are attached to one Carbon.
- ➔ The shape is similar to a soccer ball.
- ➔ The structure of a Fullerene is 3D.
- ➔ There are free electrons in Fullerene, thus allows conduction of electricity.