

CHAPTER 4

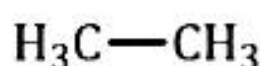
❑ INTRODUCTION TO ORGANIC CHEMISTRY

❖ 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

- 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

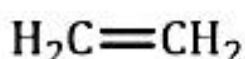


Propane

- 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

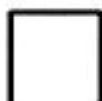


Ethylene unsaturated

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

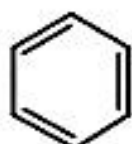


Cyclopropane



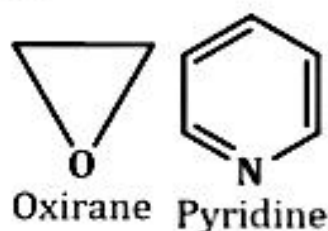
Cyclobutane

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



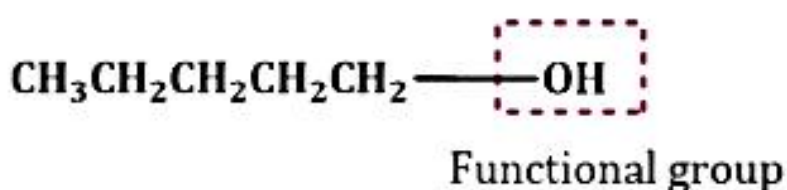
Benzene

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



❖ **Functional Groups**

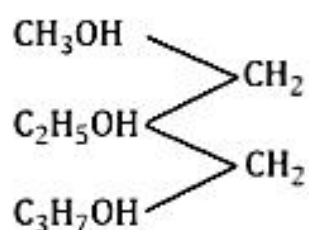
- A functional group is an atom or group of atoms in a molecule its **characteristic chemical properties**.



| 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 CH₂ 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 COMPOUND | 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} | $HC\equiv CH$ | $HC\equiv C-CH_3$ |
| 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 |

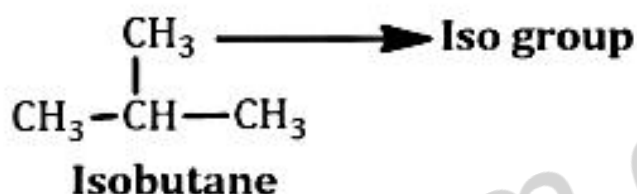
| | | | |
|----|-----------------------------------|----------------------|---------------|
| 4. | CH ₃ OH | Distillation of wood | Methyl spirit |
| 5. | NH ₂ CONH ₂ | From urine | Urea |
| 6. | CH ₃ CHOHCOOH | From lactum | Lactic acid |
| 7. | HCOOH | From rad ant | Formic acid |

❖ **Prefix used for organic compound**

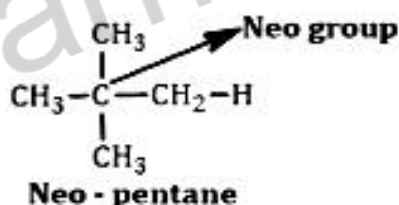
(a) **PREFIX n:** It is used for carbon atoms are in one continuous chain

Example: -CH₃-CH₂-CH₂-CH₃ n-butane

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



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



➤ **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

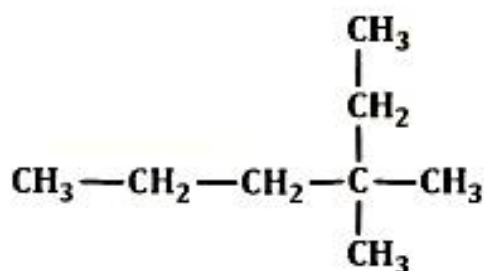
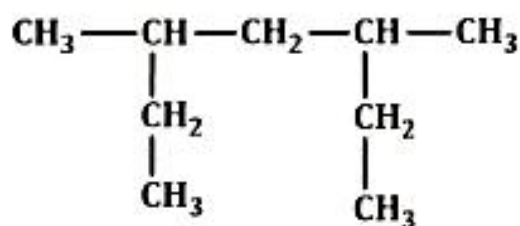
- The prefix is used to **indicate the side chains, substituents and low priority functional groups.**
- Primary prefixes:
 - Indicate the **cyclic or acyclic nature** of the given compound. The prefix 'cyclo' is used for cyclic compounds.
- Secondary prefixes:
 - Indicate the **presence of side chains or substituent groups.**
 - An example of these types of prefixes would be the 'CH₃' group, **which is called the methyl group.**
 - Secondary prefixes are:

Alkyl (-R), Nitro (-NO₂), Halo (-X), Alkoxy (-OR)

✓ IUPAC Nomenclature of saturated hydrocarbon

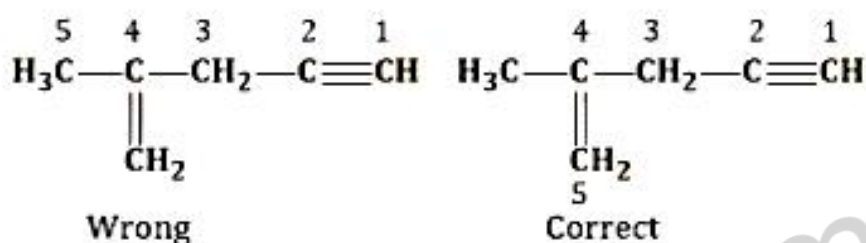
1. The selection of parent chain

- 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.



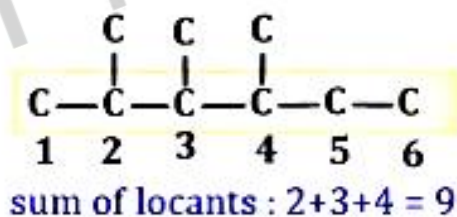
2. Numbering of selected parent carbon chain

- 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.

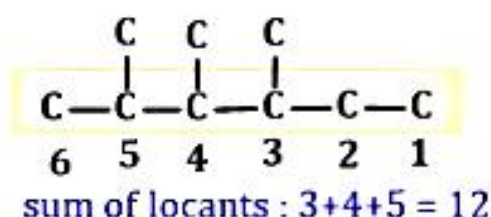


3. Lowest sum rule

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



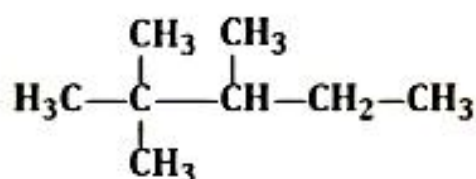
Correct



Incorrect

4. Use of prefixes di, tri, tetra

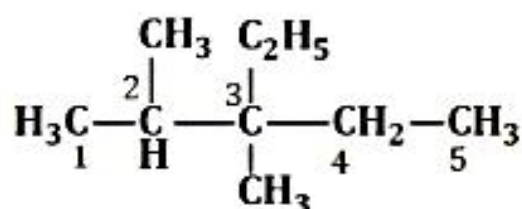
- If the compound contains more than one similar alkyl group their positions are indicated separately and an appropriate numerical prefix di, tri, tetra etc.



2,2,3-trimethyl pentane

5. Alphabetical order of side chains

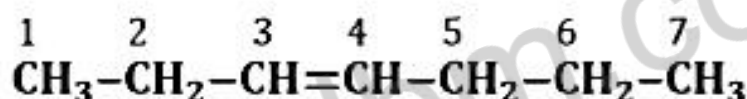
- In case two or more alkyl groups (side chains) are attached to the parent chain, these are prefixed in alphabetic order.



3-ethyl-2,3-dimethylpentane

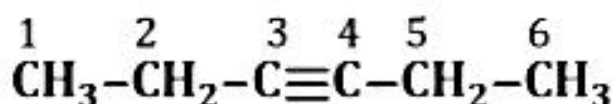
✓ IUPAC Nomenclature of unsaturated hydrocarbon

- 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

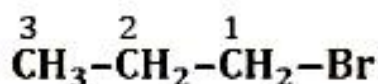
1. The longest carbon chain is selected in such a way as to **include the maximum number of functional groups**.
2. The numbering of carbon chain is done in such a way that the functional group is given minimum possible number even if it violates the lowest sum rule.
3. The functional group is added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

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

✓ **Seniority Table for Functional Groups**

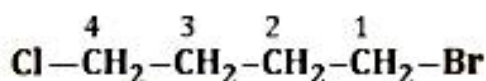
| FUNCTIONAL GROUPS | PREFIX NAME | SUFFIX NAME |
|--------------------|---------------|-----------------|
| -COOH | Carboxy- | -oic acid |
| -SO ₃ H | Sulpho- | -Sulphonic acid |
| -COX | Haloformyl- | -oyl halide |
| -CONH ₂ | Carbamoyl- | -Amide |
| -CHO | Formyl- | -al |
| -CN | Cyano- | -Nitrile |
| -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

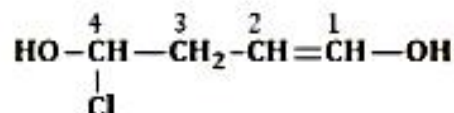


1-bromopropane

Example of polyfunctional compounds



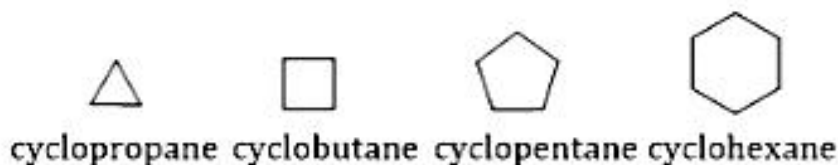
1-bromo-4-chlorobutane



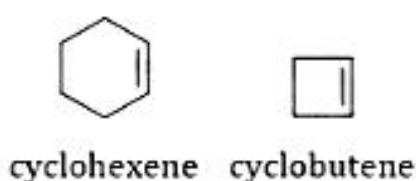
4-chlorobut-1-ene-1,4-diol

✓ 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.



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

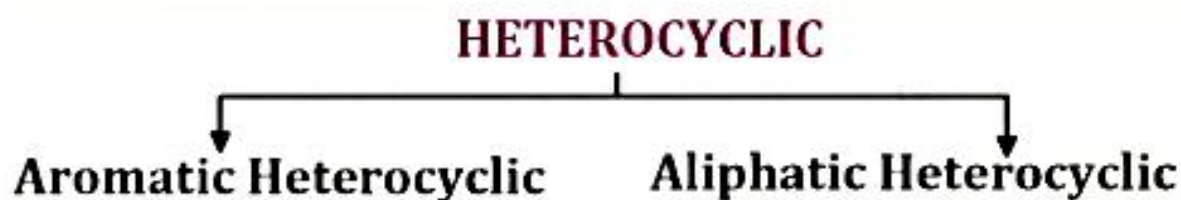


3. **Alicyclic compounds containing functional group.**



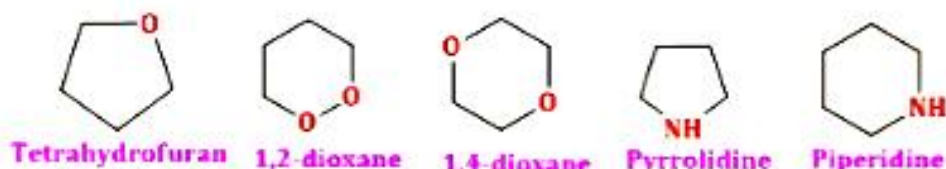
☐ HETEROCYCLIC COMPOUND

- 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 |

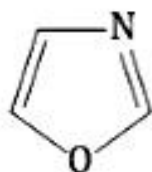
❖ **Common suffix for heteroatom (according to the ring size and preferential order)**

| 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 | |




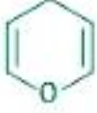
❖ 5-MEMBERED RINGS WITH ONE HETEROATOM

| COMPOUND | STRUCTURE | COMPOUND | STRUCTURE |
|-------------|-----------|--------------|-----------|
| Pyrrole | | Thiophene | |
| | | Furan | |
| Pyrrolidine | | Dihydrofuran | |

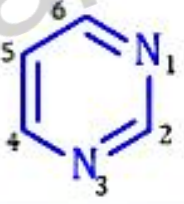
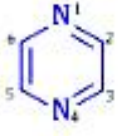


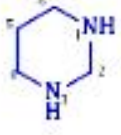
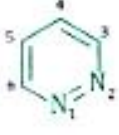
❖ 5-MEMBERED RINGS WITH TWO HETEROATOM

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

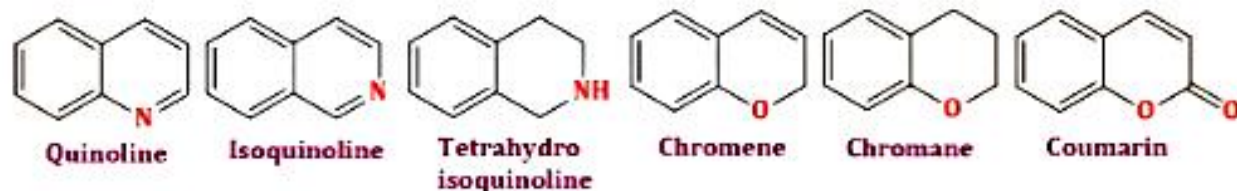
❖ 6-MEMBERED RINGS WITH ONE HETEROATOM

| COMPOUND | STRUCTURE | COMPOUND | STRUCTURE |
|-----------------|---|------------|---|
| Pyridine |  | Piperidine |  |
| Dihydropyridine |  | Pyran |  |

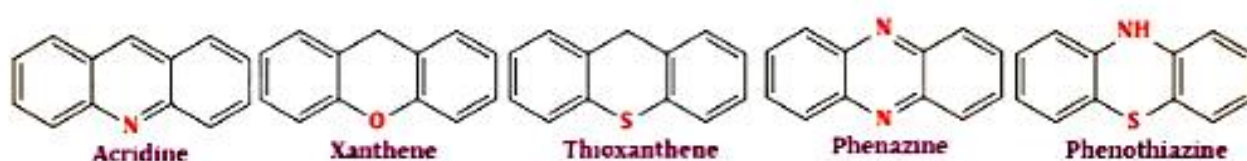
❖ 6-MEMBERED RINGS WITH TWO HETEROATOM

| COMPOUND | STRUCTURE | COMPOUND | STRUCTURE |
|----------------------|---|------------|---|
| Pyrimidine |  | Pyrazine |  |
| Tetrahydropyrimidine |  | Piperazine |  |
| Perhydropyrimidine |  | Pyridazine |  |

❖ Nomenclature two rings heterocyclic compounds



❖ Nomenclature three rings heterocyclic compounds



❑ NOMENCLATURE OF BENZO FUSED SYSTEM

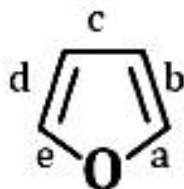
- Polycyclic compounds incorporating one **heterocyclic ring or fused heterocyclic system fused to benzene** are known as benzoheterocycles.

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

