C. ORGANIC CHEMISTRY

Chapter-9 Hydrocarbons

* **Introduction:** Organic chemistry may be defined as the branch of Chemistry which deals with the study of covalently bonded compounds of Carbon, except the oxides of carbon (CO, CO_2), carbonates, nitrides bicarbonates, carbides (Na_2CO_3, $NaHCO_3$, NaCN, KCN, CaC_2, etc) of certain metals. ~~is called organic chemistry~~.

Till 18th century, it was believed that organic compounds cannot be prepared in laboratories and there is an unseen supernatural force called "vital force" which guides the formation of organic compounds.

In 1828, a German chemist named Wohler for the first time prepared an organic compound in laboratory. He heated ammonium cyanate, an inorganic compound and got the rearranged product "urea" which is purely an organic compound.

$$NH_4CNO \xrightleftharpoons{\Delta} NH_2CONH_2$$

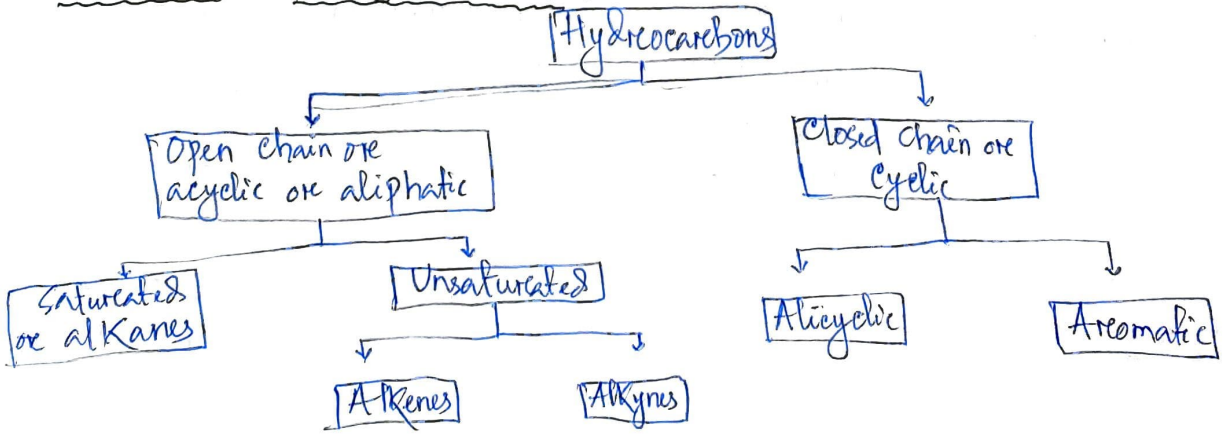
(Ammonium cyanate) (Urea)

Later, Berthelot synthesized methane (CH_4) starting from the carbon and hydrogen. Again, Lavoisier synthesized acetic acid (CH_3COOH) starting from the constituent elements C, H and O. Soon after these syntheses, the whole idea about organic chemistry has changed and the "vital force theory" got a strong blow.

* **Hydrocarbons:**

The compounds containing carbon and hydrogen are called hydrocarbons. For example: CH_4, C_2H_6, C_2H_4, C_2H_2, C_6H_6 etc.

* **Classification of hydrocarbons:**



* **Saturated hydrocarbons :**

These are the hydrocarbons containing C–C single bonds only. Example : Alkanes ; Methane, Ethane, propane, butane etc.

* **Unsaturated hydrocarbons ;**

These are the hydrocarbons containing carbon-carbon multiple bonds (C=C, C≡C).

Example : Alkenes (ethene, propene butene etc.) & alkynes (ethyne, propyne etc.)

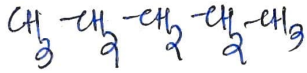
Distinction between saturated and unsaturated hydrocarbons

Sl. No	Saturated hydrocarbons	Unsaturated hydrocarbons
1.	Contain carbon-carbon single bonds and C–H bonds.	Contain carbon-carbon multiple bonds (C=C and C≡C).
2.	Less reactive	more reactive
3.	Burn with blue flame.	Burn with sooty flame.
4.	Show substitution reaction	Show addition reaction
5.	Contain only sigma bonds	Contain both sigma and pi bonds.
6.	Examples : Alkanes	Examples : Alkenes and Alkynes

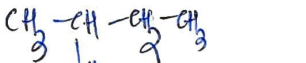
* **Aliphatic hydrocarbons :**

The open chained hydrocarbons are called aliphatic hydrocarbons or acyclic hydrocarbons. These may be straight chain or branched chain

Example :



n-pentane



2-Methylbutane

* **Aromatic hydrocarbons :**

These are the closed chain or cyclic hydrocarbons. They obey Huckel's rule of aromaticity.

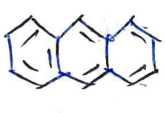
⇒ **Huckel's Rule of Aromaticity :-**

The cyclic hydrocarbon containing $(4n+2)$ π electrons in which single and double bonds are present in alternate positions is called an aromatic hydrocarbon ; where $n = 0, 1, 2, 3$ etc. whole no.

For Example :

Benzene

Naphthalene



Anthracene

* Distinction between Aliphatic and Aromatic compounds:

Sl. No.	Aliphatic compounds	Aromatic compounds
1.	Open chain or Acyclic hydrocarbons.	Cyclic hydrocarbons containing $(4n+2)\pi$ electrons in which single and double bonds are present in alternate positions.
2.	Do not obey Huckel's rule.	Obey Huckel's rule
3.	No pleasant odour.	Pleasant odour.
4.	Alkanes burn with non-sooty flame.	Burn with sooty flame.
5.	Examples: Alkanes, Alkenes, Alkynes.	Example: Benzene, Naphthalene, Toluene

* IUPAC System of Nomenclature :-

IUPAC stands for "International Union of Pure and Applied Chemistry". According to this system, an organic compound may contain the following parts.

1. Root word
2. Prefix
3. Primary suffix
4. Secondary suffix

1. Root word: It refers to the no. of Carbon atoms present in the parent chain of an organic compound.

No. of C atom	Root word	No. of C atom	Root word
1	Meth	6	Hex
2	Eth	7	Hept
3	Prop	8	Oct
4	But	9	Non
5	Pent	10	Dec

2. Prefix: It refers to the presence of substituent or side chain in the parent chain of an organic compound. Some groups that act as a substituent or side chain are:

Group	Prefix
-F	Fluoro-
-Cl	Chloro-
-Br	Bromo-
-I	Iodo-
$-NO_2$	Nitro-
-R	Alkyl-
-OR	Alkoxy-

3. Preimarey Suffix : It reeferes to the preesence of (c-c), (c=c), (c≡c) in the compound.

Nature of Bond	Preimarey suffix
All c-c bond	-ane
One c=c	-ene
Two c=c bond	-a..... diene
Three c=c bond	-a..... treiene
one c≡c bond	-yne
Two c≡c bond	-a..... diyne

4. Secondarey Suffix : It reeferes to the preesence of funetional greoups in the compounds.

Funetional group	Secondarey suffix
Alcohol (-OH)	-ol
Aldehyde (-CHO)	-al
Ketone (-CO)	-one
Careboxylie aeid (-COOH)	-oie aeid
Amine ($-NH_2$)	-amine
Aeid amide ($-CONH_2$)	-amide
Aeid chloreide (-COCl)	-oyl chloreide

* Class of Compounds :

(i) AlKanes
(ii) AlKenes
(iii) AlKynes
(iv) AlKyl halides
(v) Alcohol.

1. AlKanes : These aree the saturaeted hydroeaerbons in whieh the eaerbon atoms aree linKed by single bonds (c-c). These aree also eaelled Paeraffins.

Geneeral foremula : C_nH_{2n+2}, where 'n' is the no. of eaerbon atoms.

Preimarey suffix : -ane

Example : CH_4 - Methane (H-C(H)(H)-H)
C_2H_6 - Ethane (CH_3-CH_3)
C_3H_8 - Propane ($CH_3-CH_2-CH_3$)

2. AlKenes : These aree the unsaturaeted hydroeaerbons whieh have a eaerbon-eaerbon double bond (c=c) in theire moleeules. They aree also eaelled Olefins.

General Formula : C_nH_{2n} , where "n" is the no. of Carbon atoms.

Preimarey suffix : -ene

Example : C_2H_4 - Ethene $(CH_2 = CH_2)$

C_3H_6 - Propene $(CH_2 = CH - CH_3)$

3. Alkynes : These are the unsaturated hydrocarbons which have a carbon - carbon triple bond $(C \equiv C)$ in their molecules. These are also called Acetylenes.

General Formula : C_nH_{2n-2} , where "n" is the no. of Carbon atoms.

Preimarey suffix : -yne

Example : C_2H_2 - Ethyne $(CH \equiv CH)$

C_3H_4 - Propyne. $(CH \equiv C - CH_3)$.

4. Alkyl halides or Haloalkanes :

These are derived by replacing one H-atom of an alkane by a halogen atom.

General formula : $C_nH_{2n+1}-X$, where 'n' is the no. of Carbon atoms and 'X' refers to halogen atoms (F, Cl, Br, I)

Prefix : Halo

Example : CH_3-Cl → Chloromethane

$C_2H_5 - Br$ → Bromoethane.

5. Alcohol : These are obtained by replacing one H-atom of an alkane by hydroxyl group (-OH). The IUPAC name of an alcohol is obtained by replacing 'e' of the corresponding alkane by "ol".

General Formula : $C_nH_{2n+1}-OH$, where 'n' is the no. of Carbon atoms.

Suffix : ol

Example : CH_3-OH → Methanol

C_2H_5-OH → Ethanol.

* Rules for IUPAC System of Nomenclature :

1. **Expansion of chain :-** Sometimes condensed groups are present in organic compounds. These condensed groups are to be separated.

Examples : (i) $CH_3-CH_2-(CH_2)_2-CH_3 \longrightarrow CH_3-CH_2-CH_2-CH_2-CH_3$

Condensed group — Expanded

(ii) $(CH_3)_2CH-CH_3 \longrightarrow CH_3-CH(CH_3)-CH_3$

Condensed group — Expanded

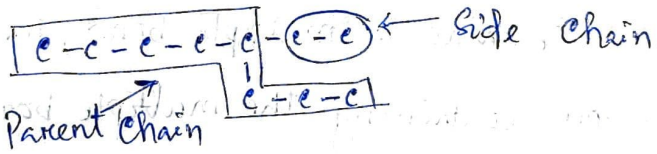
(iii) $CH_3-CH(C_2H_5)-CH_3 \longrightarrow CH_3-CH(CH_2CH_3)-CH_3$

Condensed group — Expanded.

2. **Selection of Parent chain :-**

The longest continuous carbon chain is called parent chain. The parent chain is selected and the groups which are outside the parent chain are called substituent or side chains.

Example:

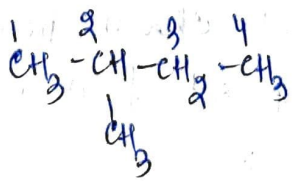


3. **Numbering of Carbon atoms : (Lowest number rule or Lowest sum rule).**

a. **Presence of one substituent or one side chain :**

The numbering of Carbon atoms in the continuous carbon chain is done from one end to the other end, so that the carbon atom carrying the substituent get the lowest number.

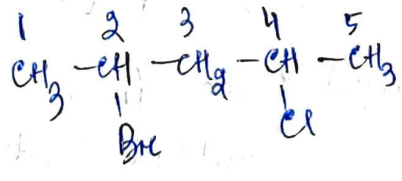
Example :



b. **Presence of 2 substituents at the same position from either end :**

In this case minimum number is given to the carbon containing the substituent which comes first in alphabetical order.

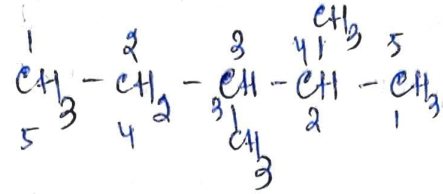
Example :



c. Presence of more than one substituents or side chains at any positions:

In this case, the number of Parent chain from such an end so as to give lowest set of numbers possible to the substituents; i.e. the "Lowest Sum Rule".

Example:



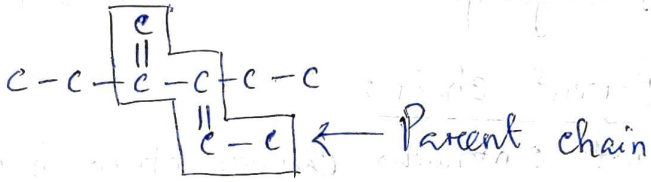
Left to Right : Sum = 3+4 = 7 ✗

Right to Left : Sum = 2+3 = 5 ✓

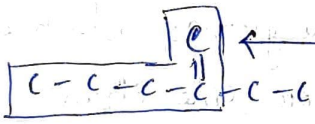
4. Presence of Multiple bonds (double and triple bonds):

(i) Select the longest continuous carbon chain as the principal chain which contains the maximum no. of multiple bonds.

Examples:-

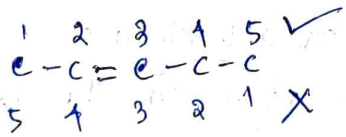


(ii)



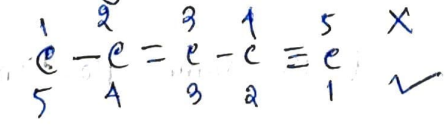
(iii) If a compound contains a multiple bond, then minimum number is given to the carbon containing the multiple bonds, irrespective of the position of the substituent or the side chain.

Example:



(iii) If the principal chain (parent chain) contains 2 or more multiple bonds, then number the principal chain from one end so that the multiple bonds get the lowest set of numbers.

Example:

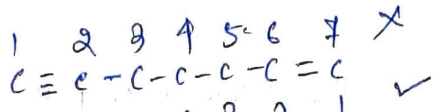


Left to right : Sum = 2+1 = 6

Right to left : Sum = 1+3 = 4 ✓

(iv) If the numbering of principal chain from both the ends gives the same set of numbers to multiple bonds, then select the set which gives lowest number to the double bond.

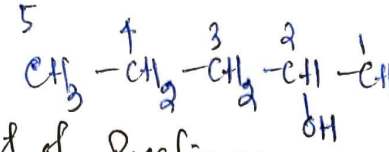
Example:



5. Presence of Functional groups:

If a compound contains a functional group then, minimum number is given to the carbon containing the functional group irrespective of the position of the substituents, side chains are even multiple bonds.

Example:



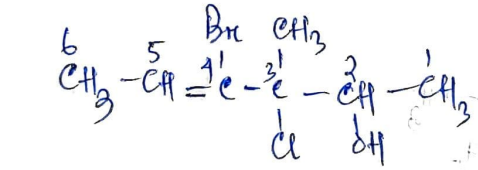
6. Arrangement of Prefixes:

In an organic compounds the word root, Prefix, Preimary suffix and Secondary suffix are arranged in the following way.

( )- Prefix ..... Root word ..... ( )- Preimary Suffix ... -( )- Secondary Suffix

Separate the numbers from the name of the substituent by a hyphen(-) and the numbers are separated by comma(,). If a particular substituent appears 2 or more times, then attach the Prefix di, tri, tetra respectively to the name of the substituent and if there are 2 different substituents then they are written in alphabetical order. While following the rules for alphabetical order, the prefixes like di, tri, tetra etc. are ignored.

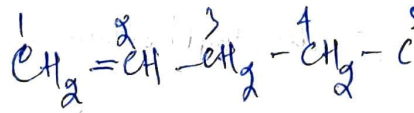
Example:



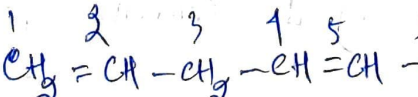
IUPAC Name: 4-Bromo-3-chloro-3-Methylhex-4-en-2-ol.

Note: The preimary suffix for double bond is ene and for treiple bond is yne. "e" of ene is ommitted if it is followed by a suffix starting with a, i, o, u, y. If the preincipal chain contains 2 double or two treiple bonds, then suffix is diene or diyne respectively. In such cases "a" is added to root word.

Examples:



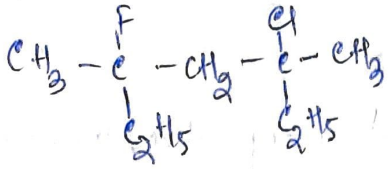
Hex-1-en-5-yne.

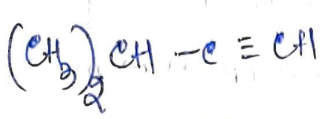


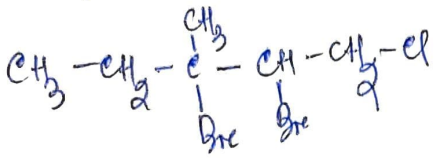
Hexa-1,4-diene.

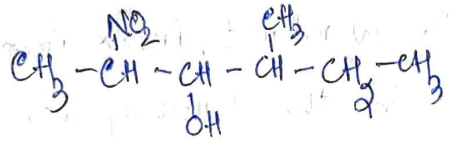
Examples :

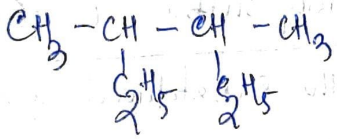
Write the IUPAC names of the following organic compounds :

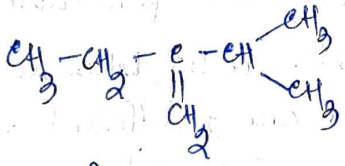
(i) 

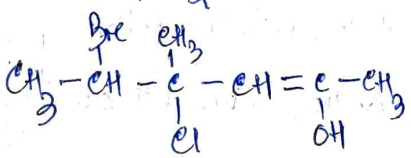
(ii) 

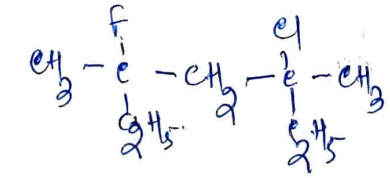
(iii) 

(iv) 

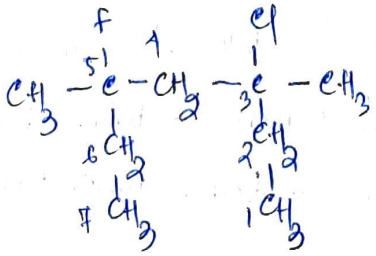
(v) 

(vi) 

(vii) 

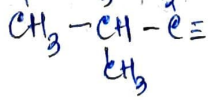
Solution : (i) 

on expanding the condensed groups, we have

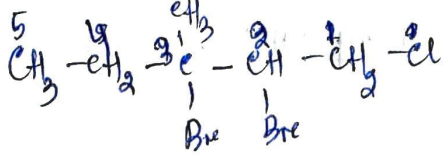


3 - Chloro - 5 - fluoro - 3,5 - dimethylheptane.

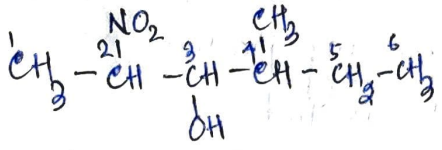
(ii) $(CH_3)_2CH-C\equiv CH$, on expanding the condensed groups, we have



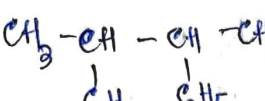
3 - Methylbut - 1 - yne

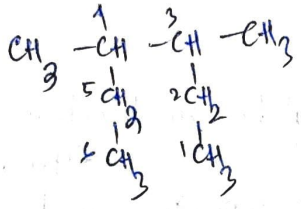
(iii) 

1 - Chloro - 2,3 - dibromo - 3 - methylpentane

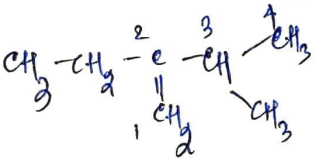
(iv) 

4 - Methyl - 2 - nitrohex - 3 - ol.

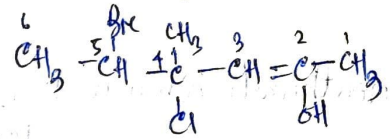
(v)  , on expanding the condensed groups, we have



3, 4 - Dimethylhexane

(vi) 

2 - Ethyl - 3 - methyl but - 1 - ene

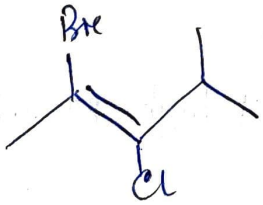
(vii) 

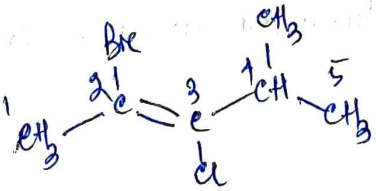
5 - Bromo - 4 - chloro - 4 - methyl hex - 2 - en - 2 - ol

* Bond - line Representation :

In Bond - line representation, each corener and terminal is considered as a carbon atom and rest are considered as hydrogen atoms to satisfy the tetra - covalency of each carbon atom.

Examples: IUPAC name of the following bond line notation :

 , Substituting the Carbon and hydrogen atoms, we have



2 - Bromo - 3 - chloro - 4 - methylpent - 2 - ene.

* Uses of some Important Aromatic compounds :

1. Benzene :- It is used :
   (a) in manufacturing rubber, tyres.
   (b) in the printing industry for cleaning and maintaining printing equipment.
   (c) as an ingredient of a variety of painting products.
   (d) in manufacturing chemical and plastic products.
   (e) to clean parts such as hydraulic system, fuel system components and brakes.

2. Toluene :- It is used :
   (a) as a solvent for paint, paint thinner, printer ink etc.
   (b) used in the synthesis of Trinitrotoluene (TNT) explosives.
   (c) in making elastic
   (d) as a radiator fluid.
   (e) in breaking of RBC in order to extract the hemoglobin in biochemistry experiments.

3. BHC (Benzene Hexachloride) :- Also called Gammaxene. It is used :
   (a) as an important insecticide.
   (b) as medication to remove head lice.
   (c) in pharmaceuticals.
   (d) to treat scabies.
   (e) in shampoo.

4. Phenol :- It is used :
   (a) as disinfectant in household cleaners and in mouthwash when used in small quantity.
   (b) as surgical antiseptic.
   (c) in the manufacturing of cough syrups and other antiseptics.
   (d) as a starting material to make plastics and drugs such as aspirin.
   (e) in the study and extraction of biomolecules.

5. Naphthalene :- It is used :
   (a) in the form of ~~both~~ moth balls and toilet deodorant blocks.
   (b) in making dyes, resins, insecticides.
   (c) in manufacturing of PVC (Polyvinyl Chloride).
   (d) to create artificial pores in the manufacture of high-porosity grinding wheels.
   (e) ~~Naphthalene~~ in egineering to study heat transfer using mass sublimation.

6. Anthracene :- It is used :

(a) in wood preservatives, insecticides.

(b) as coating materials.

(c) as a scintillator for detectors of high energy photons, electrons and alpha particles.

(d) in manufacturing of anthraquinone.

(e) in the production of red dye alizarin and other dyes.

7. Benzoic acid :- It is used :

(a) as a food preservative.

(b) in mouthwash, toothpaste, facial cleanser.

(c) in making dyes and insect repellents.

(d) a constituent of whitfield's ointment which is used for the treatment of fungal skin diseases.

(e) as a food pH adjuster.