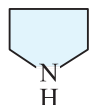
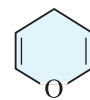


- (i) **Alicyclic heterocyclic compounds** : Alicyclic compounds containing one or more heteroatoms in their rings are called alicyclic heterocyclic compounds. For example:

Tetrahydro Furan
(THF)

Pyrrolidine



Pyran

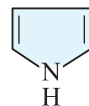
- (ii) **Aromatic heterocyclic compounds** : Aromatic cyclic compounds containing one or more heteroatoms in their molecules are called aromatic heterocyclic compounds. For example :



Pyridine



Furan



Pyrrole

Note : An aliphatic compound burns with non-smoky flame (except CHCl_3 , CCl_4). All aromatic compounds burn with a smoky flame.

NOMENCLATURE OF ORGANIC COMPOUNDS

Section - 3

The IUPAC (International Union of Pure and Applied Chemistry) has developed a systematic method of naming organic compounds. This system gives a unique IUPAC name to every organic compound. However before the IUPAC system came into existence, the trivial or common names for organic compounds were used. These were based on their origin or certain properties. Some examples are as follows : (Please note that the contents of following table are NOT to be memorised).

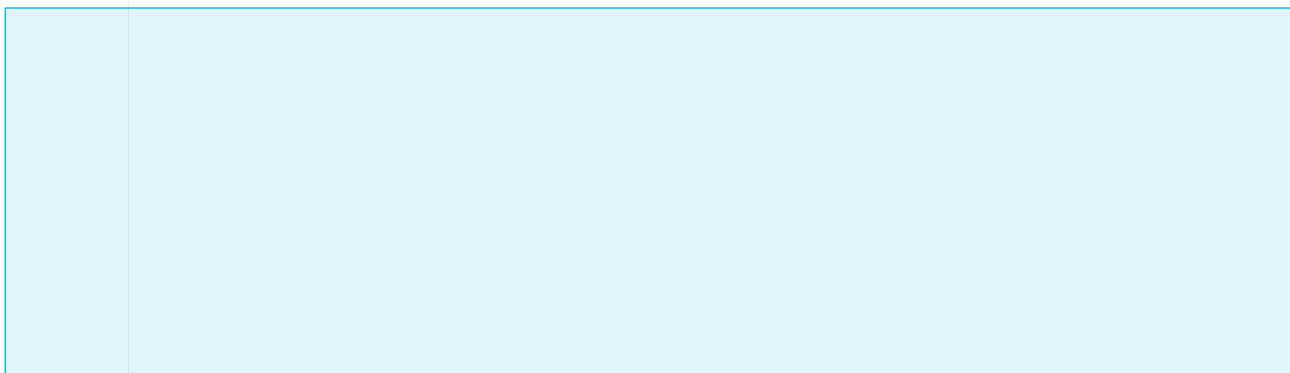
Compound	Trivial Name	Source of Compound
CH_3OH	Wood spirit	Obtained by destructive distillation of wood
CH_3OH	Methyl alcohol	Methu-spirit and hule-wood
NH_2CONH_2	Urea	Obtained from urine
CH_3COOH	Acetic acid	Obtained from Acetum-vinegar
$(\text{COOH})_2$	Oxalic acid	Obtained from oxalis plant
HCOOH	Formic acid	Obtained from ants, (in Latin, Ants $\equiv$ Formicae.)
$\text{C}_2\text{H}_5\text{OH}$	Grain alcohol (Ethanol)	Obtained by fermentation of grains.

These older names for organic compounds are still widely used by chemists and bio-chemists, and in commerce. For this reason it is necessary to learn the common names (Trivial Names) of some of the organic compounds.

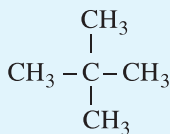
Trivial System Of Nomenclature

Classification of carbon atoms :

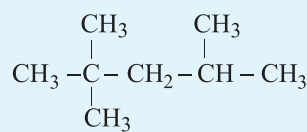
In trivial system of naming an organic compound, the carbon atoms of an alkane were classified on the basis of the number of other carbon atoms attached to them, into four categories, viz., Primary carbon atoms, Secondary carbon atoms, Tertiary carbon atoms and Quaternary carbon atoms.



Note : Neopentane has only primary hydrogen atoms.

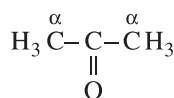
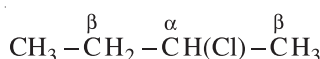
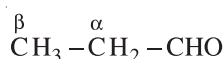
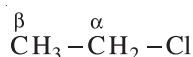


Note : Isooctane has different structure.



α - Carbon and β - Carbon atoms :

Carbon atom in the structure of a compound to which a functional group ($-\text{OH}$, $-\text{CHO}$, Cl , ... etc.) is attached is known as α - carbon and the corresponding hydrogen is referred to as α - hydrogen. The carbon atom(s) adjacent to α - carbon is known as β - carbon(s).



HCHO No α - Carbon and no α - Hydrogen

IUPAC System Of Nomenclature

The formal system of nomenclature used today is one proposed by the International Union of Pure and Applied Chemistry (IUPAC). This system was first developed in 1892 and has been revised at regular intervals to keep it up to date. The principle of IUPAC system is: *Each different compound should have a different name.*

The IUPAC nomenclature involves the use of following terms :

1. Word root
2. Primary suffix
3. Secondary suffix
4. Prefix

1. **Word Root :** The word root represents the *number of carbon atoms in the parent chain*. For the chains up to four carbon atoms special word roots are used whereas words (pent, hex, hept....etc.) indicating the number of carbons in the chain are used for the compounds containing more than four carbon atoms.

Some (straight) unbranched chains and their names :

Name	Number of C-Atoms	Structure	Name	Number of C-Atoms	Structure
Methane	1	CH_4	Octane	8	$\text{CH}_3(\text{CH}_2)_6\text{CH}_3$
Ethane	2	CH_3CH_3	Nonane	9	$\text{CH}_3(\text{CH}_2)_7\text{CH}_3$
Propane	3	$\text{CH}_3\text{CH}_2\text{CH}_3$	Decane	10	$\text{CH}_3(\text{CH}_2)_8\text{CH}_3$
Butane	4	$\text{CH}_3(\text{CH}_2)_2\text{CH}_3$	Undecane	11	$\text{CH}_3(\text{CH}_2)_9\text{CH}_3$
Pentane	5	$\text{CH}_3(\text{CH}_2)_3\text{CH}_3$	Dodecane	12	$\text{CH}_3(\text{CH}_2)_{10}\text{CH}_3$
Hexane	6	$\text{CH}_3(\text{CH}_2)_4\text{CH}_3$	Tridecane	13	$\text{CH}_3(\text{CH}_2)_{11}\text{CH}_3$
Heptane	7	$\text{CH}_3(\text{CH}_2)_5\text{CH}_3$	Tetradecane	14	$\text{CH}_3(\text{CH}_2)_{12}\text{CH}_3$

The word root of different carbon chains are obtained by leaving 'ane' from the name of the carbon chain of the respective molecule. Some word roots are given below :

Chain Length	Word Root	Chain Length	Word Root
C ₁	Meth –	C ₇	Hept (a) –
C ₂	Eth –	C ₈	Oct (a)–
C ₃	Prop (a) –	C ₉	Non (a) –
C ₄	But (a) –	C ₁₀	Dec (a)–
C ₅	Pent (a) –	C ₁₁	Undec (a) –
C ₆	Hex (a) –	C ₁₂	Dodec (a) –

Note : Extra 'a' given in parenthesis is used only if the primary suffix (explained later) to be added to the word root begins with a consonant (except y). In general, the word root for any carbon chain is alk.

- 2. Primary Suffix :** Primary suffix is used to indicate *saturation or unsaturation in the carbon chain*. While writing the name, primary suffix is added to the word root. Some of the primary suffixes are given below in the following table.

Nature of Carbon Chain	Primary Suffix
Saturated Carbon Chain	ane
Unsaturated Carbon Chains	
One C = C bond	ene
Two C = C bonds	diene
Three C = C bonds	triene
One C $\equiv$ C bond	yne
Two C $\equiv$ C bonds	diyne

- 3. Secondary Suffix :** Secondary suffix is used to indicate the *functional group in the organic compound*. It is added to the primary suffix by dropping its terminal 'e'. Secondary suffixes for various functional groups are given in the following table.

Family of Compound	General Formula	Functional Group	Secondary Suffix	IUPAC name of the family (Saturated)
Alcohols	R–OH	–OH	–ol	alkanol
Thioalcohols	R–SH	–SH	–thiol	alkanethiol
Amines	R–NH ₂	–NH ₂	–amine	alkanamine
Aldehydes	R–CHO	–CHO	–al	alkanal
Ketones	R–COR	>C=O	–one	alkanone
Sulphonic Acids	R–SO ₃ H	–SO ₃ H	–sulphonic	alkane sulphonic acid
Anhydrides	$\begin{array}{c} \text{R}-\text{CO} \diagup \text{O} \\ \text{R}-\text{CO} \diagdown \end{array}$	–(CO) ₂ O	–oic anhydride	alkanoic anhydride

Carboxylic acids	R-COOH	-COOH	-oic	alkanoic acid
Amides	R-CONH ₂	-CONH ₂	-amide	alkanamide
Acid chlorides	R-COCl	-COCl	-oyl	alkanoyl chloride
Esters	R-COOR	-COOR	-oate	alkyl alkanoate
Nitriles	R-C≡N	-C≡N	-nitrile	alkane nitrile

In addition to these some functional groups are represented as prefixes. They are discussed later

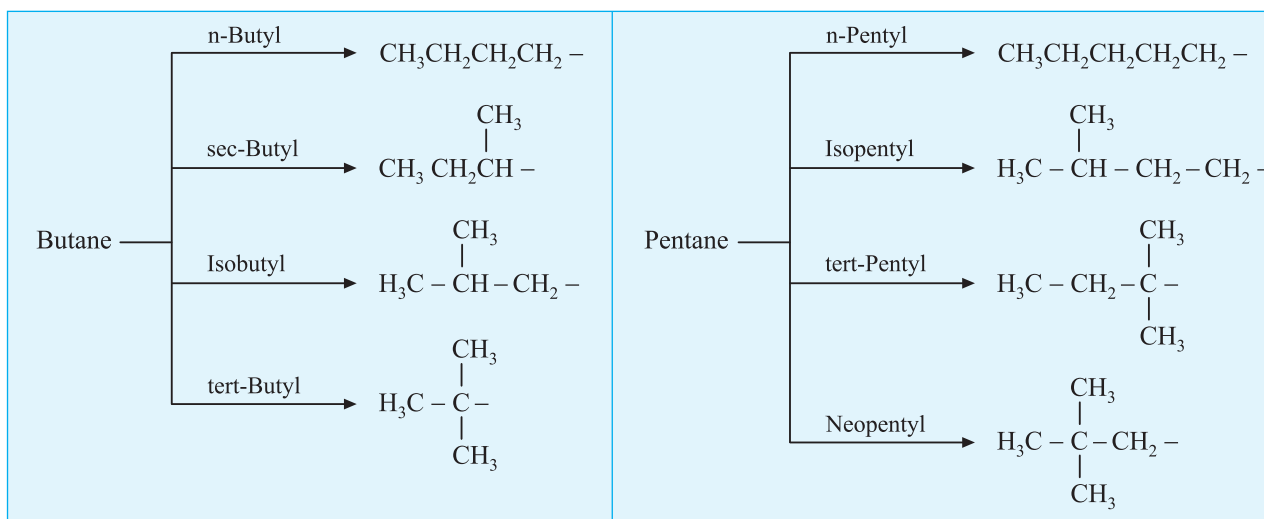
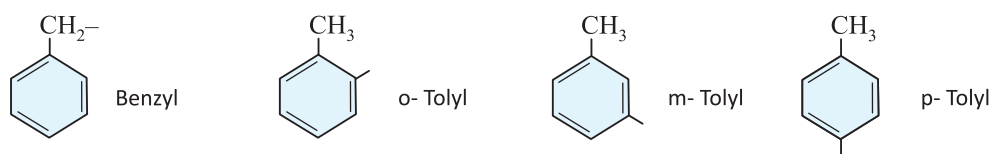
- Note :** (i) If the name of the secondary suffix begins with a consonant (except y), the terminal 'e' of the primary suffix is retained while adding secondary suffix to it. For example : Thioalcohols have secondary suffix thiol and thus 'e' of ane should not be dropped, i.e., IUPAC name is Alkane-thiol.
- (ii) The terminal 'e' of primary suffix is also retained if some numerical prefixes like di, tri etc. are used before the secondary suffix.

4. Prefix : The part of the name which appears before the word root is called prefix. Different prefixes are used for different categories of groups present in a molecule.

- (i) **Alkyl Groups :** The univalent groups or radicals obtained by the removal of one H atom from a molecule of paraffin are called alkyl groups. These alkyl groups have names that end in -yl. The symbol 'R' is often used to represent an alkyl group. Some alkyl groups with their prefixes are given in the following table.



Alkane	Alkyl Group	Abbreviation	Prefix
CH ₄ (Methane)	CH ₃ -	Me-	Methyl
C ₂ H ₆ (Ethane)	CH ₃ CH ₂ -	Et-	Ethyl
C ₃ H ₈ (Propane)	CH ₃ CH ₂ CH ₂ -	n-Pr-	n-Propyl
C ₃ H ₈ (Propane)	$\begin{array}{c} \text{CH}_3 - \text{CH} - \\ \\ \text{CH}_3 \end{array}$	iso-Pr-	Isopropyl or (1-Methylethyl)
C ₂ H ₄ (Ethene)	CH ₂ =CH-	-	Vinyl (Ethenyl)
C ₃ H ₆ (Propene)	CH ₂ =CH-CH ₂ -	-	Allyl
C ₆ H ₆ (Benzene)	C ₆ H ₅ -	Ph-	Phenyl



- (ii) Some functional groups are always indicated by prefixes instead of secondary suffixes. These with their prefixes are given in the following table.

Functional Group	Prefix	Family	IUPAC Name
$-\text{NO}_2$	Nitro	$\text{R}-\text{NO}_2$	Nitroalkane
$-\text{OR}'$	Alkoxy	$\text{R}-\text{OR}'$	Alkoxyalkane
$-\text{Cl}$	Chloro	$\text{R}-\text{Cl}$	Chloroalkane
$-\text{Br}$	Bromo	$\text{R}-\text{Br}$	Bromoalkane
$-\text{I}$	Iodo	$\text{R}-\text{I}$	Iodoalkane
$-\text{F}$	Fluoro	$\text{R}-\text{F}$	Fluoroalkane
$-\text{N}=\text{O}$	Nitroso	$\text{R}-\text{NO}$	Nitrosoalkane
	epoxy		epoxyalkane

- (iii) In polyfunctional compounds (compounds with more than one functional groups), one of the functional groups is treated as the principal functional group and is indicated by the secondary suffix whereas other functional groups, treated as substituents, are indicated by the prefixes. The order of priority among various functional groups to be treated as principal functional group has been discussed later in this chapter. The prefixes for various functional groups are given in the following table.

Prefixes for functional groups in polyfunctional compounds

Functional Group	Prefix	Functional Group	Prefix
–OH	Hydroxy	–COOH	Carboxy
–CN	Cyano	–COOR	Carbalkoxy
–NC	Isocyano	–COX	Haloformyl
–CHO	Formyl	–CONH ₂	Carbamyl
–SH	Mercapto	–NH ₂	Amino
–SR	Alkylthio	=NH	Imino
–NHR	alkylamino	–NR ₂	dialkylamino
–SO ₃ H	sulpho	>C=O	keto/oxo

Writing the IUPAC name of Organic Compounds :

While writing the IUPAC name of a compound, the word root, prefix, primary suffix and secondary suffix, follow the order:

Prefix(es) + Word root + Primary suffix + Secondary suffix

The above arrangement is illustrated by the following examples :

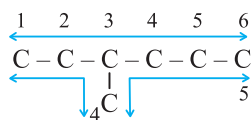
Compound	Prefix	Word root	P. suffix	Sec. suffix	IUPAC Name
$\begin{array}{c} \text{CH}_3 - \text{CH} - \text{CH}_2 - \text{CH}_2\text{OH} \\ \\ \text{CH}_3 \end{array}$	Methyl	but	an	ol	3-Methylbutan-1-ol
$\begin{array}{c} \text{CH}_3 - \text{C} = \text{CHOH} \\ \\ \text{Br} \end{array}$	Bromo	prop	en	ol	2-Bromoprop-1-en-1-ol

The Rules for naming Organic Compounds :

I. For Saturated Compounds

1. Selection of longest chain :

- The longest possible carbon chain is selected and the compound is named as derivative of hydrocarbon using word root.

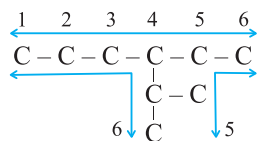


The chain of 6 carbon atoms is *selected*.

- If more than one set of longest possible chains are there, the selected longest chain should have :

- (a) Maximum number of side chains or

(b) Minimum number of branched side chains



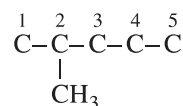
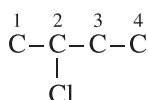
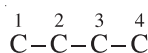
6 atoms chain with one side chain or one branched side chain is *rejected*.

6 atoms chain with two side chains or two unbranched side chains is *selected*.

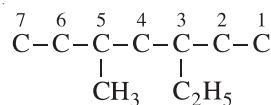
2. Numbering of selected chain :

The selected chain is numbered from one end to other. The numbers are called *locants*.

- Lowest number is assigned to first side chain (alkyl groups) or substituent group.

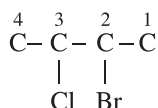
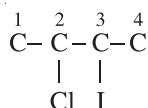


- If two different alkyl groups are at same position from opposite ends, lowest number is given to the one coming first in alphabetical listing.

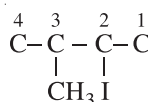


Note that ethyl gets '3' as the locant, not methyl.

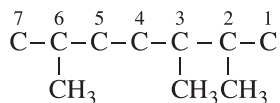
- If two different substituents are at same position from opposite ends, lowest number is assigned in order of their alphabets.



- If a substituent (such as halogen, or nitro group) and a side chain are at same position from opposite ends, lowest number is assigned to substituents.

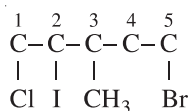


- If more than two substituents and side chains are present, then the set of locants are compared term by term, and that set is preferred which gets the least term at the first point of difference. This is the lowest set of locants rule.



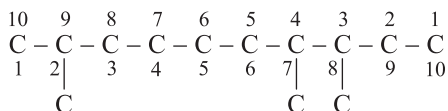
2, 3, 6 is *accepted*.

2, 5, 6 is *rejected*.



1, 2, 3, 5 is *accepted*.

1, 3, 4, 5 is *rejected*.

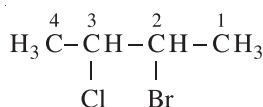


2, 7, 8, is *accepted*.

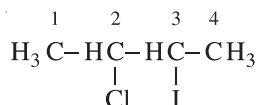
3, 4, 9 is *rejected*.

3. Arrangement of prefixes :

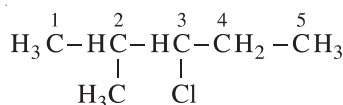
- Alkyl nature of side chain or substituent group is identified and reported as prefix, with its number (locant) in hydrocarbon name, in alphabetic order.



2-Bromo-3-chlorobutane

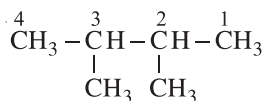


2-Chloro-3-iodobutane



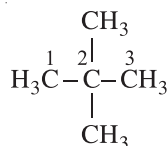
3-Chloro-2-methylpentane

- ▶ If more than one similar alkyl chains or substituents are present, prefix names are modified by putting di, tri....terms.



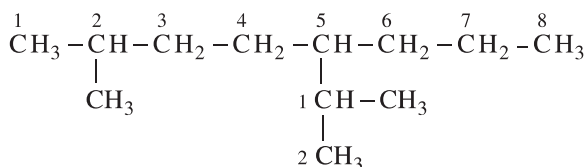
2, 3-Dimethylbutane

- If more than one similar alkyl groups or substituents are present at same position, their locant is also repeated.

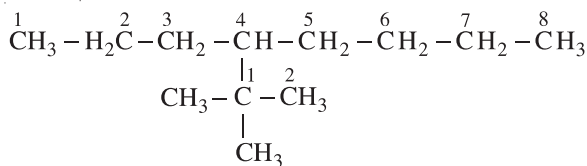


2, 2-Dimethylpropane

- In case side chain is also branched, it is numbered from the carbon atom attached to main chain and is generally written in brackets.



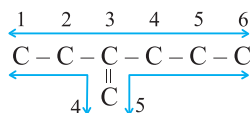
5-(1-Methylethyl)-2-methyl-octane



4-(1, 1-Dimethylethyl) octane

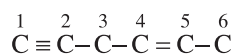
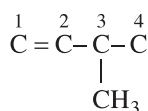
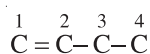
II. For Unsaturated compounds

1. Select the longest possible carbon chain having maximum number of unsaturated carbon atoms or maximum number of double or triple bonds, even if prior rules are violated.



5 carbon atoms chain with two unsaturated carbons or one double bond is *selected*.

2. Lowest number (locant) is assigned to first unsaturated carbon even if prior rules are violated.



3. In case of unsaturation suffix, name of unsaturation is used with hydrocarbon name, i.e.

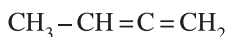
$\text{C} = \text{C}$ bond

ane of hydrocarbon is replaced by ene.

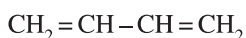
$\text{C} \equiv \text{C}$ bond

ane of hydrocarbon is replaced by yne.

4. In case of more than one double bonds we use di, tri etc. For example: diene or triene.

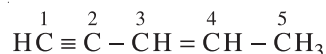


Buta-1, 2-diene



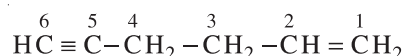
Buta-1, 3-diene

5. If a compound contains both the unsaturations then compound is named as *Alkenyne* with numbering as low as possible given to multiple bonds, following the lowest set of locants rule.



Pent-3-en-1-yne

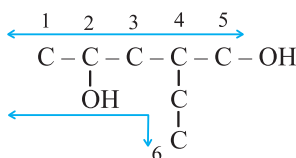
If there is a choice i.e. when the double bond and the triple bond are at the same distance from the two ends then the double bond gets the preference over the triple bond in the numbering.



Hex-1-en-5-yne

III. For Functional Groups

1. Select the longest possible carbon chain having maximum number of functional groups even if prior rules are violated, For example:



5 carbon chain inclusive of two functional groups is selected

2-ethylpentane-1, 4-diol

2. When the functional group itself contains a C atom, then the carbon atom of functional group is to be included in deciding the longest carbon chain.

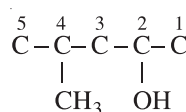
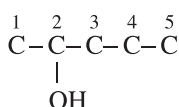
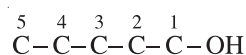


3 carbon chain, i.e., C atom of cyanide is also included.



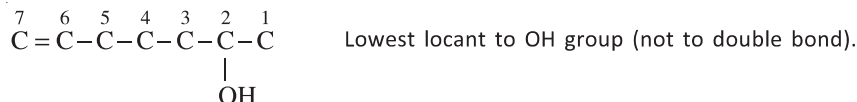
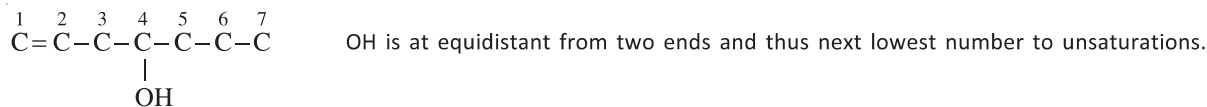
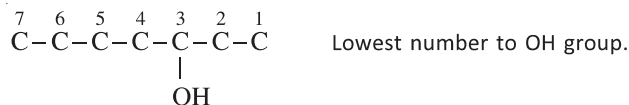
4 carbon chain, i.e., C atom of aldehyde is also included.

3. The lowest number (locant) is assigned to the functional group even if prior rules are violated.



4. The order for numbering a carbon chain, thus follows the order :

Functional Group then Unsaturation then Substituents and Side chains (or alkyl groups)

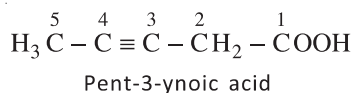
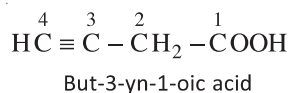


IUPAC names of some families of Organic Compounds :

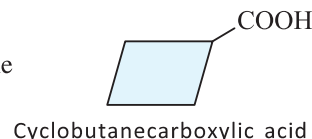
1. **Carboxylic Acids** : The IUPAC name of acids is derived from the name of the corresponding alkane by dropping the ending –e and putting the suffix –oic acid.



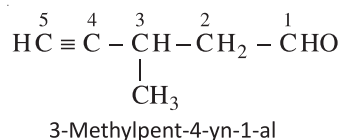
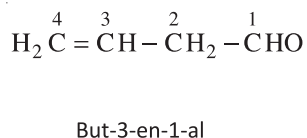
The position of the substituent is indicated by the usual numerals



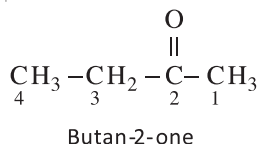
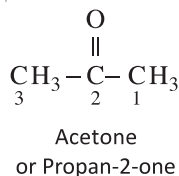
The cyclic acids cannot be named in this manner. To name them, the name of the corresponding cycloalkane precedes the word carboxylic acid.

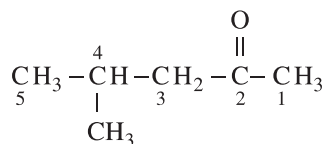


2. **Aldehydes** : Aldehydes have a hydrogen atom attached to the carbonyl group. The common name of an aldehyde is derived from the corresponding carboxylic acid by dropping the suffix –oic acid and adding the suffix –al. For example :

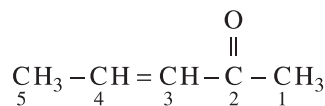


3. **Ketones** : The suffix ane is changed to –one i.e. alkanone. The numbering commences from that end of the chain which gives the lowest number to the carbonyl group. It is always necessary to prefix the name by a number to specify the position of the carbonyl group.





4-Methylpentan-2-one



Pent-3-en-2-one

4. **Ethers :** The common name of ethers is derived by naming the alkyl groups and adding the word ether. The smaller group is written first.



Methyl ethyl ether

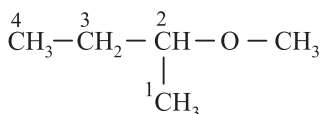


t-Butyl phenyl ether

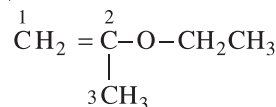
The IUPAC nomenclature is rarely used. Ethers are named as Alkoxy Alkanes. The larger alkyl group is chosen as the parent.



Methoxyethane

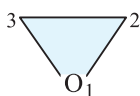
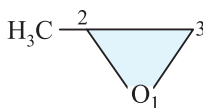
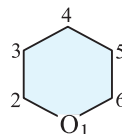


2-Methoxybutane

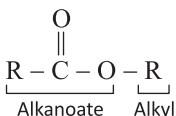


2-Ethoxypropene

In cyclic ethers, the oxygen atom is contained in a ring of carbon atoms. While numbering the cyclic group, oxygen atom is always given number – 1. While naming a prefix Epoxy is added to the number of carbon atoms in the cyclic chain.

Epoxy ethane
(Oxirane)2-Methyl epoxy ethane
(2-Methyl oxirane)Epoxy pentane
(Oxane)

5. **Esters :** In the IUPAC system the acid chain is used as the stem in naming the ester. The suffix –oate replaces the –oic acid of carboxylic acids. It is necessary to number the substituent on the chain. The first part of the name is derived from the alkyl group of the corresponding alcohol.



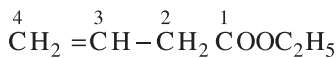
Ethylpropanoate



Methylmethanoate



Methylethanoate



Ethylbut-3-en-1-oate

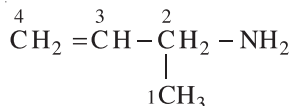
6. **Amines :** In the IUPAC system of nomenclature, amines are named similar to alcohols. The longest continuous carbon chain having max. no of amines determines the root name. The –e ending in the alkane name is replaced by suffix-amine. A number is needed to specify the position of the substituents.



Ethanol



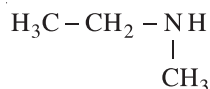
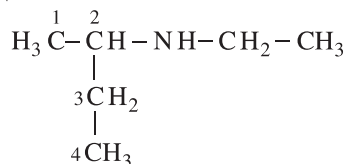
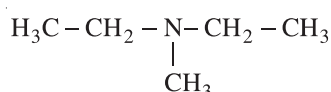
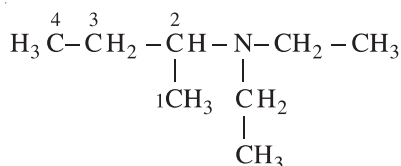
Ethanamine



But-3-en-2-amine

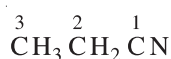
Secondary amines and Tertiary amines :

The name of any alkyl group bonded to nitrogen is preceded by a “*N*” (in *Italic*) to indicate that the group is bonded to a nitrogen rather than to carbon.

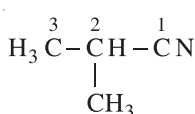
*N*-Methylethanamine*N*-Ethylbutan-2-amine*N*-Ethyl-*N*-methylethanamine*N,N*-Diethylbutan-2-amine

All the substituents (regardless of whether they are attached to the nitrogen or to the parent hydrocarbon) are listed in alphabetical order. The chain is numbered such that the functional group suffix gets the lowest possible number.

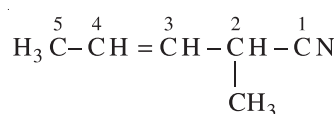
7. **Nitriles :** While writing the IUPAC name, the cyano group takes the preference and its carbon atom is numbered as 1, only suffix -nitrile is added to the name of parent hydrocarbon (including the carbon of group).



Propanenitrile



2-Methylpropanenitrile



2-Methylpent-3-enenitrile

Rules for IUPAC Nomenclature of Polyfunctional Compounds :

Organic compounds having polyfunctional groups are named as follows :

1. **Principal functional group :** When an organic compound contains two or more different functional groups, one of the functional groups is selected as the principal functional group while all other groups (also called the secondary functional groups) are treated as substituents. The choice of the principal functional group is made on the basis of the following order of preference.



The secondary suffixes for these functional groups have already been listed before.

All the remaining functional groups such as halo (fluoro, chloro, bromo, iodo), nitroso ($-\text{NO}$), nitro ($-\text{NO}_2$), and R (alkyl), C_6H_5 etc. are always treated as substituent groups.

It may be noted that while writing the names of the polyfunctional compounds, the principal functional group is indicated by adding the secondary suffix to the word root while the secondary functional groups are indicated by adding suitable prefixes to the word root. The prefixes for secondary functional groups are have already been listed before.

- Selecting the principal chain :** While selecting the principal chain present in a polyfunctional compound care should be taken that it must contain the principal functional group and the maximum number of secondary functional groups and multiple bonds, if any.
- Numbering the principal chain :** The principal chain present in a polyfunctional compound must be numbered in such a way that the principal functional group gets the lowest possible number followed by double bond, triple bond and the substituents, i.e.

Principal functional group > Double bond > Triple bond > Substituents.

- Alphabetical order :** The prefixes for the secondary functional groups and other substituents should be placed in alphabetical order before the word root as explained earlier. If, however, two groups of the same family (e.g., halogens) occupy identical positions from either end of the parent chain, the lower number must be given to the group whose prefix comes first in the alphabetical order. For example :



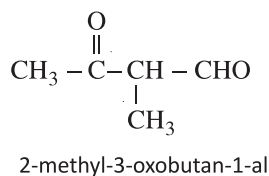
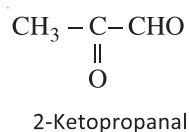
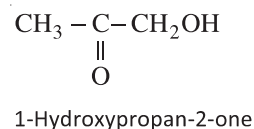
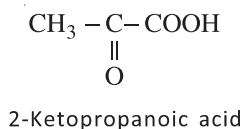
1-Bromo-4-chlorobutane (Correct)



4-Bromo-1-chlorobutane (Wrong)

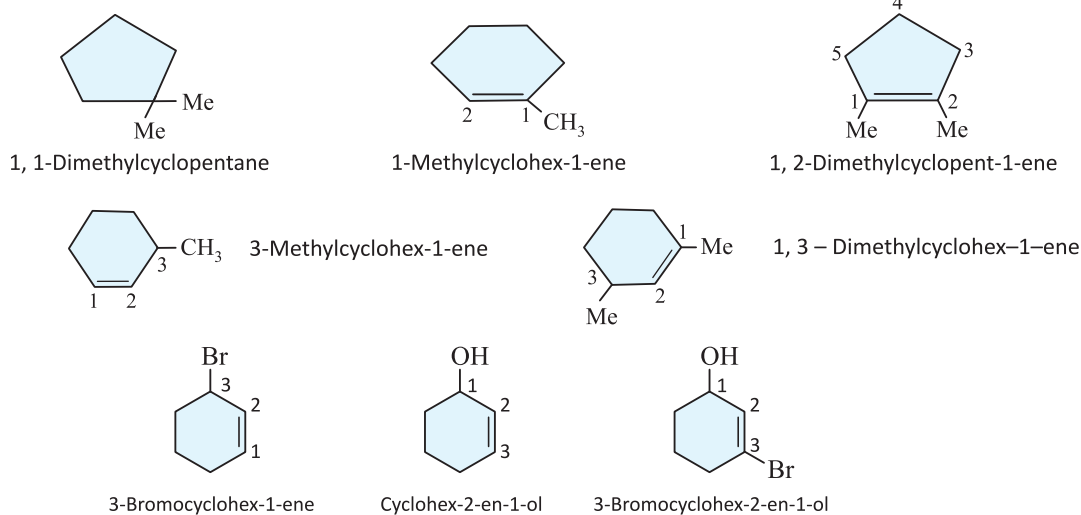
The rest of the rules for numerical prefixes are the same as explained earlier.

If more than one kind of functional groups are present, the functional group placed above (in the order of preference) decides suffix name.



Naming of Alicyclic Compounds :

The nomenclature for alicyclic compounds is derived by putting another prefix 'cyclo' before the word root of carbon atoms in ring. The suffixes ane, ene are written depending upon the nature of molecule, i.e., saturated (–ane) or unsaturated (–ene) for double bond.

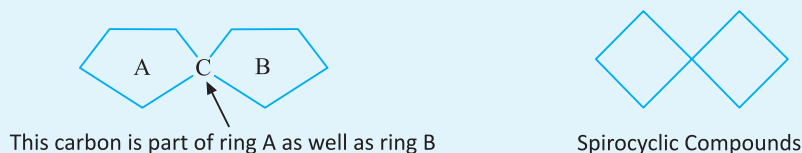


Note: From above examples, we can see that substituted cycloalkanes are named as derivatives of parent cycloalkanes. The substituted alkyl groups or functional groups around the ring are numbered from the point of greatest substitution providing the lowest series of numbers.

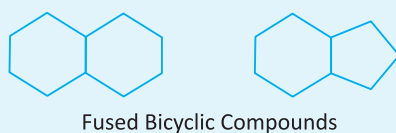
Bicyclic Compounds : (This topic is for reference only, not in JEE syllabus)

Bicyclic compounds are compounds that contain two rings.

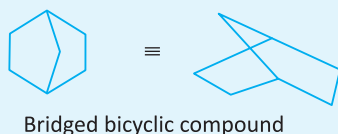
- If the two rings share one carbon, the compound is a spirocyclic compound or simply spiro compound.
For example :



- If the two rings share two adjacent carbons, the compound is a fused bicyclic compound.

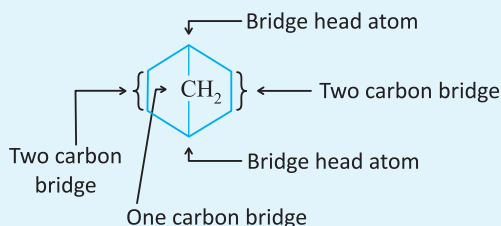


- If the two rings share more than two carbons, the compound is a bridged bicyclic compound.



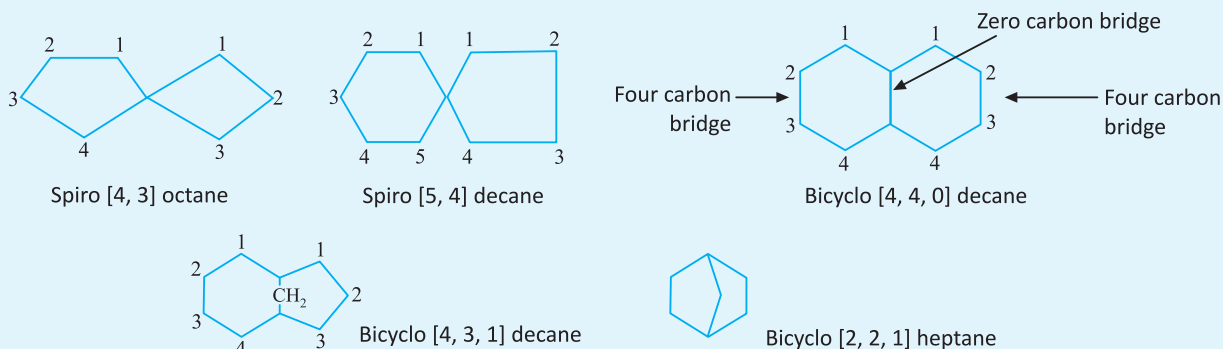
Nomenclature of Bicyclic Compounds :

1. Bicyclic compounds are named by using the alkane name to designate the total number of carbons and the prefix bicyclo or spiro to indicate the number of shared carbons.
2. Prefix spiro indicates one shared carbon and bicyclo indicates two or more shared carbons.
The following compound, for example, contains seven carbon atoms and is therefore, a bicycloheptane.

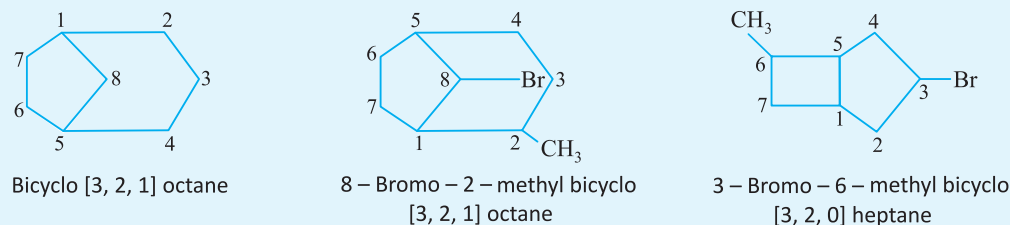


The carbon atoms common to both rings (Number of such carbons is either one in spiro or two in bicyclic) are called bridgeheads and each carbon chain of atoms, connecting the bridgehead atoms is called a bridge.

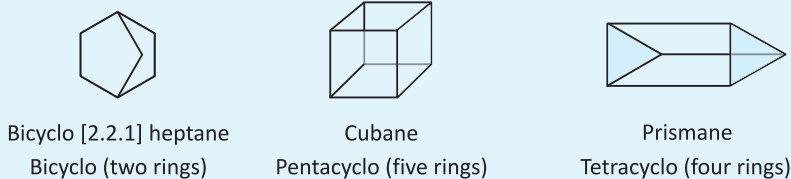
3. After the prefix spiro or bicyclic comes brackets that contain numbers indicating the number of carbons in each bridge. These are listed in order of decreasing bridge length. For example :



4. Numbering in bicyclic compounds starts at any one bridge head carbon and moves along the longest carbon bridge to the next bridge head carbon. Continue along the next longest carbon bridge to return to the first bridge head carbon so that the shortest bridge is numbered last.

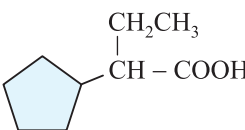
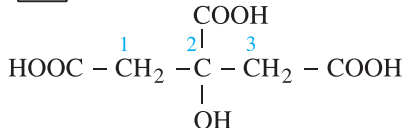
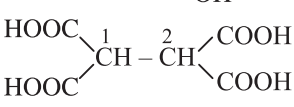
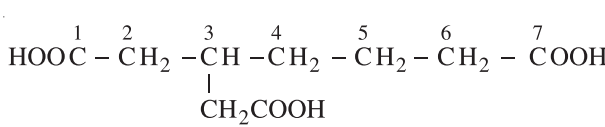
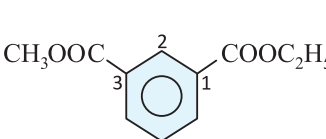
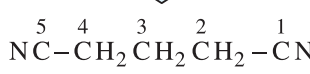
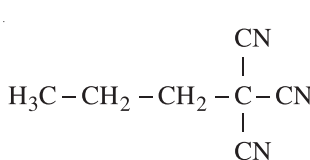
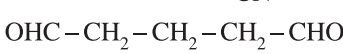
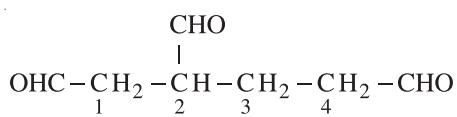
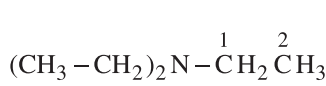
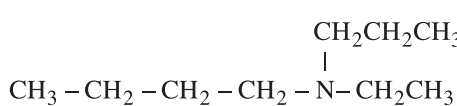
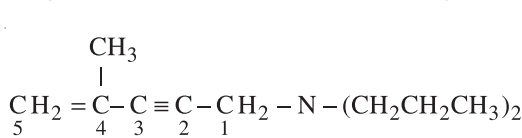
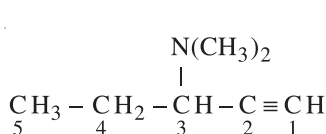


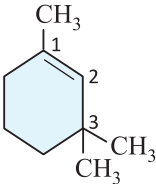
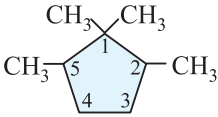
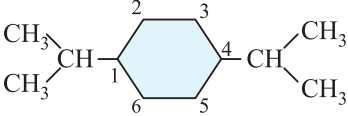
Note : Number of rings in polycyclic compounds = (S - A + 1) where 'S' is the number of single bonds in the ring and A is the number of carbon atoms in the ring.



Some Prominent IUPAC Examples

* PIN : Preferred IUPAC Name

1.  2-Cyclopentyl butanoic acid (PIN)
2.  2-Hydroxy propane-1, 2, 3,-tricarboxylic acid.
3.  Ethane-1,1,2,2-tetracarboxylic acid (PIN)
4.  3-(Carboxymethyl) heptanedioic acid (PIN)
5.  Ethyl methyl benzene-1, 3-dicarboxylate
6.  Pentane dinitrile (PIN)
7.  Butan-1, 1, 1-tricarbonitrile (PIN)
8.  Pentanedial (PIN)
9.  Butan-1, 2, 4-tricarbaldehyde
10.  N, N- Diethyl ethan-1-amine (PIN)
11.  N-Ethyl-N-propyl butan-1-amine
12.  4-Methyl-N, N-dipropylpent-4-en-2-yn-1-amine (PIN)
13.  N, N-Dimethyl pent-1-yn-3-amine (PIN)

14. $\text{H}_2\text{N}-\overset{3}{\text{CH}_2}-\overset{2}{\text{CH}_2}-\overset{1}{\text{COOH}}$ 3-Amino propanoic acid (PIN)
15. $\text{H}_2\text{N}-\overset{2}{\text{CH}_2}-\overset{1}{\text{CH}_2}-\text{NH}_2$ Ethane-1, 2-diamine (PIN)
16. $\overset{3}{\text{CH}_2}=\overset{2}{\text{CH}_2}-\overset{1}{\text{CH}_2}-\text{NH}_2$ Prop-2-en-1-amine
17. $\begin{array}{c} \text{OH} \\ | \\ \text{CH}_3-\text{CH}-\text{COOH} \end{array}$ 2-Hydroxy propanoic acid (PIN) (*Lactic acid*)
18. $\begin{array}{c} \text{O} \\ || \\ \text{CH}_3-\text{C}-\text{COOH} \end{array}$ 2-Oxopropanoic acid (PIN) (*Pyruvic acid*)
19. $\begin{array}{c} \text{COOH} \\ | \\ \text{CH}-\text{OH} \\ | \\ \text{CH}-\text{OH} \\ | \\ \text{COOH} \end{array}$ 2, 3-Dihydroxy butanedioic acid (PIN) (*Tartaric acid*)
20. $\begin{array}{c} \text{CH}_2-\text{OH} \\ | \\ \text{COOH} \end{array}$ 2-Hydroxy ethanoic acid (*Glycolic acid*)
21. $\begin{array}{c} \text{CHO} \\ | \\ \text{COOH} \end{array}$ Formylmethanoic acid (*Glyxolic acid*)
22.  1, 3, 3-Trimethylcyclohex-1-ene
23.  1, 1, 2, 5-Tetramethyl cyclopentane
and not (1, 2, 2, 3-tetramethyl cyclopentane)
24.  1, 4-Di(isopropyl) cyclohexane or 1, 4-Di(methyl ethyl) cyclohexane
25.  4-Butyl-4-tert-butylcyclohexan-1-ol (PIN)
26. $\begin{array}{ccccccc} & \text{OH} & & \text{COOH} & & \text{O} & \\ & | & & | & & || & \\ \text{HOOC}- & \text{CH} & - & \text{CH} & - & \text{C} & - \text{COOH} \\ & 1 & & 2 & & 3 & \end{array}$ 1-Hydroxy-3-oxopropane - 1, 2, 3-tricarboxylic acid (PIN)
27. $\text{Cl}-\underset{1}{\text{CH}}=\underset{2}{\text{C}}=\underset{3}{\text{CH}}-\text{Cl}$ 1, 3-Dichloropropa-1, 2-diene (PIN)

Nomenclature of Aromatic Compounds :

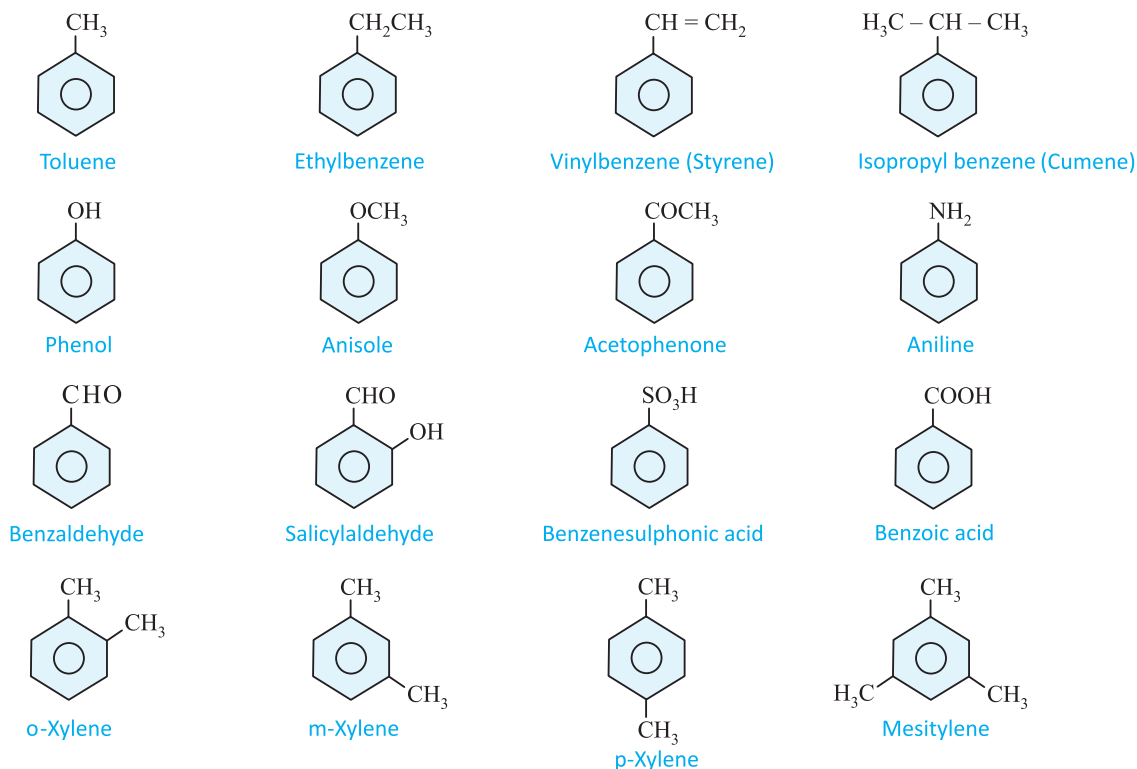
Aromatic compounds are cyclic compounds which contain one or more benzene type rings. Benzene is the simplest hydrocarbon of aromatic series which has a planar cyclic ring of six carbon atoms having three double bonds in alternate positions as shown below :

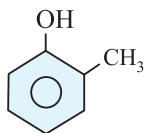


The carbon atoms of benzene are numbered from 1 to 6 as shown above. The benzene ring is called the nucleus and groups containing at least one carbon atom that too directly attached to benzene nucleus are called side chains. Benzene forms only one mono substituted derivative. However, it can form three disubstituted derivatives; namely 1, 2 ; 1, 3 and 1, 4 derivatives or ortho (*o*-), meta (*m*-) and para (*p*-) derivatives respectively.

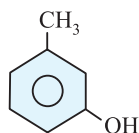


Some Important Aromatic Hydrocarbons :





o-Cresol



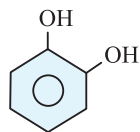
m-Cresol



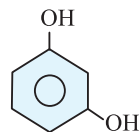
p-Cresol



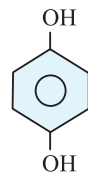
Benzonitrile



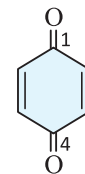
Catechol



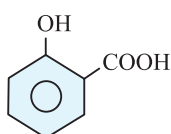
Resorcinol



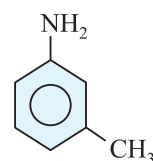
Hydroquinol



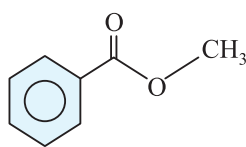
1, 4-Benzoquinone



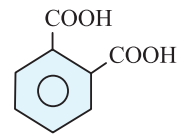
Salicylic acid



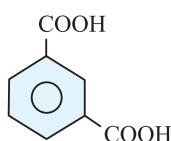
m-Toluidine



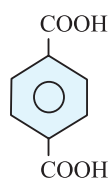
Methyl benzoate



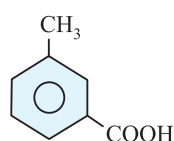
Phthalic acid



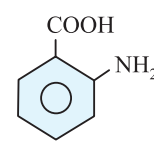
Isophthalic acid



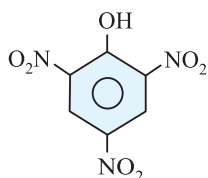
Terephthalic acid



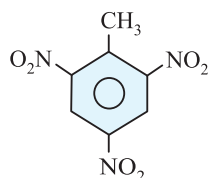
m-Toluic acid



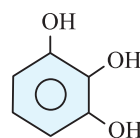
Anthranilic acid



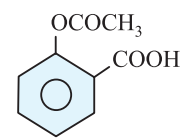
Picric acid



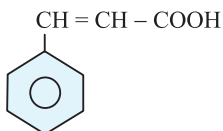
2, 4, 6-Trinitrotoluene (TNT)



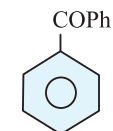
Pyrogallol



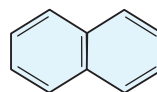
Aspirin



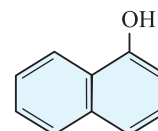
Cinnamic acid



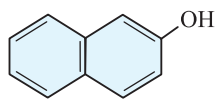
Benzophenone



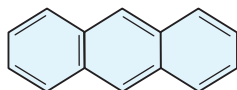
Naphthalene



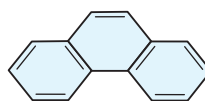
α-Naphthol



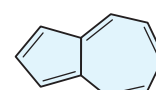
β-Naphthol



Anthracene



Phenanthrene



Azzulene

Homologous Series : A homologous series is defined as a family or group of structurally similar organic compounds all the members of which contain the same functional group, show a gradation in physical and similarity in chemical properties and any two adjacent (or consecutive) members of which differ by a $-\text{CH}_2$ group. For example : alkanes constitute a homologous series.

The first six members of this series are :

CH_4	C_2H_6	C_3H_8	C_4H_{10}	C_5H_{12}	C_6H_{14}
Methane	Ethane	Propane	Butane	Pentane	Hexane

These hydrocarbons can be represented by the same general formula, $\text{C}_n\text{H}_{2n+2}$ where n is the number of carbon atoms. Further, any two adjacent members of this class differ by a CH_2 group.

If a hydrogen atom from the above hydrocarbons is replaced by a hydroxyl group i.e., $-\text{OH}$, we get a new homologous series. This homologous series is called alcohols. The different members of this series can be represented by the general formula $\text{C}_n\text{H}_{2n+1}\text{OH}$. The first four members of this series are :

CH_3OH	$\text{CH}_3\text{CH}_2\text{OH}$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
Methanol	Ethanol	Propan-1-ol	Butan-1-ol

Some other homologous series are alkenes, alkynes, alkyl halides, ethers, aldehydes, ketones, amines, esters and carboxylic acids etc.

Characteristics of a Homologous Series :

1. Each homologous series can be represented by a general formula. For example, $\text{C}_n\text{H}_{2n+1}\text{COOH}$ is the general formula of saturated carboxylic acids.
2. All the members of a given homologous series possess the same functional group. For example, the functional group of alcohols is the hydroxyl group i.e., $-\text{OH}$ group. Similarly, the functional group of aldehydes is the aldehydic group i.e., $-\text{CHO}$ and that of the ketones is the ketonic group, i.e., $>\text{C}=\text{O}$.
3. The successive members of a homologous series differ by a CH_2 group or by $12 + 2 \times 1 = 14$ mass units.
4. The individual members of a homologous series can be prepared by the general methods of preparation developed for that series.
5. The physical properties such as density, melting point, boiling point of the members of a homologous series show a regular gradation with rise in molecular mass.
6. The chemical properties of the members of a homologous series are similar though the first member may vary considerably from rest of the members.

Degree of Unsaturation (DU)

Degree of Unsaturation also known as “index of Hydrogen deficiency (IHD)” or “rings plus double bonds” is helpful in Organic Chemistry while drawing Chemical structures.

For a compound with formula : $\text{C}_a\text{H}_b\text{N}_c\text{O}_d\text{X}_e$ where X is F, Cl, Br or I,

$$\text{DU} = \frac{1}{2} (2 + 2a - b + c - e) \quad \text{or} \quad \text{DU} = \frac{1}{2} [2 + 2 \times \text{No. of C atoms} - \text{No. of H atoms} + \text{No. of N atoms} - \text{No. of Halide atoms}]$$

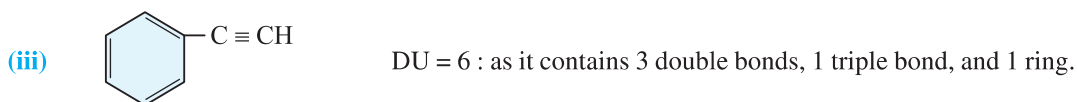
Rules :

- (i) Do not count group 16 elements e.g. O, S etc. Remove them from the formula but count H-atoms attached to them.
- (ii) Each double bond, adds 'one' to DU.
- (iii) Each triple bond, adds 'two' to DU.
- (iv) Each ring adds 'one' to DU.

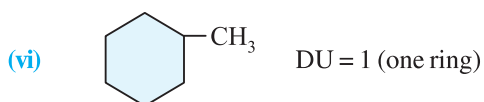
Illustrating the Concept :

(i) C_3H_6 : $DU = \frac{1}{2}[2 + 2 \times 3 - 6] = 1 \Rightarrow$ It contains a double bond OR a ring.

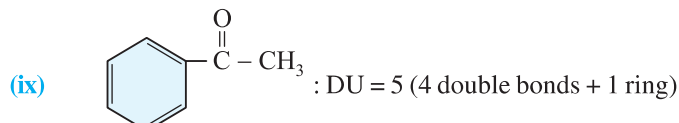
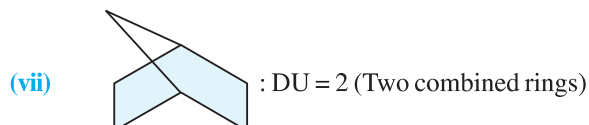
(ii) C_5H_8 : $DU = \frac{1}{2}[2 + 2 \times 5 - 8] = 2$
 $\Rightarrow$ Two double bonds OR 1 triple bonds OR 2 rings OR 1 double bond and 1 ring.



(iv) $C_6H_{12}O_6$: $DU = \frac{1}{2}[2 + 2 \times 6 - 12] = 1$



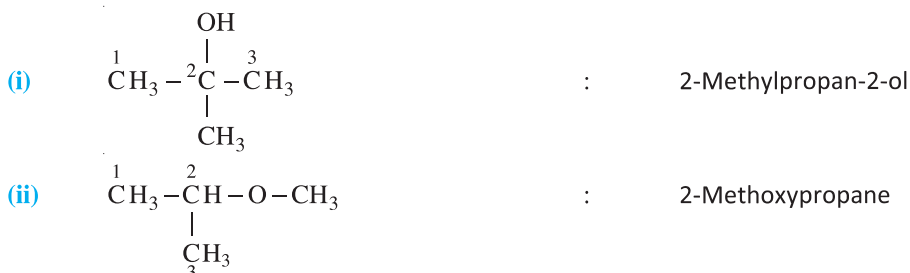
(v) $C_6H_{12}N_2Br_2$: $DU = \frac{1}{2}[2 + 2 \times 6 - 12 + 2 - 2] = 1$



Note : $DU \geq 4$ doesn't demand but suggest the possibility of an aromatic (benzene) ring.

Illustration - 1 Draw the condensed structures of following compounds. Also write their IUPAC name.

- | | | |
|---------------------------------------|-----------------------------|--------------------------------------|
| (i) <i>tert</i> -Butyl alcohol | (ii) Isopropyl methyl ether | (iii) <i>sec</i> -Butyl ethyl ketone |
| (iv) Phenyl methyl ether | (v) Isopropyl isobutyrate | (vi) <i>sec</i> -Butyl formate |
| (vii) Methyl vinyl ether | (viii) Isopropyl benzene | (ix) Dimethyl <i>n</i> -propyl amine |
| (x) Methyl <i>n</i> -propyl acetylene | | |

SOLUTION :

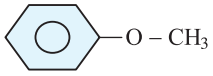
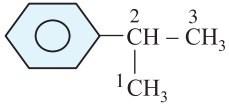
- (iii) $\begin{array}{ccccccc} 1 & 2 & 3 & 4 & 5 & 6 \\ \text{CH}_3 & \text{CH}_2 & -\text{C}- & \text{CH}- & \text{CH}_2 & -\text{CH}_3 \\ & & \parallel & | \\ & & \text{O} & \text{CH}_3 \end{array}$: 4-Methylhexan-3-one
- (iv)  : Methoxybenzene ; (called as **anisole** : trade name as IUPAC name)
- (v) $\begin{array}{ccccccc} & & \text{O} & & & & \\ & & \parallel & & & & \\ 3 & 2 & 1 & & 1 & 2 & \\ \text{CH}_3 & -\text{CH}- & \text{C}-\text{O}- & \text{CH}- & \text{CH}_3 \\ & | & & | \\ & \text{CH}_3 & & \text{CH}_3 \end{array}$: (1-Methylethyl) 2-methylpropanoate
- (vi) $\begin{array}{ccccccc} & & \text{O} & & & & \\ & & \parallel & & & & \\ \text{H} & -\text{C}-\text{O}- & 1 & 2 & 3 & & \\ & & | & \text{CH}_2 & \text{CH}_3 \\ & & \text{CH}_3 & & \end{array}$: (1-Methylpropyl) methanoate
- (vii) $\text{CH}_3-\text{O}-\text{CH}=\text{CH}_2$: Methoxyethene
- (viii)  : (2-Propyl) benzene (or cumene) or (1-Methylethyl) benzene.
- (ix) $\begin{array}{c} \text{CH}_3-\text{N}-\text{CH}_3 \\ | \\ \text{CH}_2\text{CH}_2\text{CH}_3 \\ 1 \quad 2 \quad 3 \end{array}$: N, N-Dimethyl- propan - 1 - amine
- (x) $\text{CH}_3-\text{C}\equiv\text{C}-\text{CH}_2-\text{CH}_2-\text{CH}_3$: Hex - 2 - yne

Illustration - 2 Draw the bond line structures for each of above compounds in Illustration - 1

SOLUTION :

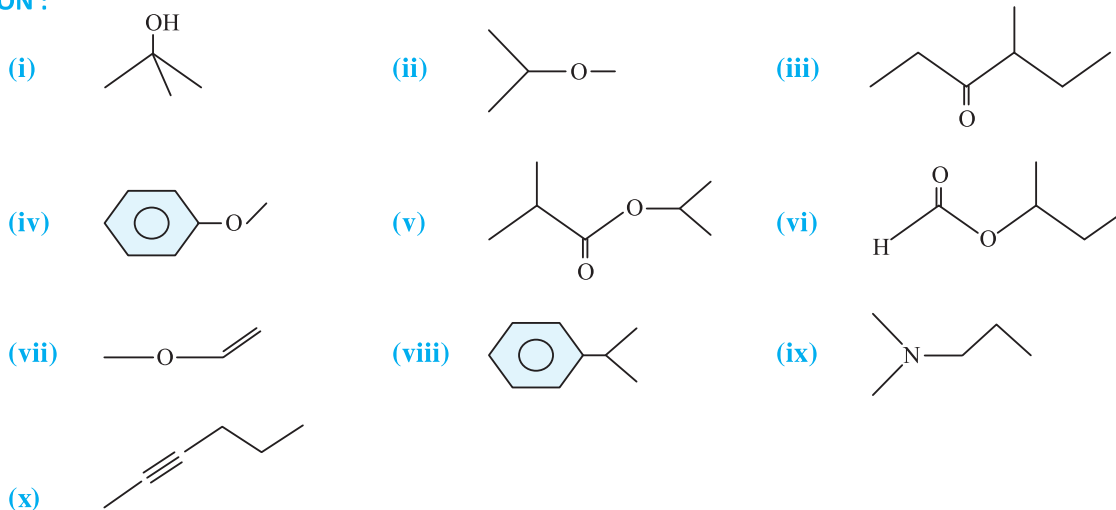
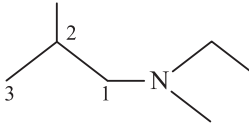
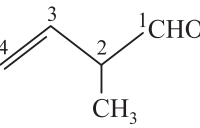
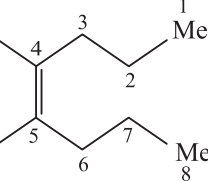
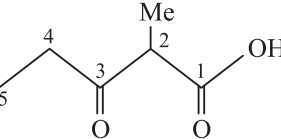
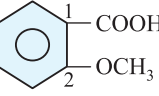
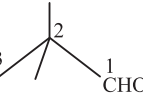
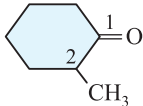
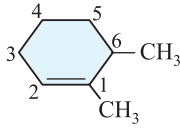
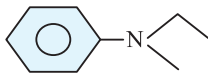
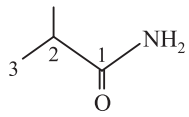
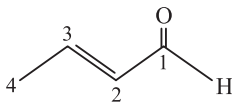
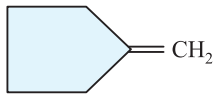


Illustration - 3 Give the IUPAC names of the following structures.**SOLUTION :**

1.
$$\begin{array}{c} \text{OH} \\ | \\ {}^4\text{CH}_3 - {}^3\text{CH} - {}^2\text{CH}_2 - {}^1\text{COOC}_2\text{H}_5 \end{array}$$
 (Ethyl) 3-hydroxybutanoate
2.
$$\begin{array}{c} {}^4\text{CH}_3 - {}^3\text{CH}_2 - {}^2\text{CH} - {}^1\text{COCl} \\ | \\ \text{Br} \end{array}$$
 2-Bromobutanoyl chloride
3.
$$\begin{array}{c} {}^6\text{H}_2\text{C} = {}^5\text{C} - {}^4\text{CH}_2 - {}^3\text{CH}_2 - {}^2\text{CH} - {}^1\text{COOH} \\ | \qquad \qquad | \\ \text{CH}_3 \qquad \qquad \text{OH} \end{array}$$
 2-Hydroxy-5-methylhex-5-enoic acid
4.  N-Ethyl-N-methyl-2-methylpropan-1-amine
5.
$$\begin{array}{c} {}^4\text{CH}_2 = {}^3\text{C} - {}^2\text{CH} - {}^1\text{CH}_3 \\ | \qquad | \\ \text{CH}_3 \quad \text{OH} \end{array}$$
 3-Methylbut-3-en-2-ol
6.
$$\begin{array}{c} \text{O} \\ || \\ \text{ph} - \text{O} - \text{C} - {}^2\text{CH} - {}^3\text{CH}_3 \\ | \\ \text{CH}_3 \end{array}$$
 (Phenyl) 2-methylpropanoate
7.  2-Methylbut-3-en-1-al
8.  4, 5-Dimethyloct-4-ene
9.  2-Methyl-3-Oxopentanoic acid
10.  2-Methoxybenzoic acid
11.  2, 2-Dimethylpropan - 1- al

12.  2-Methylcyclohexan - 1-one
13.  1, 6-Dimethyl cyclohex-1-ene
14. $\text{ph}-\overset{3}{\text{CH}}=\overset{2}{\text{CH}}-\overset{1}{\text{COOH}}$ 3-Phenylprop-2-enoic acid
15. $\text{CH}_3-\overset{6}{\underset{\text{OH}}{\text{CH}}}-\overset{5}{\text{CH}}=\overset{4}{\text{CH}}-\overset{3}{\text{CH}_2}-\overset{2}{\underset{\text{OCH}_3}{\text{CH}}}-\overset{1}{\text{CHO}}$ 6-Hydroxy-2-methoxyhept-4-en-1-al
16. $\text{C}_2\text{H}_5-\text{NH}-\overset{1}{\underset{\text{CH}_3}{\text{CH}}}-\overset{2}{\text{CH}}-\overset{3}{\text{CH}_2}-\overset{4}{\text{CH}_3}$ N-Ethylbutan-2-amine
17. $\text{CH}_3\text{NHCH}(\overset{3}{\text{CH}_3})-\overset{1}{\underset{\text{O}}{\parallel}}\text{C}-\text{OH}$ 2(N-Methylamino)propanoic acid
18.  N-Ethyl-N-methylaniline
19.  2-Methylpropanamide
20.  But-2-en - 1- al
21. $\text{C}_2\text{H}_5-\overset{2}{\underset{\text{COOCH}_3}{\text{CH}}}-\overset{1}{\text{COOCH}_3}$ Trivial Name : (Dimethyl) - α - ethylmalonate
IUPAC Name : (Dimethyl) 2-ethylpropane-1,3-dioate
22.  Methylenecyclopentane

IN-CHAPTER EXERCISE-A

1. Choose the correct alternative. Only one choice is correct. However, questions marked '*' may have More than one correct option.

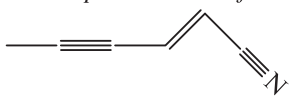
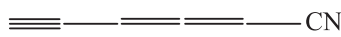
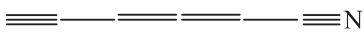
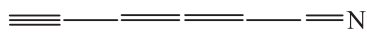
(i) The smallest alkane to have 1° , 2° , 3° and 4° C has _____ hydrogen.

- (A) 16 (B) 18 (C) 20 (D) 22

*(ii) The smallest alkene to have 1° , 2° and 3° H has _____.

- (A) 6 C (B) 5 C (C) 12 H (D) 10 H

*(iii) The bond line representation of $\text{HC}\equiv\text{C}-\text{CH}=\text{C}=\text{CH}-\text{CN}$ is :

- (A)  (B) 
 (C)  (D) 

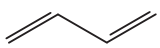
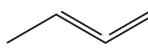
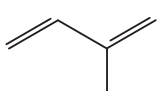
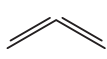
(iv) The total number of alcohols and ethers with molecular formula: $\text{C}_4\text{H}_{10}\text{O}$ is :

- (A) 5 (B) 6 (C) 7 (D) 8

(v) The number of esters with molecular formula $\text{C}_4\text{H}_8\text{O}_2$ is :

- (A) 7 (B) 6 (C) 5 (D) 4

*(vi) Which of the following is(are) conjugate dienes ?

- (A)  (B) 
 (C)  (D) 

(vii) 2° amine of the molecular formula $\text{C}_4\text{H}_{11}\text{N}$ are :

- (A) 1 (B) 2 (C) 3 (D) 4

(viii) $\text{C}_4\text{H}_8\text{Cl}_2$ has _____ gem, _____ vicinal, and _____ total dichloride structures.

- (A) 2, 2, 6 (B) 3, 3, 8 (C) 2, 3, 8 (D) 3, 3, 9

(ix) The number of aldehydes and ketones with molecular formula: $\text{C}_5\text{H}_{10}\text{O}$ is :

- (A) 7 (B) 6 (C) 8 (D) 5

(x) General formula $\text{C}_n\text{H}_{2n}\text{O}_2$ can be for open chain _____.

- (A) Dialdehydes (B) Diketones (C) Carboxylic acids (D) Diols

2. Give the dash structures of the following :

- (i) Isobutyl radical (ii) Neopentyl radical
 (iii) tert-Pentyl radical (iv) sec-Butyl radical
 (vi) tert-butyl radical (v) Benzyl radical

3. Give IUPAC name of following :

- (i) $(\text{CH}_3)_3\text{C}-\text{COOCH}_3$ (ii) $(\text{CH}_3)_2\text{CH}-\underset{\text{CH}_3}{\underset{|}{\text{CH}}}-\overset{\text{CH}_3}{\underset{|}{\text{CH}}}-\text{CH}=\text{CH}_2$
- (iii) $\text{CH}_3-\underset{\text{Cl}}{\underset{|}{\text{CH}}}-\text{CH}_2\text{COOH}$ (iv) $(\text{CH}_3)_2\text{CH}-\underset{\text{OH}}{\underset{|}{\text{C}}}(\text{CH}_3)_2$
- (v) $\text{CH}_3-\text{CH}_2-\text{CH}_2-\underset{\text{COOH}}{\underset{|}{\text{CH}}}-\text{C}_2\text{H}_5$ (vi) $\text{CH}_3-\text{CH}_2-\underset{\text{CH}_2}{\underset{||}{\text{C}}}-\text{CH}_2\text{CH}_3$
- (vii) $(\text{CH}_3)_2\text{CH}-\underset{\text{CH}(\text{CH}_3)_2}{\underset{|}{\text{CH}}}-\overset{\text{CH}_3}{\underset{|}{\text{C}}}=\text{CH}_2$ (viii) $(\text{CH}_3)_2\text{CH}-\underset{\text{N}-\text{CH}_3}{\underset{|}{\text{CH}}}-\text{CH}(\text{CH}_3)_2$
- (ix) $\text{CH}_3-\overset{\text{C}_2\text{H}_5}{\underset{|}{\text{C}}}-\underset{\text{CH}_3}{\underset{|}{\text{C}}}=\text{C}(\text{CH}_3)_2$ (x) $\text{CH}_3-\text{CH}_2-\underset{\text{CH}_3}{\underset{|}{\text{CH}}}-\underset{\text{CH}_3}{\underset{|}{\text{CH}}}-\text{O}-\text{CH} < \begin{smallmatrix} \text{CH}_3 \\ \text{CH}_3 \end{smallmatrix}$

4. Give the structure of following aromatic compounds :

- (i) *o*-Cresol (ii) *p*-Toluidine (iii) *m*-Toluic acid
 (iv) Benzoyl chloride (v) Benzo phenone (vi) Aniline
 (vii) Benzoic anhydride (viii) Acetophenone (ix) Phenol
 (x) Terephthalic acid

5. Give IUPAC name of following :

- (i) $\text{CH}_3-\text{C}(\text{CH}_3)_2\text{CH}_2-\underset{\text{CH}_3}{\underset{|}{\text{CH}}}-\text{CH}_3$ (ii) $\text{H}_3\text{C}-\text{CH}_2-\text{CH}_2-\underset{\text{C}_2\text{H}_5}{\underset{|}{\text{C}}}=\text{CH}_2$
- (iii) $\text{CH}_2=\underset{\text{CH}_3}{\underset{|}{\text{C}}}-\underset{\text{CH}_3}{\underset{|}{\text{C}}}=\text{CH}_2$ (iv) $\text{CH}_3-\text{CH}=\text{CH}-\underset{\text{O}}{\underset{||}{\text{C}}}-\text{CH}_3$
- (v) $\text{H}-\text{COO}-\underset{\text{CH}_3}{\underset{|}{\text{CH}}}-\text{CH}_3$ (vi) $\text{CH}_2=\text{CHCH}_2-\text{C}_6\text{H}_5$

***Note :** For Practice, please refer to questions given in Supplement-3 (Introduction to Organic Chemistry)