CHAPTER 4

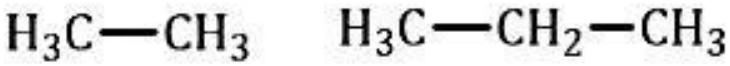
❑ INTRODUCTION TO ORGANIC CHEMISTRY

❖ Organic Chemistry

- Organic chemistry is the branch of chemistry that deals with the study of structure, properties, composition, reactions, and preparation of carbon containing compounds.

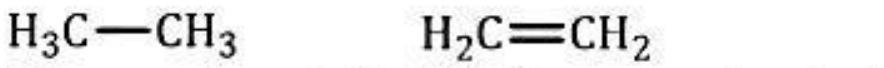
❑ TYPE OF ORGANIC COMPOUNDS

1. **Aliphatic compounds** - An aliphatic compound or aliphatic hydrocarbon is an organic compound containing hydrogen and carbon atoms that are usually linked together in chains via single, double or triple bonds.



Ethane Propane

2. **Saturated and unsaturated compounds** - A hydrocarbon is said to be saturated if it contains only C-C single bonds. A hydrocarbon is said to be unsaturated if it contains C=C or C≡C multiple bonds.



Ethane saturated Ethylene unsaturated

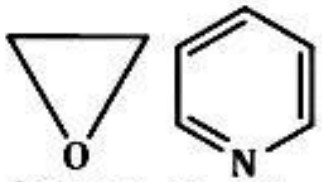
3. **Alicyclic compounds** - Cyclic compounds which consist only of carbon atoms are called alicyclic or carbocyclic compounds

Cyclopropane Cyclobutane

4. **Aromatic compounds** - Aromatic hydrocarbon, are hydrocarbons containing sigma bonds and delocalized pi electrons between carbon atoms in a ring.

Benzene

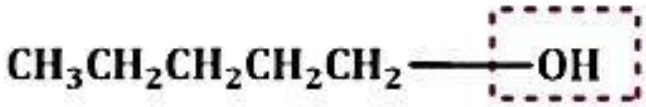
5. Heterocyclic compounds - Heterocyclic compounds are cyclic compounds with the ring containing carbon and other element, the component being oxygen, nitrogen and sulfur.



Oxirane Pyridine

❖ Functional Groups

- A functional group is an atom or group of atoms in a molecule its **characteristic chemical properties.**

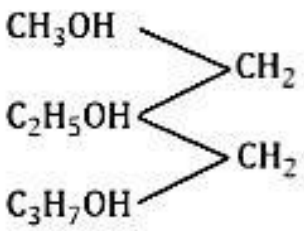


Functional group

CLASS	FUNCTIONAL GROUP	CLASS	FUNCTIONAL GROUP
Alcohols	–OH	Acid amides	$-CONH_2$
Aldehydes	–CHO	Ketones	>C=O
Carboxylic acids	–COOH	Esters	–COOR
Amines	$-NH_2$	Acid chlorides	–COCl
Nitriles	–CN	Thiols	–SH
Amino	$-NH_2$	Nitro	$-NO_2$

❖ Homologous Series

A homologous series refers to a series of carbon compounds in which **adjacent members differ by a CH_2 unit.** However, they contain the same functional group.



Characteristics of homologous series

- Members have the **same general formula.**
- Members have the almost **same chemical properties** due to same functional group.
- All compounds in the series can be **prepared by similar methods.**
- The physical properties of the members show a **gradation in properties as the molecular mass increases.**

S. NO.	NAME OF COMPOND	GENERAL FORMULA	HOMOLOGOUS SERIES - I	HOMOLOGOUS SERIES - II
1.	Alkanes	C_nH_{2n+2}	CH_4	CH_3-CH_3
1.	Alkenes	C_nH_{2n}	CH_2=CH_2	CH_2=CH-CH_3
1.	Alkynes	C_nH_{2n-2}	HC≡CH	HC≡C-CH_3
1.	Alcohol	$C_nH_{2n+2}O$	CH_3-OH	CH_3-CH_2-OH
1.	Aldehyde	$C_nH_{2n}O$	CH_3-CHO	CH_3-CH_2-CHO
1.	Carboxylic acid	$C_nH_{2n}O_2$	CH_3-COOH	CH_3-CH_2COOH
1.	Ester	$C_nH_{2n}O_2$	CH_3-COO-CH_3	CH_3-COO-CH_2-CH_3

❖ Nomenclature System

- The organic compounds are generally named in two systems:

1. Trivial name system (Common Names)
2. IUPAC name system

3. Trivial Names System (Common Names)

- The trivial name was generally **based on the source.**
- Trivial name is a **nonsystematic name** of an organic compound.
- There are no specific rules about the trivial name of the compound.

S. NO.	ORGANIC COMPOUND	SOURCE	TRIVIAL NAME
1.	CH_4	Marsh places	Marsh gas
2.	C_2H_5OH	From barley	Grain alcohol
3.	CH_3COOH	From vinegar	Vinegar

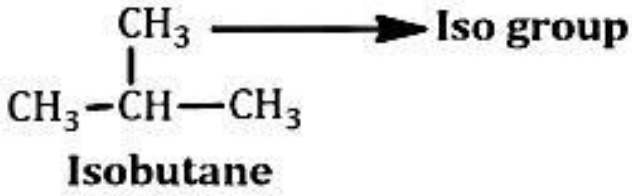
4.	CH_3OH	Distillation of wood	Methyl spirit
5.	NH_2CONH_2	From urine	Urea
6.	$CH_3CHOHCOOH$	From lactum	Lactic acid
7.	HCOOH	From rad ant	Formic acid

❖ Prefix used for organic compound

(a) PREFIX n: It is used for carbon atoms are in one contineous chain

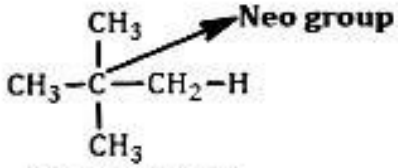
Example: $-CH_3-CH_2-CH_2-CH_3$ n-butane

(b) PREFIX iso: It is used when one **methyl group is attached to the second last carbon atom** of the continuous chain.



Isobutane

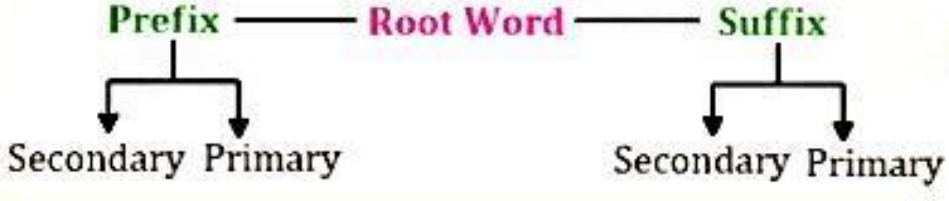
© PREFIX neo: When **two methyl groups** are attached to the **second last carbon atom** of the continuous chain.



Neo - pentane

➢ IUPAC Name System (International Union of Pure and Applied Chemistry)

- The **IUPAC** system of nomenclature is a set of logical rules framed which are mainly aimed at giving an unambiguous name to an organic compound.
- The **IUPAC** name of an organic compound consists of three parts:



✓ Root Word

- The root word of iupac name indicates the **number of carbon atoms in the longest possible continuous carbon** chain also known as parent chain chosen by a set of rules.

NUMBER OF CARBONS	ROOT WORD	NUMBER OF CARBON	ROOT WORD
1	Meth	**6**	Hex
2	Eth	**7**	Hept
3	Prop	**8**	Oct
4	But	**9**	Non
5	Pent	**10**	Dec

✓ Suffix

- It is added **immediately after the Root word** of IUPAC name.
- There are two types of suffixes: Primary and Secondary.

❍ Primary suffix:

- It is used to indicate the **degree of saturation or unsaturation** in the main chain.

S.NO.	TYPE OF CARBON CHAIN	PRIMARY SUFFIX
1.	Saturated (all C-C bonds)	-ane
2.	Unsaturated: one C=C	-ene
3.	Unsaturated: two C=C	-diene
4.	Unsaturated: one C≡C	-yne
5.	Unsaturated: two C≡C	-diyne

❍ Secondary suffixes:

- Suffixes, added after the primary suffix to indicate the **particular functional group** present in the carbon chain, are known as secondary suffixes.

CLASS	FUNCTIONAL GROUP	SECONDARY SUFFIX	CLASS	FUNCTIONAL GROUP	SECONDARY SUFFIX
Alcohols	–OH	–ol	Acid amides	$-CONH_2$	–amide
Aldehydes	–CHO	–al	Ketones	> C = O	–one
Carboxylic acids	–COOH	–oic acid	Esters	–COOR'	alkyl... – oate
Amines	$-NH_2$	amine	Acid chlorides	–COCl	–oyl chloride
Nitriles	–CN	–nitrile	Thiols	–SH	–thiol

✓ Prefix

- The prefix is used to **indicate the side chains, substituents and low priority functional groups.**

❍ Primary prefixes:

- Indicate the **cyclic or acyclic nature** of the given compound. The prefix 'cyclo' is used for cyclic compounds.

❍ Secondary prefixes:

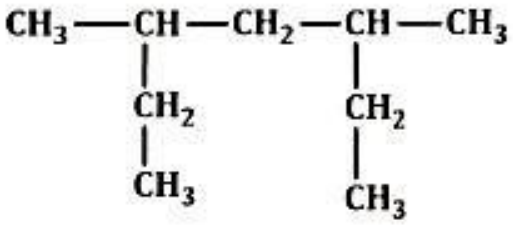
- Indicate the **presence of side chains or substituent groups**.
- An example of these types of prefixes would be the 'CH_3' group, **which is called the methyl group.**
- Secondary prefixes are:

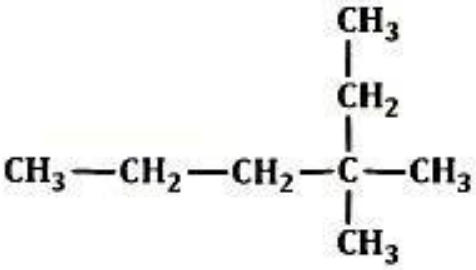
Alkyl (-R), Nitro ($-NO_2$), Halo (-X), Alkoxy (-OR)

✓ IUPAC Nomenclature of saturated hydrocarbon

1. The selection of parent chain

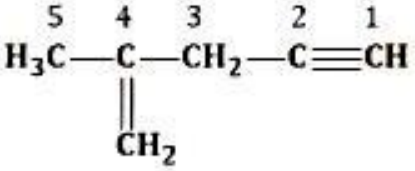
- The parent chain in an organic molecule is the **longest continuous carbon chain** containing as many functional groups, double bonds, triple bonds, side chains and substituents as possible.



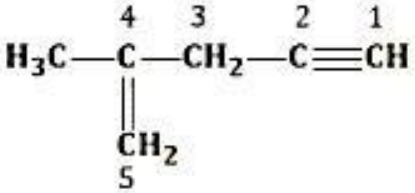


2. Numbering of selected parent carbon chain

- Selected parent chain is numbered from that side from **which functional group or multiple bond or substituents gets lowest number.**
- **Priority order: Functional group > Multiple bond > Substituents.**



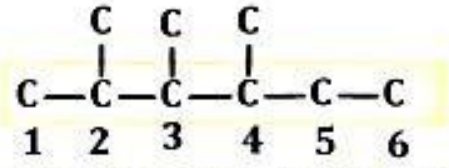
Wrong



Correct

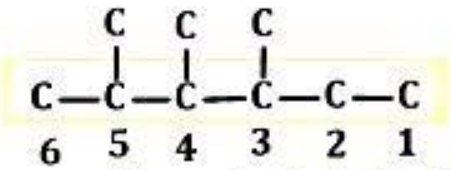
3. Lowest sum rule

- When numbering of a chain is possible form more than one side, prefer numbering of the chain from the side having lowest sum of all the locant numbers.



sum of locants : 2+3+4 = 9

Correct

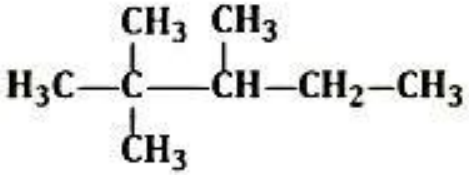


sum of locants : 3+4+5 = 12

Incorrect

4. Use of prefixes di, tri, tetra

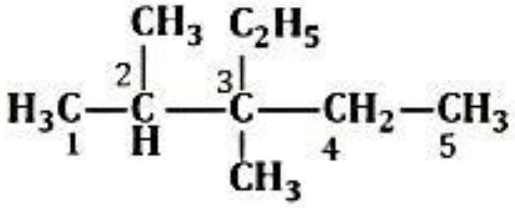
- If the compound contains more than **one similar alkyl group** their positions are indicated separately and an appropriate numerical **prefix di, tri, tetra etc.**



2,2,3-trimethyl pentane

5. **Alphabetical order of side chains**

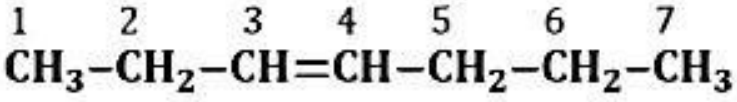
- In case two or more alkyl groups (side chains) are attached to the parent chain, these are prefixed in alphabetic order.



3-ethyl-2,3-dimethylpentane

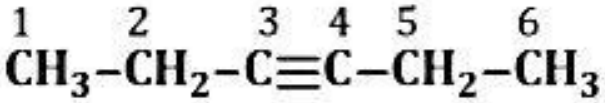
✓ **IUPAC Nomenclature of unsaturated hydrocarbon**

- Start the numbering in such way, so that the **double or triple bond get the lowest number.**
- In the nomenclature of double bond, the **suffix 'ene' is added in the longest carbon chain,** in which the double bond is **lowest numbered.**



Hept-3-ene

- In the nomenclature of triple bond, the **suffix 'yne' is added in the longest carbon** chain, in which the **triple bond is lowest numbered.**



Hex-3-yne

✓ **Naming of Compounds having Functional Groups**

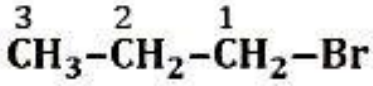
1. The longest carbon chain is selected in such a way as to **include the maximum number of functional groups.**
2. The numbering of carbon chain is done in such a way that the functional group is given minimum possible number even if it violates the lowest sum rule.
3. The functional group is added in the parent chain hydrocarbon by removing the terminal 'e'.

4. The name of the **substituents is prefixed to the parent hydrocarbon according to IUPAC rules.**
5. Halo, nitro and sometime amino groups are not regarded as functional groups. They are considered as substituents.

✓ **Seniority Table for Functional Groups**

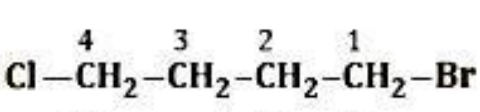
FUNCTIONAL GROUPS	PREFIX NAME	SUFFIX NAME
-COOH	Carboxy-	-oic acid
$-SO_3H$	Sulpho-	-Sulphonic acid
-COX	Haloformyl-	-oyl halide
$-CONH_2$	Carbamoyl-	-Amide
-CHO	Formyl-	-al
-CN	Cyano-	-Nitrile
-CO	Keto- or Oxo-	-one
-OH	Hydroxy-	-ol
$-NH_2$	Amino-	-amine
-SH	Mercapto-	-thiol
>C=C< ; -C≡C-	-	-Ene, -yne
-X (Halogen)	Halo-	-
$-NO_2$	Nitro-	-
-NO	Nitroso-	-
-O-	Epoxy-	-
R-	Alkyl-	-
-O-R	Alkoxy-	-

Example of monofunctional compounds

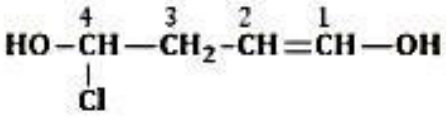


1-bromopropane

Example of polyfunctional compounds



1-bromo-4-chlorobutane



4-chlorobut-1-ene-1,4-diol

✓ IUPAC Nomenclature for cyclic compound

1. Name of monocyclic, saturated hydrocarbons are formed by attaching the **prefix "cyclo" to the name of acyclic, saturated hydrocarbons** with same number of carbons.

cyclopropane cyclobutane cyclopentane cyclohexane

2. The word Cyclo is **prefixed before the name of alkene and alkyne having the same number of carbon atoms as in the ring.**

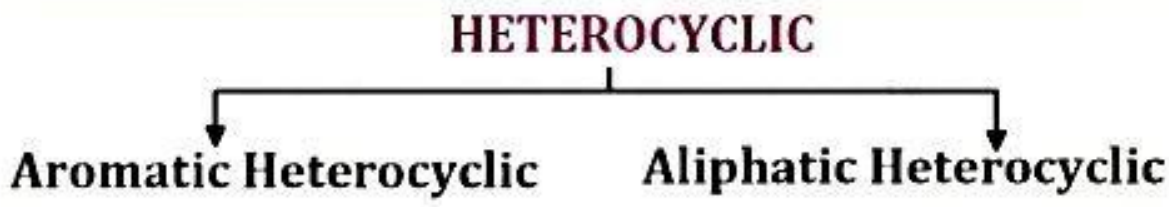
cyclohexene cyclobutene

3. **Alicyclic compounds containing functional group.**

cyclohexanone cyclobutanecarboxylic acid

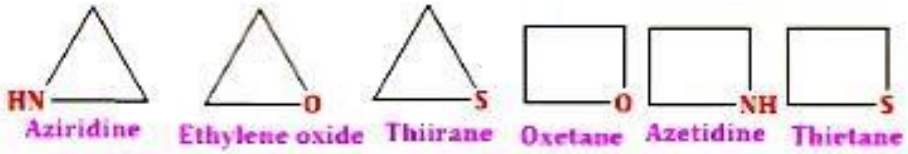
❑ HETEROCYCLIC COMPOUND

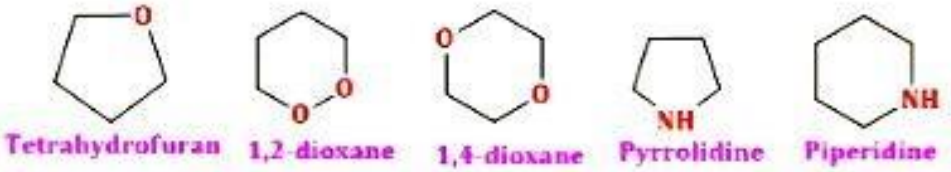
- Heterocyclic compounds are organic compounds that contain ring structure containing atoms other than carbons such as **Oxygen, Nitrogen, Sulphur** as a part of ring.
- Based on the structural and **electronic arrangement** the heterocyclic compounds may be classified into two categories:



❖ Aliphatic Heterocyclic Compounds

- Aliphatic heterocyclic compounds are cyclic heterocycles that **do not contain any double bond and triple bond.**





❖ Aromatic Heterocyclic Compounds

- Aromatic heterocyclic compounds are **cyclic aromatic compounds.**

❖ Hantzsch-Widman System of Nomenclature

- This nomenclature system specifies the **nature, position, ring size, number and types of heteroatoms present in any heterocyclic compounds.**
- This system of nomenclature applies to monocyclic three to ten membered ring heterocycles.
- The nomenclature of heterocyclic compounds is assigned by combining '**Prefix**' (that indicate the heteroatom present) with '**Stem**' (that indicate the ring size as well as the saturation and unsaturation in the ring) and '**suffixes**'.

Prefix + Stem + Suffix

❖ **Common prefix for heteroatoms (arranged in the preferential order)**

HETEROATOM	SYMBOL	PREFIX
Oxygen	O	Oxa
Sulphur	S	Thia
Nitrogen	N	Aza
Phosphorous	P	Phospha
Selenium	Se	Selena

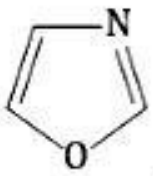
❖ **Common suffix for heteroatom (according to the ring size and preferential order)**

RING SIZE	SUFFIX	RING SIZE	SUFFIX
3	ir	7	ep
4	et	8	oc
5	ol	9	on
6	in	10	ec

❖ **Size and Degree of Unsaturation**

S.NO.	RING SIZE	SATURATED	UNSATURATED	SATURATED (WITH NITROGEN)
1.	3	-irane	-irene	-iridine
2.	4	-etan	-ete	-etidine
3.	5	-olane	-ole	-olidine
4.	6	-ane	-in	-
5.	7	-epane	-epin	-
6.	8	-ocane	-	-Ocin
7.	9	-onan	-onin	-
8.	10	-ecan	-ecin	-

Example



Oxa + aza + ol + e
= Oxazole

Oxa + aza + ir + idine
= Oxaziridine

COMMON RINGS FOR HETEROCYCLE

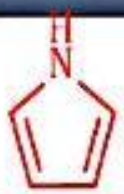
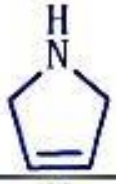
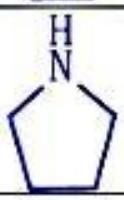
❖ 3-MEMBERED RINGS

ONE HETEROATOM	
Compound	**Structure**
Aziridine	
Oxirane	
Thiirane	

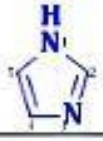
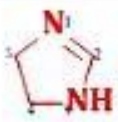
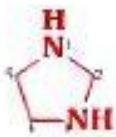
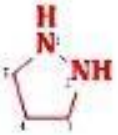
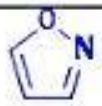
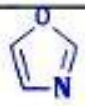
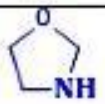
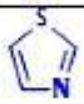
❖ 4-MEMBERED RINGS

ONE HETEROATOM	
Compound	**Structure**
Azetidine	
Thietane	
Oxetane	

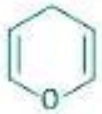
❖ 5-MEMBERED RINGS WITH ONE HETEROATOM

COMPOUND	STRUCTURE	COMPOUND	STRUCTURE
Pyrrole		Thiophene	
		Furan	
Pyrrolidine		Dihydrofuran	

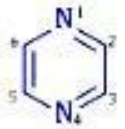
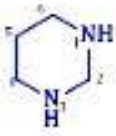
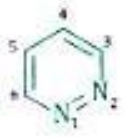
❖ 5-MEMBERED RINGS WITH TWO HETEROATOM

COMPOUND	STRUCTURE	COMPOUND	STRUCTURE
Imidazole		Pyrazole	
Imidazoline		Pyrazoline	
Imidazolidine		Pyrazolidine	
Isoxazole		Oxazole	
Oxazolidine		Thiazole	

❖ 6-MEMBERED RINGS WITH ONE HETEROATOM

COMPOUND	STRUCTURE	COMPOUND	STRUCTURE
Pyridine		Piperidine	
Dihydropyridine		Pyran	

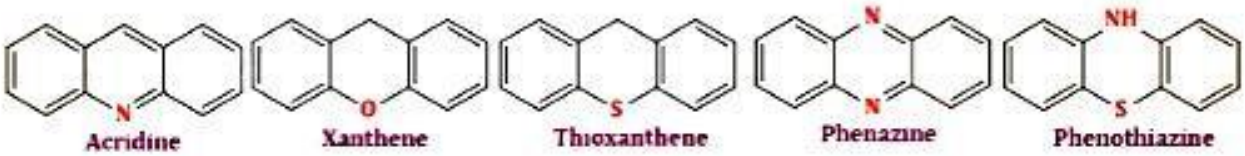
❖ 6-MEMBERED RINGS WITH TWO HETEROATOM

COMPOUND	STRUCTURE	COMPOUND	STRUCTURE
Pyrimidine		Pyrazine	
Tetrahydro pyrimidine		Piperazine	
Perhydro pyrimidine		Pyridazine	

❖ Nomenclature two rings heterocyclic compounds

Quinoline | Isoquinoline | Tetrahydro isoquinoline | Chromene | Chromane | Coumarin

❖ Nomenclature three rings heterocyclic compounds



Acridine | Xanthene | Thioxanthene | Phenazine | Phenothiazine

❑ NOMENCLATURE OF BENZO FUSED SYSTEM

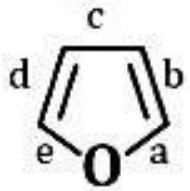
- Polycyclic compounds incorporating one **heterocyclic ring or fused heterocyclic system fused to benzene** are known as benzoheterocycles.

Rule's for naming benzo fused system

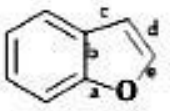
1) **Prefix: The word benzo**
2) **Letter in square brackets** indicate the position of fusion
3) **Name of heterocyclic ring**

Example

- In furan, there are 5 connecting sites, which are written as **a, b, c, d and e.**



- In this structure, **furan ring is attached with benzene ring**. The point of attachment is [b]. hence the structure is written as



Benzo[b]oxole
(Benzofuran)