

CHAPTER 4

NOMENCLATURE OF ORGANIC COMPOUNDS



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Usefulness of IUPAC System

The IUPAC system continues to hold great significance in modern science society and technology for several key reasons.

- (i) It plays a crucial role by offering a uniform language to chemists globally.
- (ii) The established rules and guidelines for organic compounds enable advancement in research and sharing of scientific knowledge among scientists.

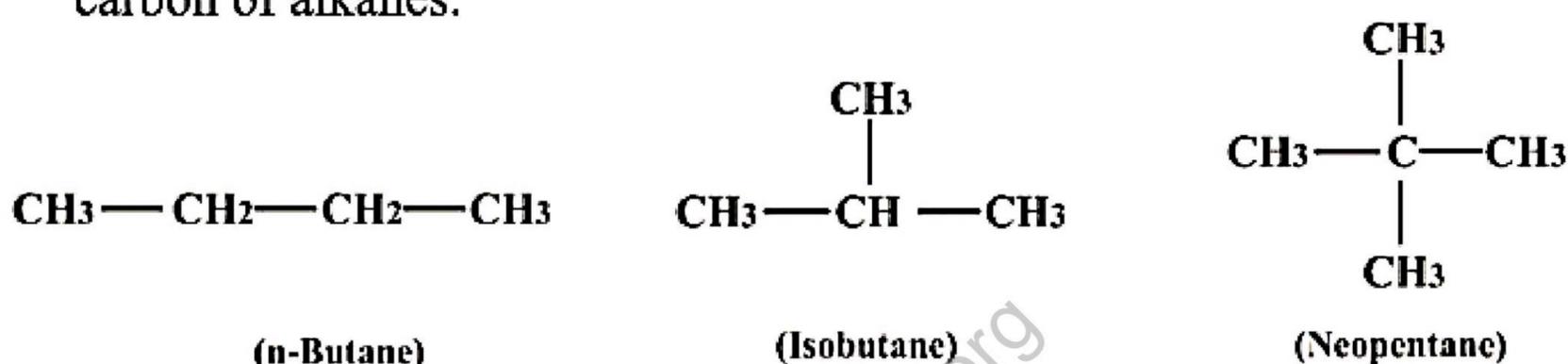
HYDROCARBONS

Number of carbon atoms in chain	Prefixes	Alkane	Alkene	Alkyne
1	Meth-	Methane		
2	Eth-	Ethane	Ethene	Ethyne
3	Prop-	Propane	Propene	Propyne
4	But-	Butane	Butene	Butyne
5	Pent-	Pentane	Pentene	Pentyne
6	Hex-	Hexane	Hexene	Hexyne
7	Hept-	Heptane	Heptene	Heptyne
8	Oct-	Octane	Octene	Octyne
9	Non-	Nonane	Nonene	Nonyne
10	Dec-	Decane	Decene	Decyne
11	Undec-	Undecane	Undecene	Undecyne
12	Dodec-	Dodecane	Dodecene	Dodecyne

NOMENCLATURE OF ALKANES

Common System

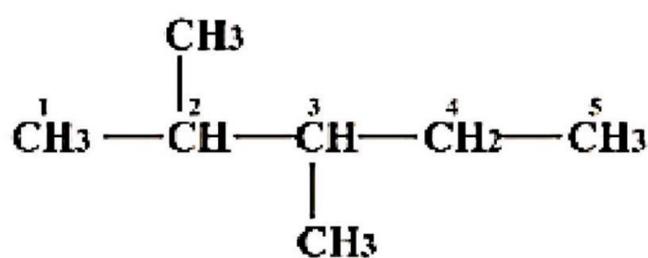
- (i) The prefix n- is utilized for alkanes where all the carbon atoms are arranged in a single uninterrupted straight chain.
- (ii) The prefix Iso- is utilized if in the structure of alkane molecule one branch (e.g. $-\text{CH}_3$) is attached to the second last carbon atom of the chain.
- (iii) The prefix Neo- is utilized if two branches are attached on the second last carbon of alkanes.



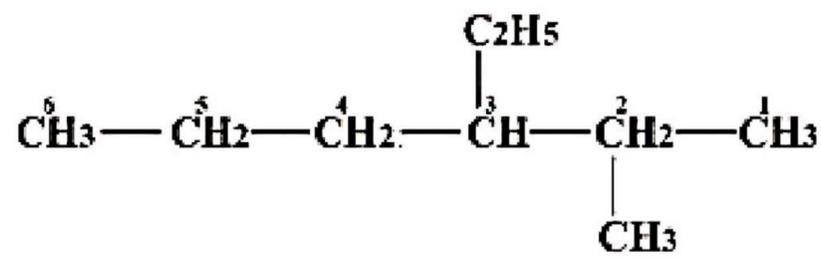
IUPAC System

- (i) Select the longest continuous carbon chain in the molecule and number the carbon chain from one of its terminal. The name of the chain is retained as propane, butane, pentane, hexane etc.
- (ii) The numbering of carbon chain should be assigned, starting from the terminal where functional group or an alkyl group (substituent) is nearest.
- (iii) If the identical substituents are attached at the same position from both ends of main carbon chain, numbering can be done from either terminal. However, if the identical substituents are attached at different positions, the numbering should be done from the side where the substituent is nearer.
- (iv) When two different substituents are attached at the same position from either side of the carbon chain, the numbering of chain is determined from the terminal where the substituent with the lower alphabetical order is nearer.

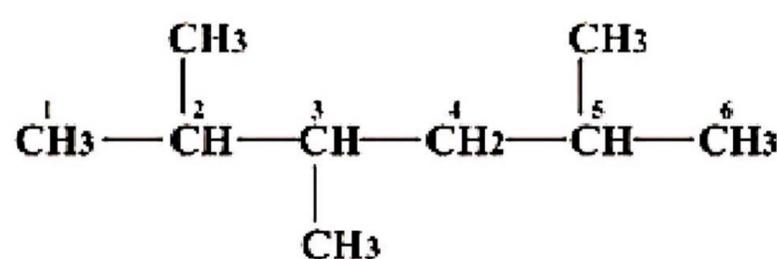
- (v) When two or more same substituents are attached to the carbon chain, indicate the quantity of each substituent by using di, tri and so forth.
- (vi) Prefix cyclo is used to name cycloalkanes.



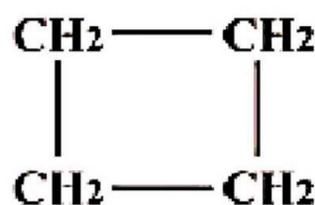
(2, 3-Dimethylpentane)



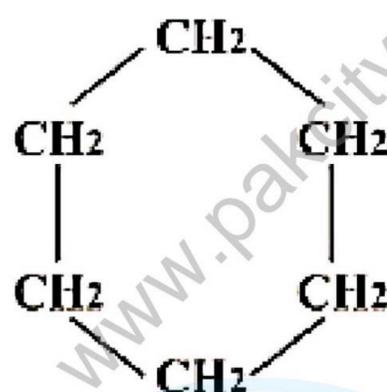
(3-Ethyl-2-methylhexane)



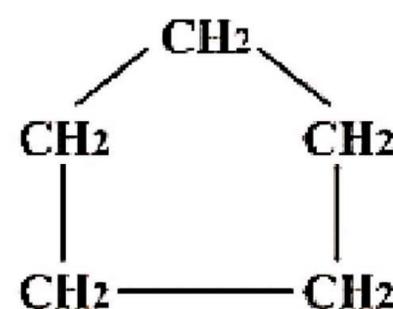
(2, 3, 5-Trimethylhexane)



(Cyclobutane)



(Cyclohexane)



(Cyclopentane)

NOMENCLATURE OF ALKENES

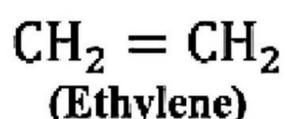


Area of a triangle
= bh
Newton's Law Motion
Form

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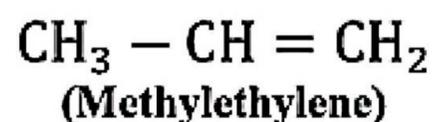
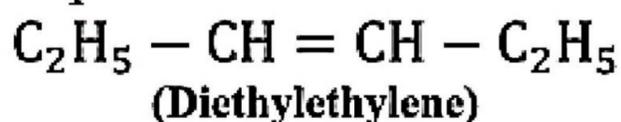
Common system

In common system, alkenes are named by replacing the suffix “ane” with “ylene” for example ethylene, propylene, butylene.



An alternative way of naming alkenes is by considering them as derivatives of ethylene.

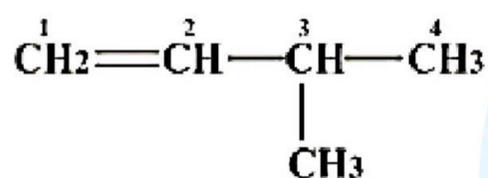
For example



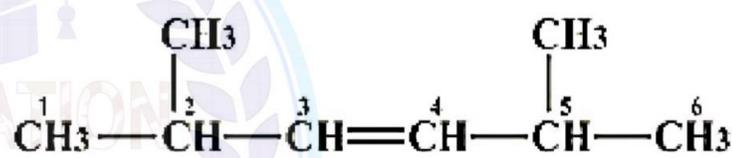
IUPAC System



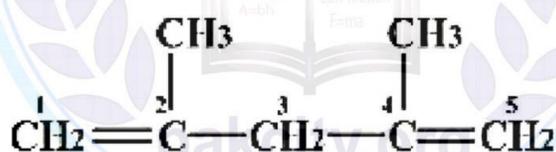
- (i) Select the longest carbon chain which must contain double bonded carbon atoms.
- (ii) The numbering of the longest chain starts from that end nearest to the carbon-carbon double bond irrespective of the location of alkyl radicals.
- (iii) Indicate the position of double bond by specifying the location of carbon atoms involved in the double bond.
- (iv) If there are more than one double bonds present within the carbon chain they are indicated by adding the prefixes di, tri etc. before the suffix “ene”.



(3-Methyl-1-butene)



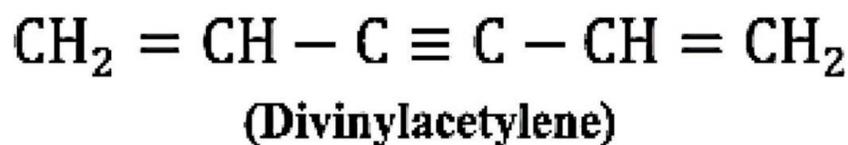
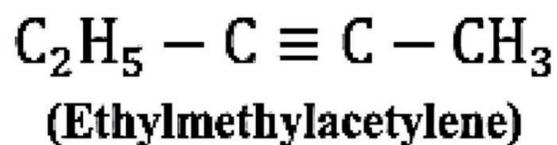
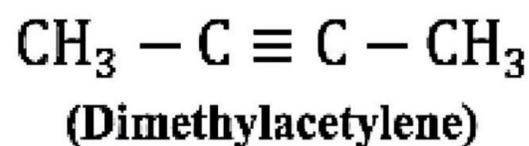
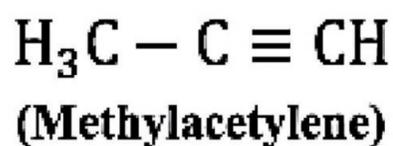
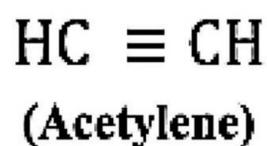
(2, 5-Dimethyl-3-hexene)



(2, 4-Dimethyl-1, 4-pentadiene)

NOMENCLATURE OF ALKYNES

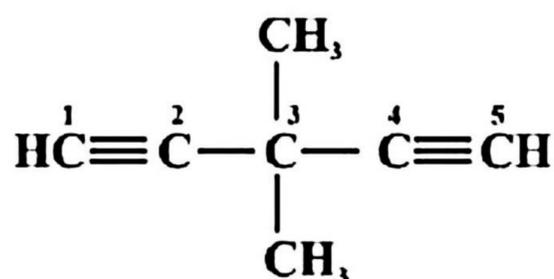
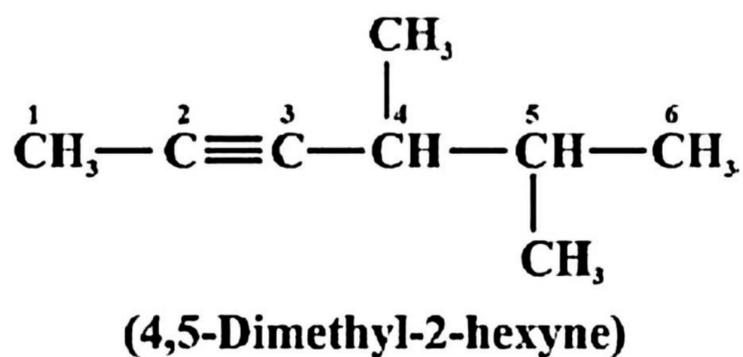
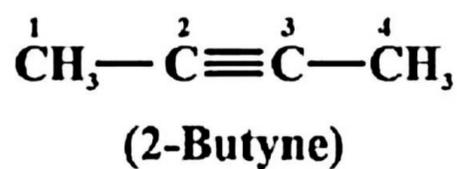
Common System



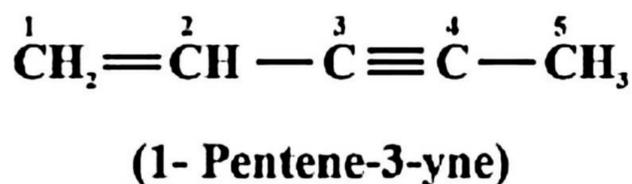
IUPAC System



- (i) Select the longest continuous carbon chain which must include both the carbon atoms containing triple bond.
- (ii) The numbering of carbon chain starts from the terminal which is nearest to the carbon-carbon triple bond.
- (iii) Write the name of parent alkanes for the same number of carbon atoms, replacing suffix "ane" with "yne" to indicate the presence of triple bond.
- (iv) Indicate the position of triple bond by specifying the location of the carbon atom involved in the bond.
- (v) If two or more triple bond are present in the chain then they are indicated by adding the prefix di, tri etc. before the suffix -yne.
- (vi) When both double and triple bonds are present in the molecule at different positions then the numbering starts from the end where the bond (double or triple) is nearest.
- (vii) When double and triple bonds are present in the molecule at equal positions from the end, then the preference of numbering is given to double bond.



(3,3-Dimethyl-1, 4-pentadiyne)

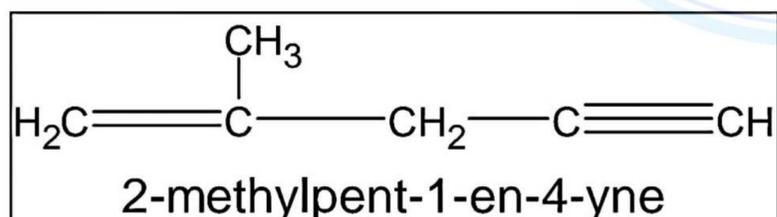
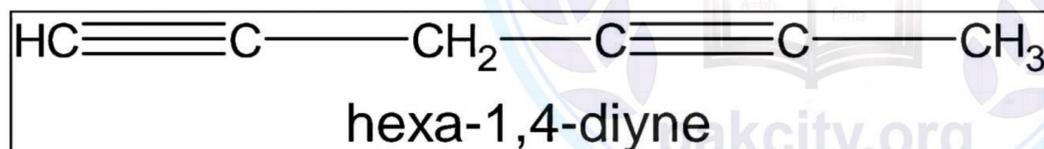
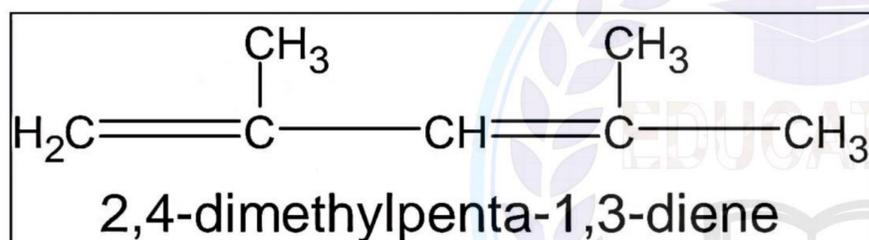
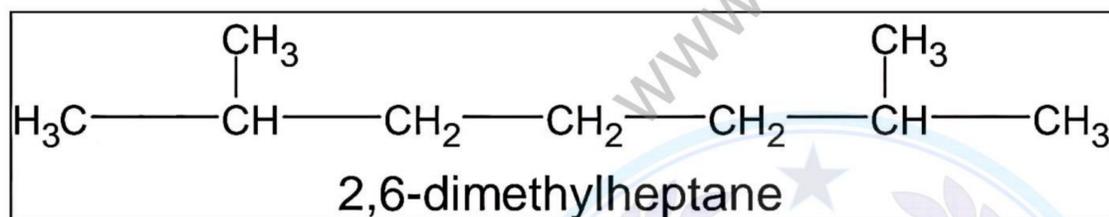


Self-Assessment

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Name the following compounds by IUPAC method.

- $(\text{CH}_3)_2 \text{CH} - (\text{CH}_2)_3 - \text{CH}(\text{CH}_3)_2$
- $\text{CH}_2 = \text{C}(\text{CH}_3) - \text{CH} = \text{C}(\text{CH}_3) - \text{CH}_3$
- $\text{CH} \equiv \text{C} - \text{CH}_2 - \text{C} \equiv \text{C} - \text{CH}_3$
- $\text{CH}_2 = \text{C}(\text{CH}_3) - \text{CH}_2 - \text{C} \equiv \text{CH}$



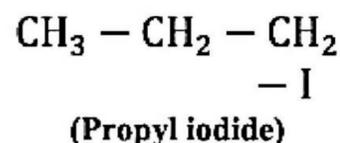
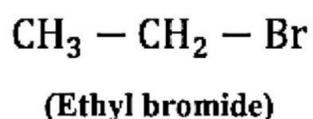
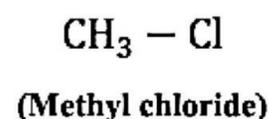
NOMENCLATURE OF ALKYL HALIDES

Alkyl halides are the derivatives of alkanes in which one or more hydrogen of alkanes are replaced by halogen atom.

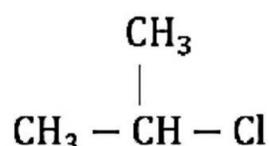


Common System

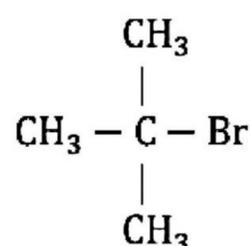
The common name of an alkyl halide is formed by naming the alkyl group first, followed by the term "halide".



The term secondary (sec.) and tertiary (tert.) are used as prefix if the carbon atom bonded to halogen is further attached to two and three other carbon atoms respectively.

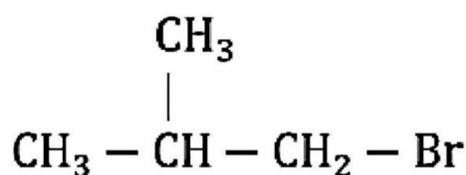


(sec-Propyl chloride)

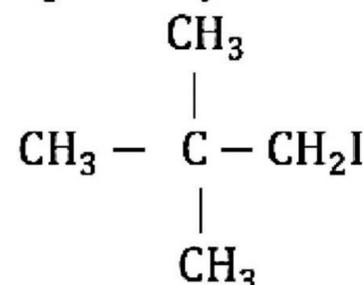


(tert-Butyl bromide)

The term iso and neo are also used as prefix when penultimate carbon is further attached to two or three other carbon atoms respectively.



(Isobutyl bromide)



(Neo pentyl iodide)

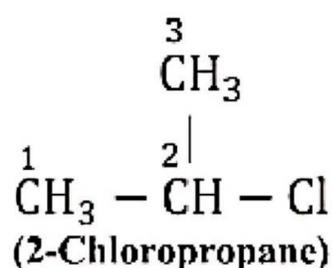
IUPAC System

- (i) Determine the longest carbon chain that contains the carbon atom directly bonded to halogen.
- (ii) Number the carbon atoms in the chain from the end closest to the halogen atom.

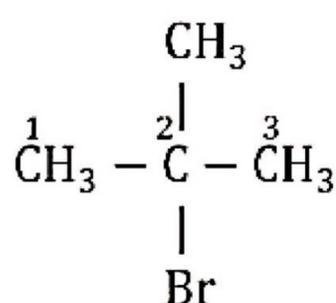
- (iii) When a double or triple bond is present in the halogenated carbon chain it is recommended to number the chain from the end nearest to the double or triple bond.
- (iv) Prefix di, tri, tetra etc are used to indicate the number of halogens attached to the main carbon chain.
- (v) When two different halogens are attached to the carbon chain at the same position from opposite ends, the halogen name will be written by its alphabetical order.



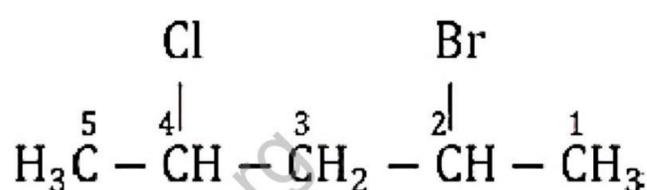
(Bromoethane)



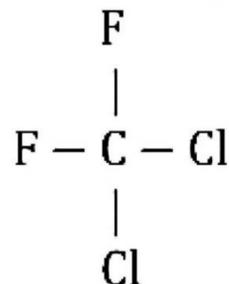
(2-Chloropropane)



(2-Bromo-2-methylpropane)



(2-Bromo-4-chloropentane)



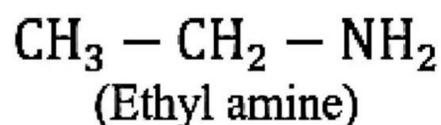
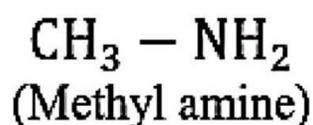
(Dichlorodifluoromethane)

NOMENCLATURE OF AMINES

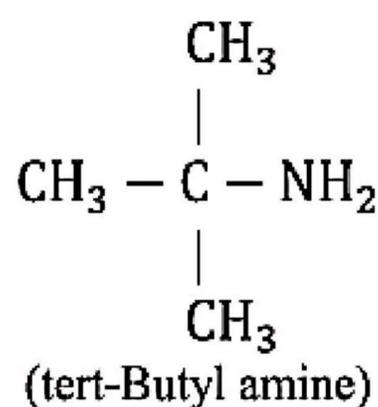
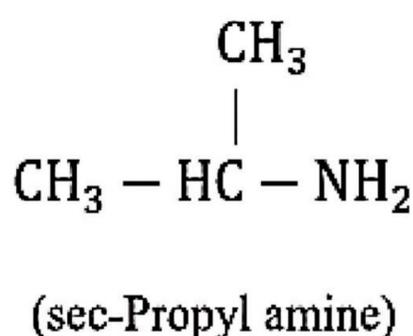
Amines are organic compounds that contain a nitrogen atom bonded to one or more alkyl or aryl groups. Primary amines contains one alkyl group bonded to the nitrogen atom while secondary and tertiary amine are identified by the direct attachment of two and three alkyl groups with the nitrogen atom respectively.

Common System

The common name of a primary amine is formed by combining the name of alkyl group with the suffix "amine".



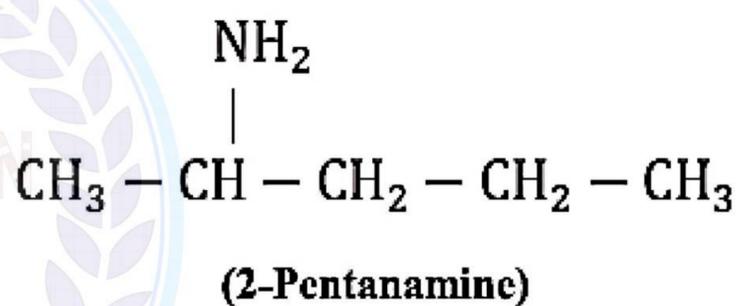
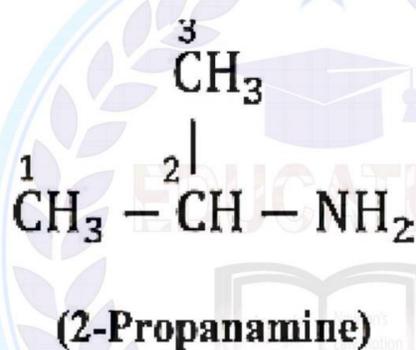
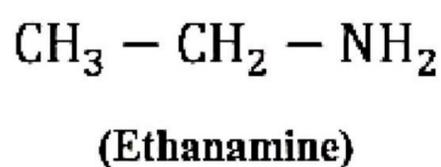
The prefix sec. and tert. are used if the carbon atom bonded to nitrogen is further attached with two or three alkyl radicals.



IUPAC System

In IUPAC system, primary amines are named as alkanamine

- (i) Select the longest carbon chain that contain the carbon atom directly bonded to $-\text{NH}_2$ group.
- (ii) Write the name of compound by replacing the ending "e" of alkane chain by adding the suffix "amine".





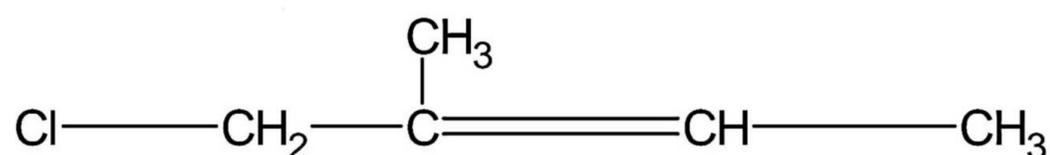
Self-Assessment



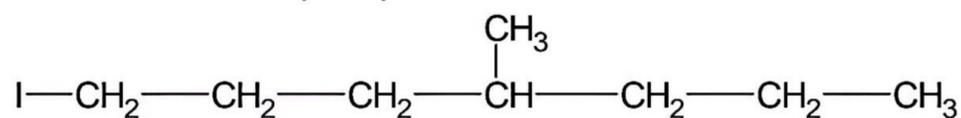
Write the structure of the following organic compounds.

- 1-chloro-2-methyl-2-butene
- 1-iodo-4-methylheptane
- Neobutyl iodide
- 3-methyl-2-butanamine

- 1-chloro-2-methyl-2-butene



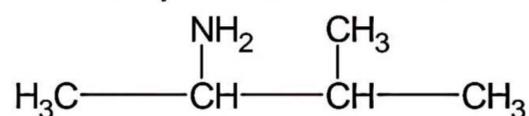
- 1-iodo-4-methylheptane



- Neobutyl iodide

This structure is not possible.

- 3-methyl-2-butanamine



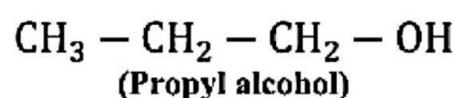
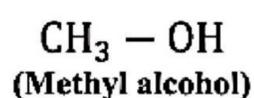
NOMENCLATURE OF ALCOHOLS



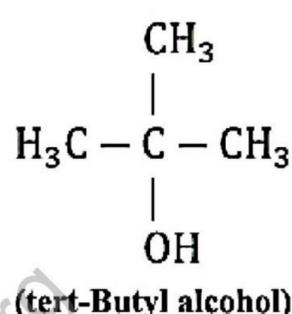
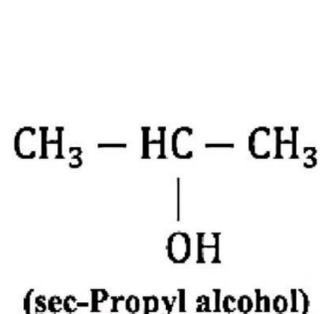
Organic compounds that contain one or more hydroxyl (-OH) functional group attached to the carbon chain are called alcohols.

Common System

Since alcohols are hydroxyl derivatives of hydrocarbons, their common names are formed by combining the name of alkyl group with the suffix "alcohol".



If the carbon atom bearing the hydroxyl group is directly connected to two or three other carbon atoms, the term secondary and tertiary is used as a prefix.

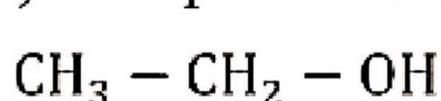


IUPAC System

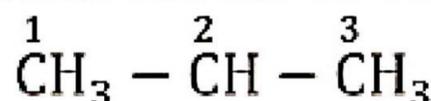
The set of rules established by IUPAC system for the naming of alcohol is given as follow:

- (i) Identify the longest continuous carbon chain that include the carbon atom bearing the hydroxyl group (-OH).
- (ii) Number the carbon atoms in the chain starting from the end nearest to the hydroxyl group.
- (iii) The end "e" of the parent alkane is replaced by "ol".
- (iv) If the molecule of alcohol has substituents (CH_3 , C_2H_5 , Br, Cl, I etc), name them as prefixes.
- (v) If two or more hydroxyl groups are present in the carbon chain, use di, tri etc. before the suffix "-ol".

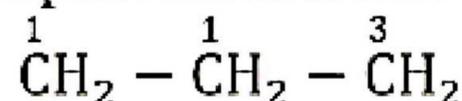
(vi) The positions of substituents should be written in alphabetical order.



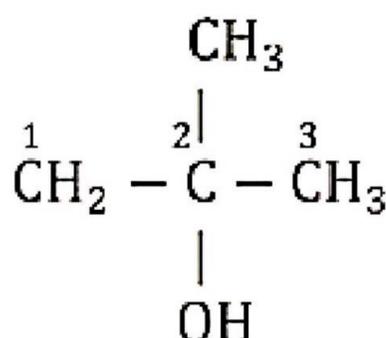
(Ethanol)



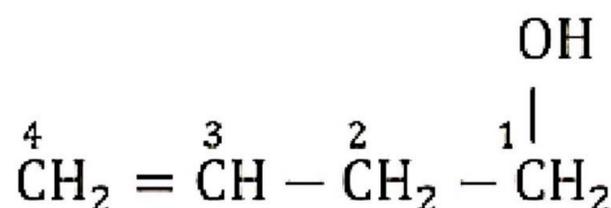
(2-Propanol)



(1, 3-Propanediol)



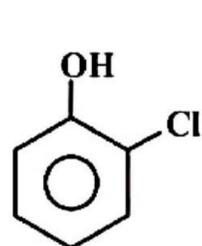
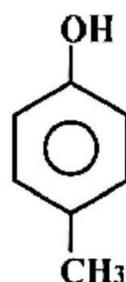
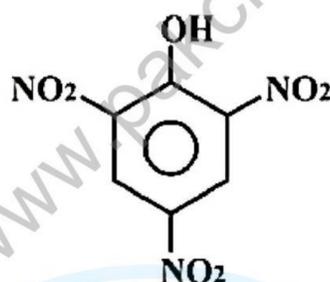
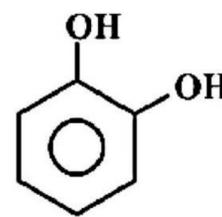
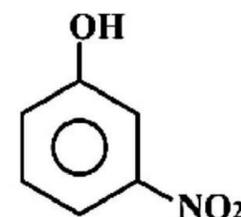
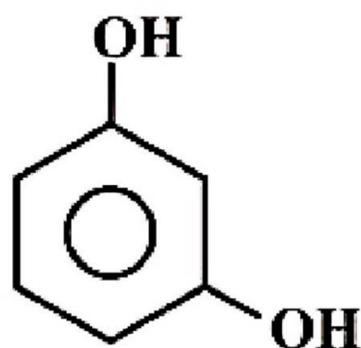
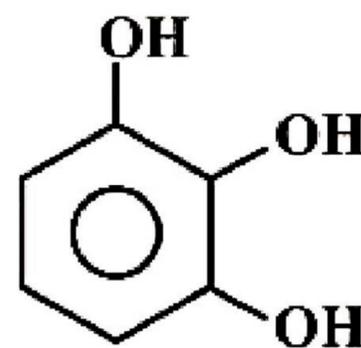
(2-Methyl-2-propanol)



(3-Buten-1-ol)

NOMENCLATURE OF PHENOLS

The class of organic compounds in which one or more hydroxyl group are directly attached with the benzene ring are called as phenols.

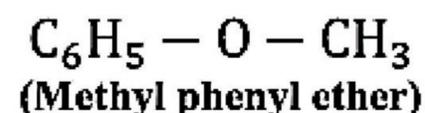
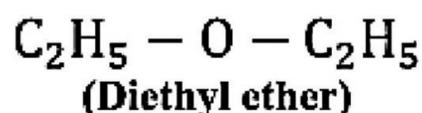
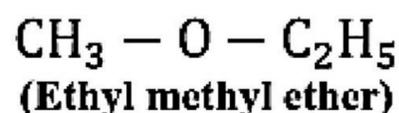
(2-Chlorophenol)
(o-Chlorophenol)(4-Methylphenol)
(p-Cresol)(2, 4, 6-Trinitrophenol)
(Picric acid)(1, 2-Benzenediol)
(Catechol)(3-Nitrophenol)
(m-Nitrophenol)(1, 3-Benzenediol)
(Resorcinol)(1, 4-Benzenediol)
(Hydroquinone)(1, 2, 3-Benzenetriol)
(Pyrogallol)

NOMENCLATURE OF ETHERS

Ether is a family of organic compounds in which two alkyl or aryl radicals are attached to an oxygen atom. These compounds are represented by R–O–R'.

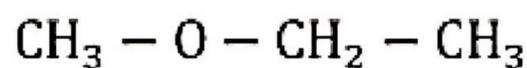
Common System

In the common system of naming of ethers, the two alkyl groups are written in alphabetical order and the term ether is added at the end of the name.

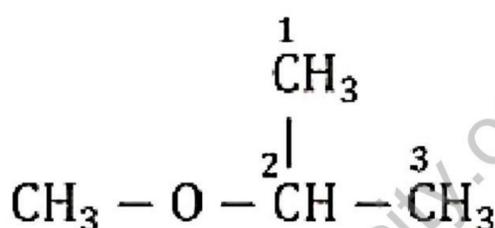


IUPAC System

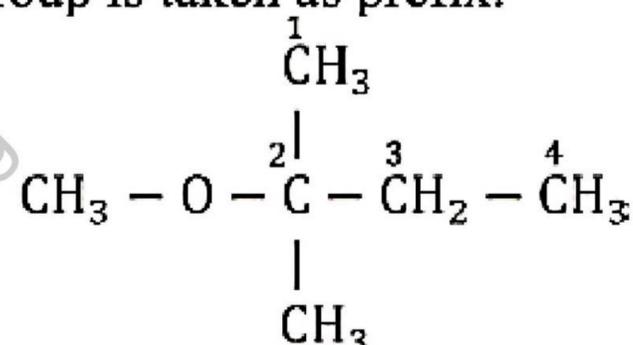
In IUPAC system of nomenclature, ethers are referred to as alkoxy derivatives of alkanes. The alkyl group of larger number of carbon atoms is considered as the main carbon chain whereas the smaller alkyl group, along with its oxygen is named as alkoxy group. The alkoxy group is taken as prefix.



(Methoxyethane)



(2-Methoxypropane)



(2-Methoxy-2-methylbutane)



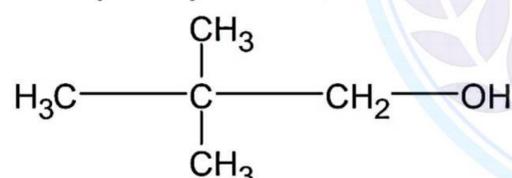
Self-Assessment

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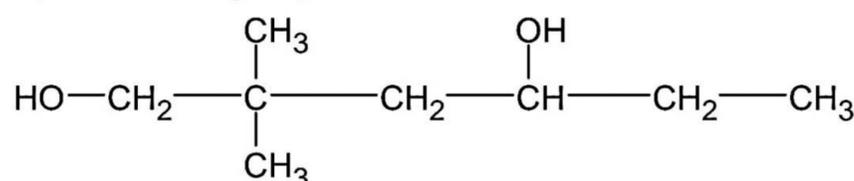
Write the structure of the following organic compounds.

- Neopentyl alcohol
- Ethyl, tert-butyl ether
- 2,2-Dimethyl-1,4 hexandiol
- 2,4,6-Tribromophenol

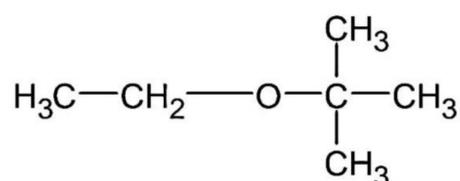
- Neopentyl alcohol



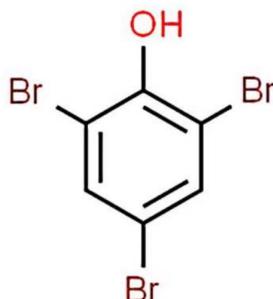
- 2,2-dimethyl-1,4-hexandiol



- Ethyl tert-butyl ether



➤ 2,4,6-tribromophenol



NOMENCLATURE OF ALDEHYDES AND KETONES

Aldehydes and ketones are characterized by the presence of a carbonyl group. (>C=O). Aldehydes have carbonyl group at the end of carbon chain whereas ketones have the carbonyl group within the carbon chain.

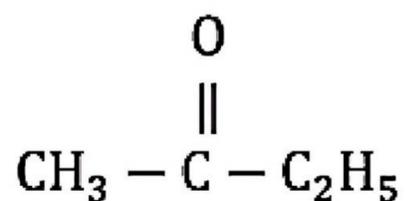
Common System

Latin Number + Aldehyde

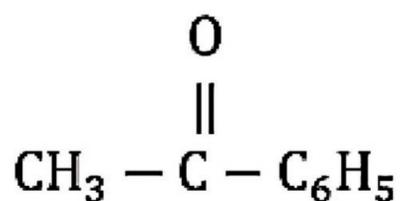
Latin Numbers (1=form, 2=acet, 3=propion, 4=butyr, 5=valer, 6=capro)

Aldehyde
$\begin{array}{c} \text{O} \\ \\ \text{H} - \text{C} - \text{H} \\ \text{(Formaldehyde)} \end{array}$
$\begin{array}{c} \text{O} \\ \\ \text{CH}_3 - \text{C} - \text{H} \\ \text{(Acetaldehyde)} \end{array}$

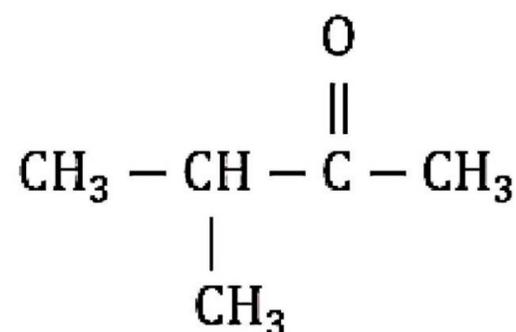
The common naming system of ketones is quite similar to that of ether. The two alkyl groups attached to the carbonyl carbon are named in alphabetical order and the term ketone is added at the end of the name.



(Ethyl methyl ketone)



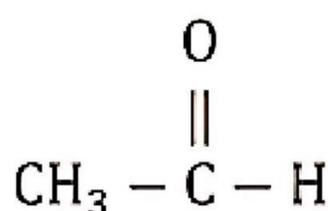
(Methyl phenyl ketone)



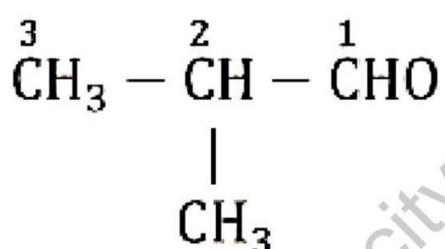
(Methyl isopropyl ketone)

IUPAC System

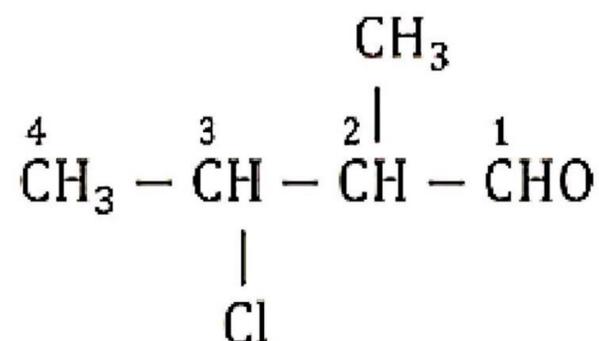
General IUPAC name of aldehydes is Alkanal in which we count all the carbon atoms.



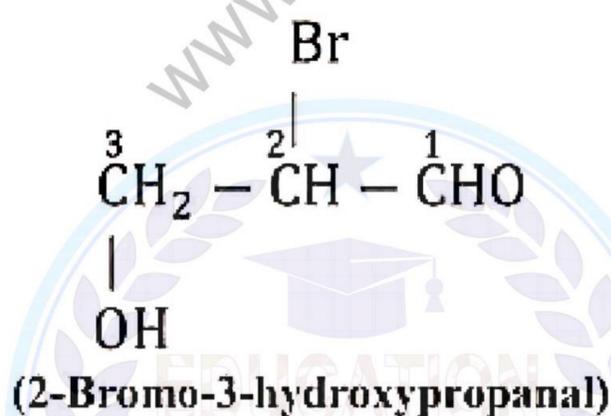
(Ethanal)



(2-Methylpropanal)

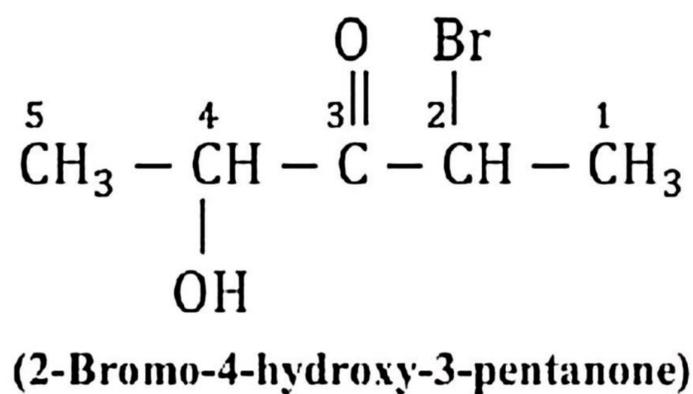
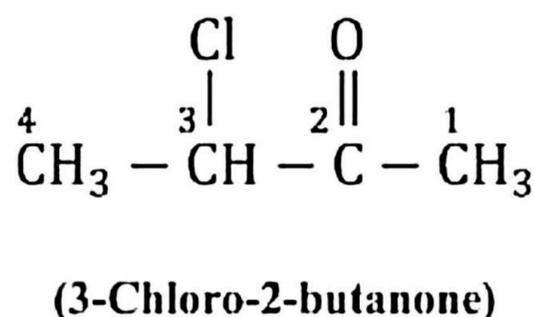
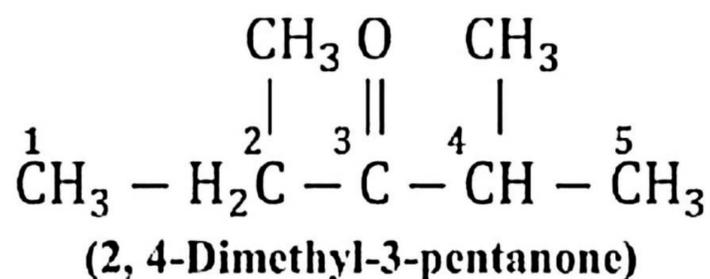
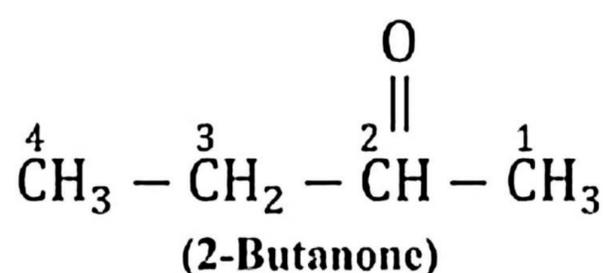


(3-Chloro-2-methylbutanal)



(2-Bromo-3-hydroxypropanal)

General IUPAC name of ketones is **propanone** in which we count all the carbon atoms.



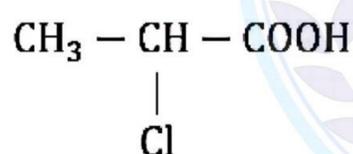
NOMENCLATURE OF CARBOXYLIC ACIDS

Organic compounds which contain carboxyl group (-COOH) are known as carboxylic acids.

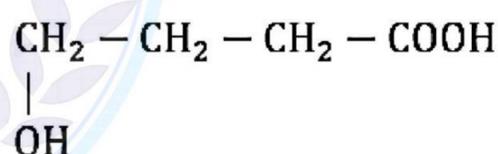
Common System

Structure	Common name
HCOOH	Formic acid
CH ₃ COOH	Acetic acid
CH ₃ CH ₂ COOH	Propionic acid
CH ₃ (CH ₂) ₂ COOH	Butyric acid
CH ₃ (CH ₂) ₃ COOH	Valeric acid
CH ₃ (CH ₂) ₄ COOH	Caproic acid

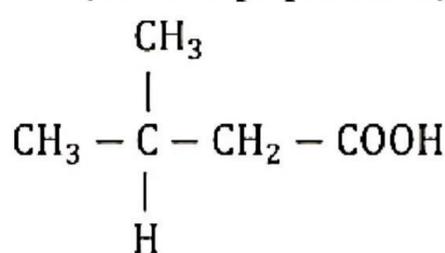
Common names of carboxylic acid are given as



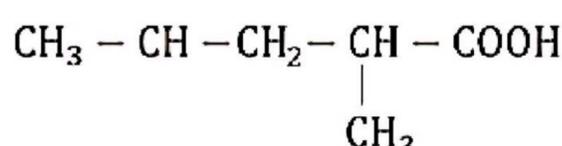
(α -Chloro propionic acid)



(γ -Hydroxy butyric acid)



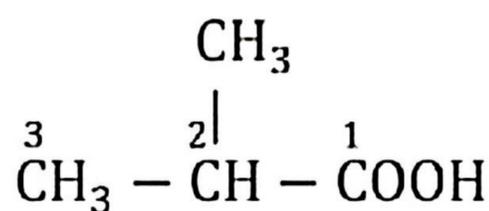
(β -Methyl butyric acid)



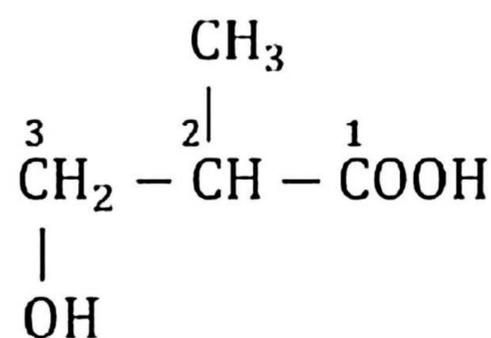
(α, β -Dimethyl valeric acid)

IUPAC System

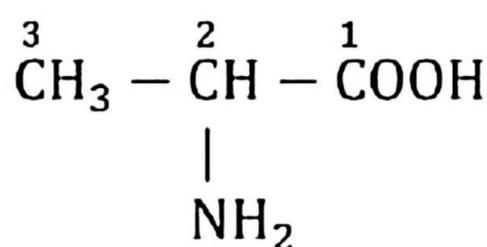
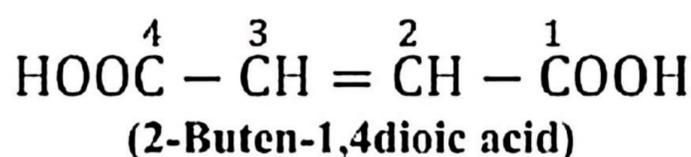
The name of carboxylic acid in IUPAC system is referred as alcanoic acid.



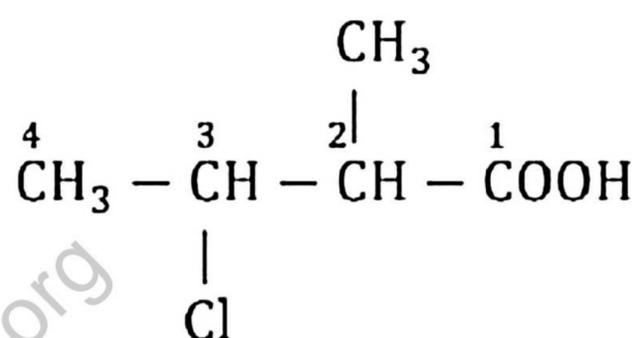
(2-Methyl propanoic acid)



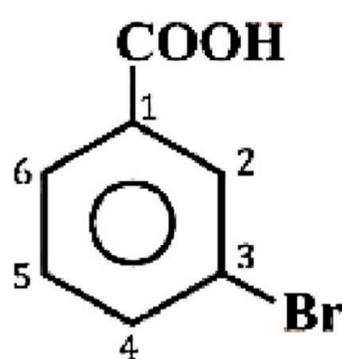
(3-Hydroxy-2-methyl propanoic acid)



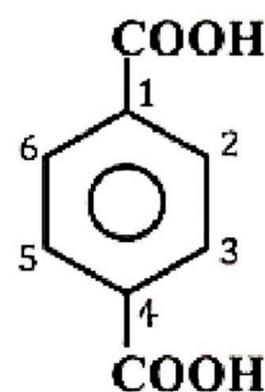
(2-Aminopropanoic acid)



(3-Chloro-2-methylbutanoic acid)



(3-Bromobenzoic acid)



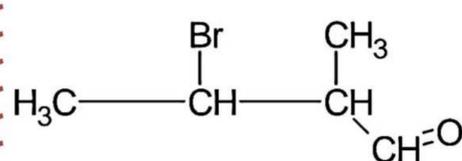
(Benzen-1,4-dioic acid)



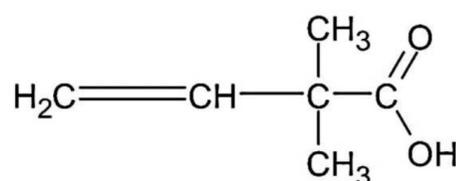
Self-Assessment

Write the IUPAC name of the following molecules.

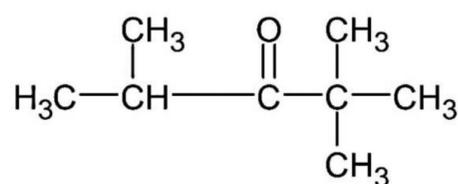
- $\text{CH}_3 - \text{CH}(\text{Br}) - \text{CH}(\text{CH}_3) - \text{CHO}$ ➤ $\text{CH}_2 = \text{CH} - \text{C}(\text{CH}_3)_2 - \text{COOH}$
 ➤ $(\text{CH}_3)_2\text{CH} - \text{CO} - \text{C}(\text{CH}_3)_3$ ➤ $\text{HOOC} - \text{CH}_2 - \text{HC} = \text{CHCOOH}$



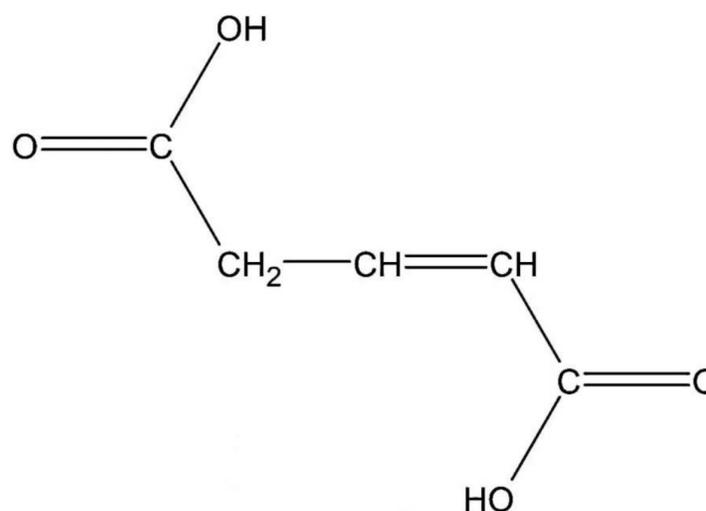
3-bromo-2-methylbutanal



2,2-dimethylbut-3-enoic acid



2,2,4-trimethylpentan-3-one



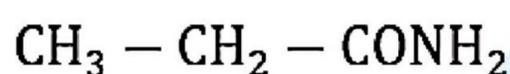
pent-2-enedioic acid

NOMENCLATURE OF ESTERS

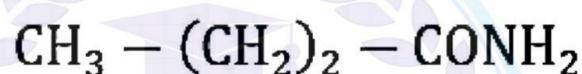
Structure of Ester	Common Name	IUPAC Name
HCOOC_2H_5	Ethyl formate	Ethyl methanoate
$\text{CH}_3-\text{CH}_2-\text{COO}-\text{CH}_3$	Methyl propionate	Methyl propanoate
$\text{CH}_3(\text{CH}_2)_2\text{COOC}_2\text{H}_5$	Ethyl butyrate	Ethyl butanoate
$\text{CH}_3\text{COOCH}(\text{CH}_3)_2$	Isopropyl acetate	Isopropyl ethanoate

NOMENCLATURE OF AMIDE

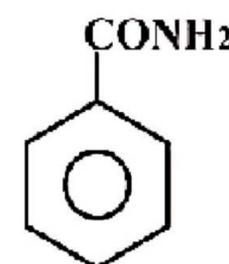
Amides are the derivate of carboxylic acids formed by replacing $-\text{OH}$ group of carboxylic acid by $-\text{NH}_2$ group. The nomenclature of amide is based on replacing the suffix -oic acid with amide. For example



(Propanamide)



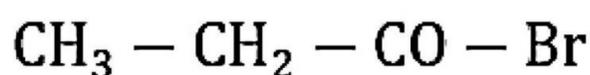
(Butanamide)



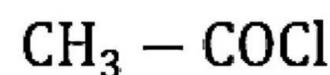
(Benzamide)

NOMENCLATURE OF ACYL HALIDES

Acyl halides or acid halides are derived from carboxylic acids.



Propanoyl bromide (IUPAC)
Propionyl bromide (common)



Ethanoyl chloride (IUPAC)
Acetyl chloride (common)

Multiple Choice Questions

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- (i) Which of the following molecule possess acyl functional group:
(a) R-CO-X
(b) R-CONH₂
(c) R-COO-CH₃
(d) R-CO-R
- (ii) A hydrocarbon with the molecular formula C₇H₁₂ is possibly:
(a) Heptane
(b) Heptene
(c) Heptyne
(d) Hepta diene
- (iii) An organic compound possesses the structural formula CH₃CH = CH – C ≡ CH, its correct IUPAC name is:
(a) 1-pentyne-3-ene
(b) 3-pentene-1-pentyne
(c) 3-penten-1-yne
(d) 2-pentene-3-yne
- (iv) IUPAC name of isopropyl alcohol is:
(a) 1-propanol
(b) 2-propanol
(c) 1-butanol
(d) 2-butanol
- (v) Resorcinol is a phenol, it contains two –OH groups at:
(a) Position 1 and 2
(b) Position 1 and 3
(c) Position 1 and 4
(d) Position 2 and 4

(vi) Formula of a saturated hydrocarbon is C_4H_8 , it should be:

- (a) Butane (b) Butene
(c) Butyne (d) Cyclobutane

(vii) In the IUPAC naming of ketones the ending $-e$ of main carbon chain is replaced by:

- (a) yl (b) ol
(c) al (d) one

(viii) In the common system, carboxylic acid with six carbon atoms in straight chain is named as:

- (a) propionic acid (b) valeric acid
(c) caproic acid (d) steric acid



(ix) The correct structure of 1, 3-penta diene is:

- (a) $H_3C-CH=CH-HC=CH_2-CH_3$ (b) $CH_2=CH-CH_2-CH=CH_2$
(c) $CH_2=CH-HC=CH-CH_3$ (d) $CH_3-CH=C=CH-CH_3$

(x) The IUPAC name of $CH_3COOCH(CH_3)_2$ is:

- (a) propyl ethanoate (b) ethyl propanoate
(c) isopropyl acetate (d) isopropyl ethanoate

Short Questions

1. Why IUPAC system of nomenclature is preferred on common system of naming of organic compounds?

Ans.

- The IUPAC system of naming has provided unique names for more than fifteen millions organic compounds and offer the name of millions of compounds that are yet to be discovered.
- The disadvantage of common or trivial name of organic compound in that they do not describe the structure and functional group of the compounds.
- The IUPAC naming has established some general rules for naming organic compounds. These rules were revised in 2013.

2. Write the name of five organic families and mention the functional group present in them.

Answer.

1. Alcohol Family (R-OH) contains hydroxy (-OH) functional group.
2. Ether Family (R-O-R) contains alkoxy (-OR) functional group.
3. Alkyl Halide Family (R-X) contains halide (-X) functional group.
4. Aldehyde Family (R-CHO) contains aldehydic (-CHO) functional group.
5. Ketone Family (R-COR) contains ketonic (-COR) functional group.

3. Write down basic rules for IUPAC naming of organic compound.

Answer.

The general rules set for IUPAC method of naming organic compounds are as follow:

- (i) Identify the longest unbroken carbon chain within the molecule which will act as parent chain.
- (ii) Allocate numerical designations to the carbon atoms within the parent chain to the terminal side, to which functional group is nearer.
- (iii) Identify substituents and name them using prefix such as methyl, ethyl, methoxy, chloro, bromo etc. and mention their position in the longest carbon chain.
- (iv) If any functional group is present in the molecule, name it by using appropriate suffix such as "one" for ketone, "-al" for aldehyde and "-ol" for alcohol etc.
- (v) If there are more than one functional group present in the molecule, write their name on priority basis set by priority rules i.e. (-COOH) > (-CHO) > (C = O) > (-OH) > (-NH₂) > (-O-) > (=) > (≡).

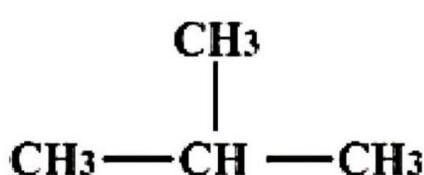
4. We often use the term Iso and Neo in the common system of naming of alkanes. Explain with example

Ans.

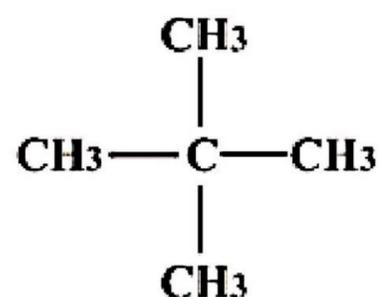
- (i) The prefix n- is utilized for alkanes where all the carbon atoms are arranged in a single uninterrupted straight chain.
- (ii) The prefix Iso- is utilized if in the structure of alkane molecule one branch (e.g. $-\text{CH}_3$) is attached to the second last carbon atom of the chain.
- (iii) The prefix Neo- is utilized if two branches are attached on the second last carbon of alkanes.



(n-Butane)



(Isobutane)



(Neopentane)

5. Write the common names of first five members of carboxylic acid.

Common name

Formic acid

Acetic acid

Propionic acid

Butyric acid

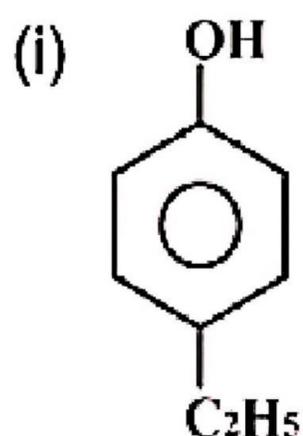
Valeric acid



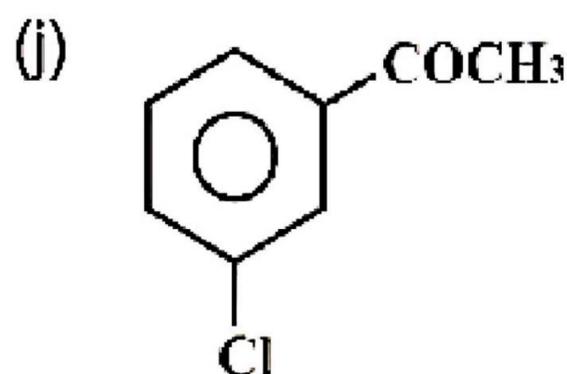
6. If an organic compound contains both double and triple bond, in the main carbon chain, what rules you follow to write its IUPAC name. Explain by giving an example.

Ans.

- First of all, we have to draw a chain which contains all the double and triple bonds.



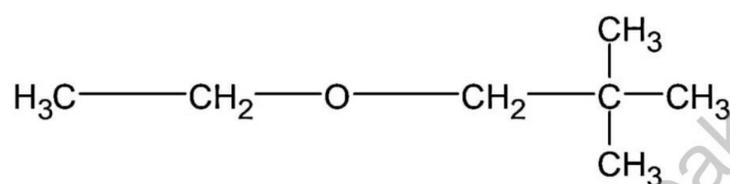
4-ethylphenol



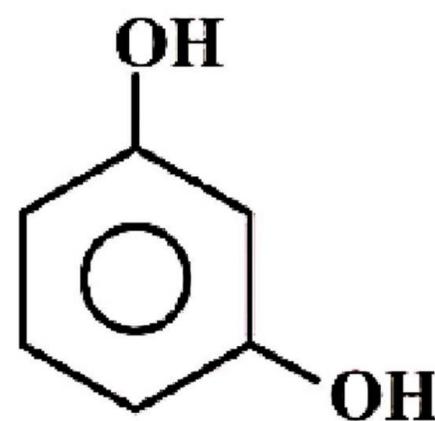
3-chloroacetophenone

2. Outline the structure of each of the following molecules.

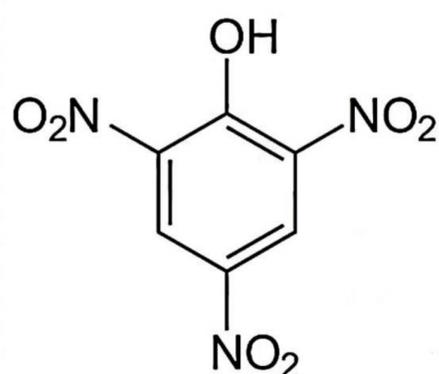
(a) Ethyl neo-pentyl ether



(b) Resorcinol



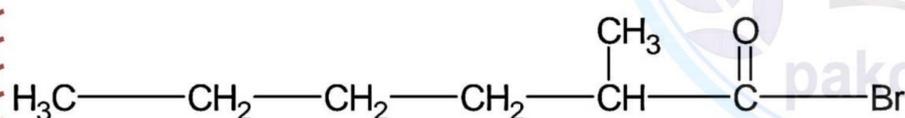
(c) Picric acid



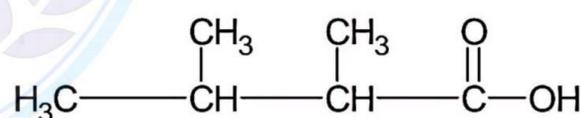
(d) Isopropylbutanoate



(e) 1-Bromo-3-methyl hexane-2-one

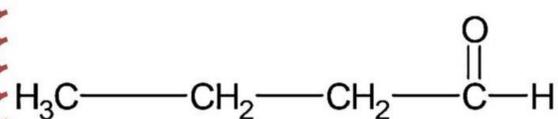


(f) α , β -dimethyl butyric acid

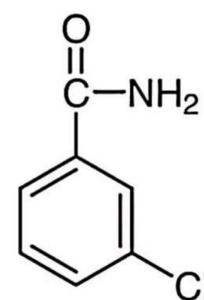


(g) Butyraldehyde

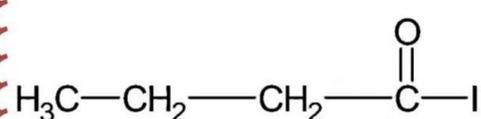
(h) 3-Chlorobenzamide



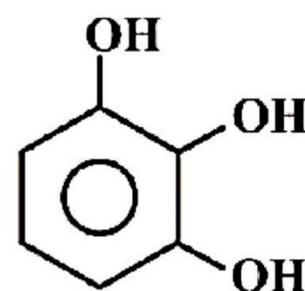
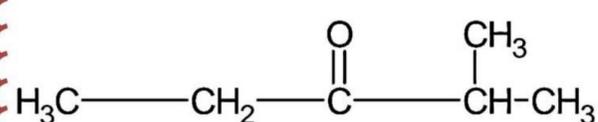
(i) Butanoyl iodide



(j) 1, 2, 3-benzotriol



(k) Ethyl isopropyl ketone

(l) α -Methyl butyraldehyde(m) α -Chloro- β -methyl valeric acid