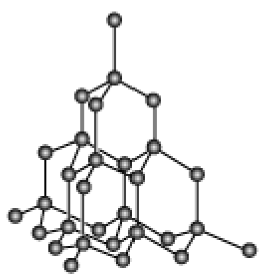
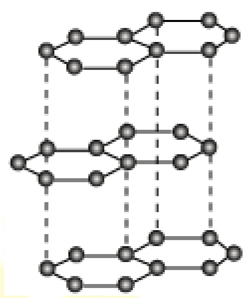
# 4. Carbon and Its Compounds

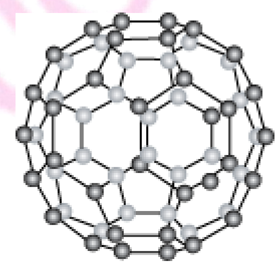
- Covalent bonds
  - The bonds formed by the sharing of electrons are known as covalent bonds.
  - In covalent bonding, both the atoms (that are participating in the bonding) share electrons, i.e., the shared electrons belong to both the atoms.
  - Carbon contains four electrons in its valence shell. It always forms covalent bonds as it is difficult for it to lose or gain four electrons in order to complete its octet.
- Allotropes of Carbon
  - Allotropes have different appearances and physical properties, but chemically they are the same.
  - There are three allotropes of carbon: diamond, graphite, and buckminsterfullerene.



Diamond



Graphite



Buckminsterfullerene

- **Catenation**
  - Catenation is the ability of an element to combine with itself through covalent bonds.
  - Carbon shows extensive catenation, giving rise to large number of compounds.
  - It can form strong single, double, and triple bonds with other atoms of carbons. Carbon can combine with itself to form chain, branched, and ring structures.
- **Hydrocarbons**
  - The compounds made up of only carbon and hydrogen are called hydrocarbons.
  - The compounds of carbon that contain only single bonds among carbon atoms are called saturated compounds
  - Compounds containing double and triple bonds among carbon atoms are called unsaturated compounds.
  - If the hydrocarbons are saturated (like methane and ethane), then they are called alkanes; if they are unsaturated, then they are alkenes (containing double bonds) and alkynes (containing triple bonds).

## ➢ Functional groups

- Carbon also forms covalent bonds with oxygen, nitrogen, and sulphur atoms.
- Presence of any of these elements in a compound confers specific properties to the compound.
- A group of atoms that imparts specific properties to hydrocarbons is called a functional group.

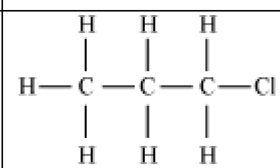
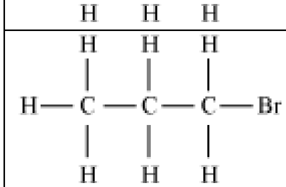
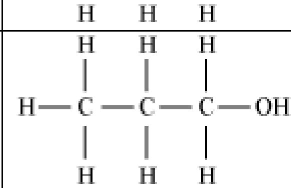
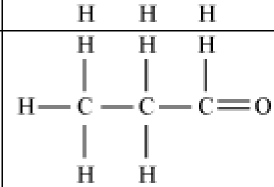
## ➢ Homologous series

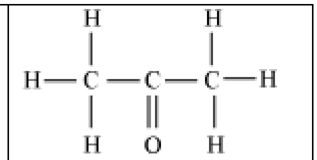
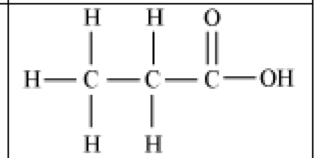
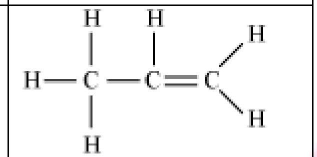
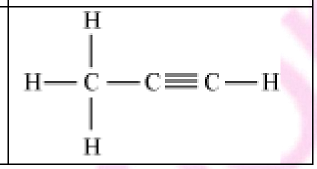
A homologous series is a series of carbon compounds having different numbers of carbon atoms, but containing the same functional group. Some functional groups in carbon compounds are shown in the given table.

| Hetero atom | Name of functional group | Formula of functional group |
|---|---|---|
| Chlorine/Bromine | Halo- (Chloro/Bromo) | –Cl, –Br |
| Oxygen | Alcohol | –OH |
| | Aldehyde | –CHO |
| | Ketone | >C=O |
| | Carboxylic acid | –COOH |

## ➢ Nomenclature of organic compounds

- The nomenclature of organic compounds is done by using a set of rules. Names of some common compounds are shown in the given table.

| Functional group | Prefix/Suffix | Example |
|---|---|---|
| 1. Halogen | Prefix: chloro, bromo, etc. | <br> |
| 2. Alcohol | Suffix: -ol |  |
| 3. Aldehyde | Suffix: -al |  |

| | | |
|---|---|---|
| 4. Ketone | Suffix: -one |  |
| 5. Carboxylic acid | Suffix: -oic acid |  |
| 6. Double bond (alkenes) | Suffix: -ene |  |
| 7. Triple bond (alkynes) | Suffix: -yne |  |

- **Chemical properties of carbon compounds**
  - **Combustion reaction**:
    - Carbon burns in air to form carbon dioxide and hydrocarbons burn in air to give carbon dioxide and water. Heat and light are also released in these processes.

      $C + O_2 \longrightarrow CO_2$

      $CH_4 + O_2 \longrightarrow CO_2 + H_2O$ + Heat and light

      $CH_3CH_2OH + O_2 \longrightarrow CO_2 + H_2O$ + Heat and light
  - **Oxidation reaction**:
    - Combustion of carbon to form carbon dioxide is an oxidation reaction. When alcohols are oxidised, carboxylic acids are obtained.

      $CH_3CH_2OH \xrightarrow[\text{Heat}]{\text{Alkaline } KMnO_4} CH_3COOH$
  - **Addition reaction**:
    - Unsaturated hydrocarbons yield saturated hydrocarbons when reacted with hydrogen in the presence of catalysts.

      $RCH = CHR \xrightarrow[H_2]{\text{Nickel catalyst}} RCH_2 - CH_2R$
  - **Substitution reaction**:
    - Under specific conditions, hydrogen atoms present in hydrocarbons can be replaced by atoms of other elements like chlorine and bromine.

$$CH_4 + Cl_2 \xrightarrow{\text{in presence of sunlight}} CH_3Cl + HCl$$

- **Ethanol** (alcohol), $CH_3CH_2OH$:
  - Liquid at room temperature
  - It is a good solvent
  - Soluble in water in all proportions
  - Chemical properties of ethanol

$$2\,Na + 2\,CH_3CH_2OH \longrightarrow 2\,CH_3CH_2O^-Na^+ + H_2$$

Sodium ethoxide

$$CH_3CH_2OH \xrightarrow[H_2SO_4]{\text{Hot conc.}} CH_2 = CH_2 + H_2O$$

Ethene

- **Ethanoic acid** (acetic acid), $CH_3COOH$:
  - Its melting point is 290 K
  - 5-8% solution of acetic acid is known as Vinegar
  - It is a weak acid
  - Chemical properties of ethanoic acid

Esterification reaction :

$$CH_3CH_2OH + CH_3COOH \xrightarrow{\text{Acid}} CH_3COOCH_2CH_3$$

Ethanol    Ethanoic acid    Ester

- Esters react in the presence of an acid or a base to give back alcohol and carboxylic acid as follows:

$$CH_3COOC_2H_5 \xrightarrow{NaOH} C_2H_5OH + CH_3COOH$$

Ethyl ethanoate    Ethanol    Ethanoic acid

- This reaction is used in the preparation of soaps and is known as saponification reaction.

$$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$$

Sodium ethanoate

$$2\,CH_3COOH + Na_2CO_3 \longrightarrow 2\,CH_3COONa + H_2O + CO_2$$

Sodium ethanoate

$$CH_3COOH + NaHCO_3 \longrightarrow CH_3COONa + H_2O + CO_2$$

Sodium ethanoate

- **Cleansing action of soaps and detergents**

- The two ends of molecules of soaps and detergents are different. Their one end is hydrophilic and the other is hydrophobic.
- When soap molecules are present in water, the molecules arrange themselves in the form of a cluster called a micelle.
- Soap does not work properly when water is hard. This is primarily because hard water contains salts of calcium and magnesium. When soap is added to hard water, it reacts with these salts to form an insoluble substance called **scum.**

☺ * ☺ * ☺