INTRODUCTION and CLASSIFICATION

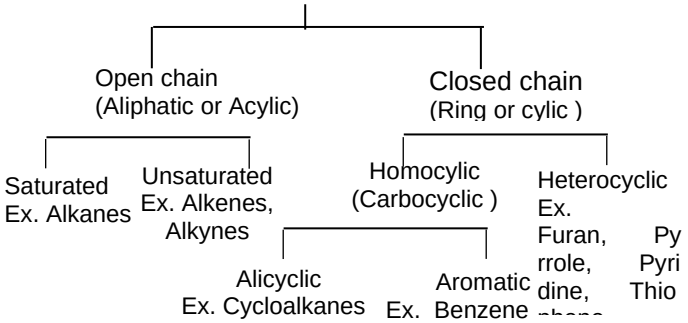
1. Based on their source, chemical compounds are classified into 3 types by Lemery:

   i) Mineral source ii) Vegetable source

   iii) Animal source

Vital force theory :

- Lavoiser found that the compounds from vegetable and animal sources contain similar composition.
- Then Berzelius classified the above 3 types into 2 types and he coined the new terms Organic and Inorganic.
  i) Organic compounds: These are present in living beings (plants, animals etc.)
  ii) Inorganic compounds: These are present in minerals
- But now based on the structure and chemical behaviour, the compounds are classified as
  i) Organic compounds ii) Inorganic compounds
- Organic compounds are carbon compounds and the study of chemistry of carbon compounds is called organic chemistry.



- Organic compounds contain Carbon, Hydrogen, essentially and Oxygen, Nitrogen, Sulphur, Phosphorus, Halogen etc frequently.
- Father of organic chemistry is Wohler who synthesized the first organic compound in laboratory from inorganic substances.

$$NH_4Cl + KCNO \xrightarrow{-KCl} \underset{\text{ammonium cyanate}}{NH_4CNO} \xrightarrow{\Delta} NH_2-\underset{\underset{O}{\|}}{C}-NH_2$$

- With the synthesis of urea vital force theory of Berzelius was discarded, according to which organic compounds cannot be synthesized without any vital force.
- Kolbe synthesised CH_3COOH from its elements.
- Berthelot synthesised CH_4
- Carbon is tetravalent as it contains four unpaired electrons in its excited state configuration. The tetravalency of carbon was given by Vanthoff and Lebel who were awarded the first nobel prize in chemistry.
- Ground state configuration of 'C' **:**

$$_6C \rightarrow 1s^2 2s^2 2p_x^1 2p_y^1 2p_z^0$$

Excited state configuration of 'C' **:**

$$_6C \rightarrow 1s^2 2s^1 2p_x^1 2p_y^1 2p_z^1$$

Carbon alone forms about 10 millions of organic compounds where as the remaining elements together could form just about 50000 compounds.

Largest number of compounds formed by carbon because of its marked features.

1) Highest catenation
2) Tetravalency
3) Ease of formation of multiple bonds

- Natural sources of organic compounds are coal, petroleum, natural gas, animals and plants.

Classification of organic compounds:

Classification based on carbon chain:

Carbon compounds are classified into various types based on the nature of functional groups:

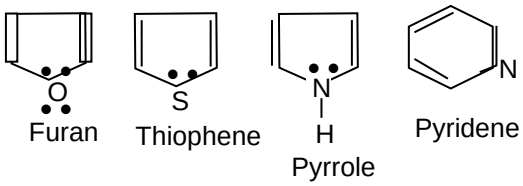
Name	**Formula**	**Functional group**	**Name of the functional group**
1) Alkanes (paraffins)	R – H	→C–C←	Single bond
2) Alkenes (olefins)	R–CH =CH_2	> C = C<	Double bond
3) Alkynes (acetylenes)	R – C ≡ CH	–C ≡ C –	Triple bond
4) Alkyl halides (Haloalkanes)	R – X	–X	Halogen
5) Alcohols (Alkanols)	R – OH	–OH	Hydroxy
6) Ethers	R –O–R	– O –	Ether
7) Amines (Amino alkanes)	R – NH_2	– NH_2	Amino
8) Aldehydes (Alkanals)	R – CHO	– CHO	Aldehyde

9) Ketones (Alkanones)	R –CO– R	> C = O	Keto
10) Carboxylic acids(Alkanonic acids)	R – COOH	– COOH	Carboxyl
11) Esters (Alkyl alkanoates	R – COOR	– COOR	Ester
12) Amides	R – $CONH_2$	–$CONH_2$	Amide
13) Cyanides	R – CN	– CN	Cyanide
14) Nitro compounds	R – NO_2	– NO_2	Nitro
15) Sulphonic acids	R – SO_3H	–SO_3 H	Sulphonic Acid

- **Open chain compounds:** Carbon atoms are linked to one another to form straight chains or branched ones but not rings.
- Open chain compounds are also called aliphatic compounds. Ex: Alkanes, alkenes, alkynes and their derivatives.
- **Cyclic compounds:** Carbon atoms are linked to one another to form ring.
- Based on the number of rings, they may be monocyclic or polycyclic.

  Homocyclic: Ring is formed by carbon atoms only. Ex: Benzene, Phenol, Toluene, Cyclopropane etc.

  Heterocyclic: Along with carbons some hetero atom like, N, O, S, P, etc is involved in forming the ring.

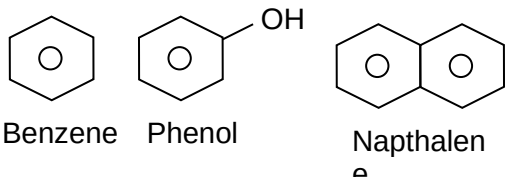


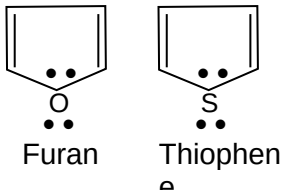
Alicyclic: These are cyclic compounds but resemble open chain compounds in properties. Ex.: Cycloalkanes, cycloalkenes, cycloalkynes

Aromatic: The ring compounds which resemble benzene in structure and properties are called aromatic compounds.

- These may be homocyclic or heterocyclic.

  Ex.:





Bonding in carbon compounds :

- In all its compounds, carbon undergoes only 3 types of hybridization i.e. sp, sp^2 and sp^3.
- The tetravalency of carbon is possible in its excited state configuration, as it contains four unpaired electrons
- The energy required for the promotion of electron from 2s orbital to 2p orbital is 501.6 kJ/mol.
- sp^3 hybridization is found in alkanes. sp^3 hybrid carbon forms four single bonds or four sigma bonds. The ratio of s – character to p – character in each sp^3 hybrid orbital is 1 : 4. sp^3 hybrid carbon forms C – C and C – H bonds. Shape of the molecule is tetrahedral and bond angle is 109°.
- sp^2 hybridisation is found in alkenes. sp^2 hybrid carbon forms 3 sigma bonds and 1pi bond or one double bond and two sigma bonds. The ratio of s – character to p – character in sp^2 hybrid orbital is 1 : 2. Shape of molecule is trigonal planar and bond angle is 120°.
- sp hybridisation is found in alkynes and cumulative dienes. SP hybrid carbons forms 2σ and 2 bonds i.e. 1 triple and 1 single or 2 double bonds.
- The ratio of s character to p character in sp hybrid orbital is 1 : 1.
- Shape of molecule is linear and bond angle is 180°.

Bond energy order:

i) $-C\equiv C- > -\underset{|}{\overset{|}{C}}=\underset{|}{\overset{|}{C}}- > -\underset{|}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}-$

ii) $-\underset{|}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}- < -\underset{|}{\overset{|}{C}}-H$

iii) $H-C\equiv > H-\underset{|}{C} = > H-\underset{|}{\overset{|}{C}}-$

Bond length order:

i) $-C\equiv C- < -\underset{|}{C}=\underset{|}{C}- < -\underset{|}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}-$

ii) $-\underset{|}{\overset{|}{C}}-H < -\underset{|}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}-$

iii) $H-C\equiv < H-\underset{|}{C} = < H-\underset{|}{\overset{|}{C}}-$

Bond energy data:

For $-\underset{|}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}-$ bond = 341.1 kJ /mol

For $-\underset{|}{C}=\underset{|}{C}-$ bond = 610.7 kJ/mol

For - $C\equiv C$ - bond = 827.64 kJ/mol

For $-\underset{|}{\overset{|}{C}}-H$ bond in alkanes = 415.9 kJ /mol

For = $\underset{|}{C}-H$ bond in alkenes = 443.08 kJ / mol^{-1}

For $\equiv C$ - H bond in alkynes = 505.78 kJ /mol^{-1}

Bond length data:

For $C-C$ bond = 1.54 A°

For $C=C$ bond = 1.34 A°

For $C\equiv C$ bond = 1.20 A°

For $-\underset{|}{\overset{|}{C}}-H$ bond in alkanes = 1.09 A°

For $=\underset{|}{\overset{|}{C}}-H$ bond in alkenes = 1.08 A°

For $\equiv C-H$ bond in alkynes = 1.06 A°

Homologous series :

- The series of organic compounds having a common difference of – CH_2 between any two successive members is called homologous series.
- The classification and study of the members of the homologous series is called homology and the members of the series are called homologues.

Characteristic features of homologous series :

i) There is a common difference of – CH_2 between two successive members. There is a common difference of 14 in molecular weight between two successive members.
ii) They possess similar chemical properties.
iii) There is regular gradation in their physical properties
iv) They can be prepared by similar methods.
v) They can be represented by a general molecular formula.

Ex. Alkanes – C_nH_{2n+2}

Alkenes – C_nH_{2n}

Alkynes – $C_n H_{2n-2}$

Alkyl halides – C_nH_{2n+1} "X"

Alcohols and ethers – $C_nH_{2n+2}O$

Aldehydes and ketones – $C_nH_{2n}O$

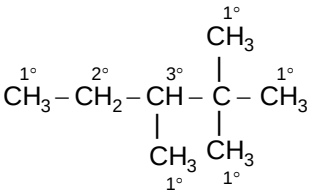
Carboxylic acids and esters – $C_nH_{2n}O_2$

Types of Carbons and Hydrogens :

- **Primary Carbon (1° – carbon) :** It is bonded to just one another carbon or to no other carbon.
- **Secondary carbon (2° – carbon) :** It is bonded to two other carbons.
- **Tertiary carbon (3° – carbon)** – It is bonded to three other carbons.
- **Quaternary carbon (4° carbon) :** It is bonded to four other carbons.

Types of hydrogens :

- **Primary hydrogen :** Hydrogen attached to primary carbon.
- **Secondary hydrogen :** Hydrogen attached to secondary carbon.
- **Tertiary hydrogen :** Hydrogen attached to tertiary carbon.

Ex. 

In the above structure, five primary carbons, one secondary carbon, one tertiary carbon and one quaternary carbon are present. Similarly, the number of primary hydrogens – 15, secondary hydrogens – 2, tertiary hydrogen – 1, and there is no quaternary hydrogen.