By- SHAILENDRA SHUKLA SIR

GENERAL ORGANIC CHEMISTRY

Organic compounds

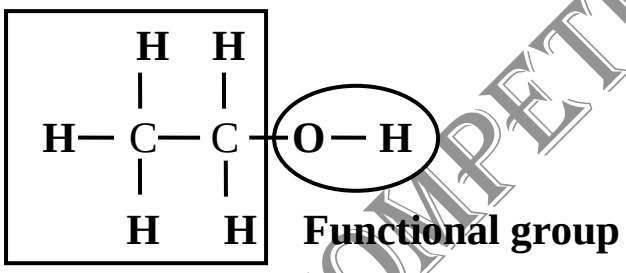
Such compounds which contain carbon as their essential part are called organic compounds.

In general organic compounds consist of following two parts-

(1) Hydrocarbon part (alkyl or aryl group)- It consist of only carbon and hydrogen and decides physical properties such as physical state, melting point, boiling point, density etc. of the compounds.

(2) Functional group- It decides chemical properties of the compounds.

For example, in ethanol molecule, these two parts can be represented as under-



If there is any change in hydrocarbon part, there is change in physical properties of the compound but, if there is a change in functional group, there is change in chemical properties of the compound.

On the basis of functional groups present in the compounds, organic compounds have been classified into a number of families such an alcohol family, aldehyde family, ketone family, carboxylic acid etc.

Homologous Series

"If different members of an organic family are arranged in increasing order of their molecular masses then a series is obtained which is called homologous series."

Characteristics of Homologous Series

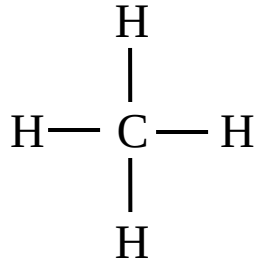
(1) Each homologous series has a simple general formula by which all the members of series can be derived.

For example, general formula of alkanes is C_nH_{2n+2}.

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Here, if n = 1, then formula of alkane = $C_1H_{2\times1+2}$ = CH_4

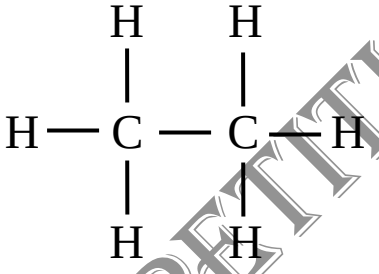
or



Methane

Here, if n = 2, then formula of alkane = $C_2H_{2\times2+2}$ = C_2H_6

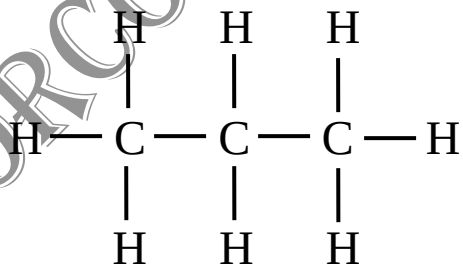
or



Ethane

Here, if n = 3, then formula of alkane = $C_3H_{2\times3+2}$ = C_3H_8

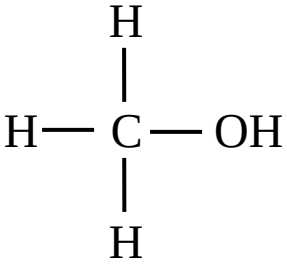
or



Propane

Similarly, general formula of alcohols is $C_nH_{2n+1}OH$.
Here, if n = 1, then formula of alcohol = $C_1H_{2\times1+1}OH$ = CH_3OH

or

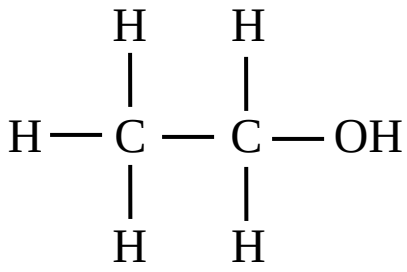


Methanol

Here, if n = 2, then formula of alcohol = $C_2H_{2\times2+1}OH$ = C_2H_5OH

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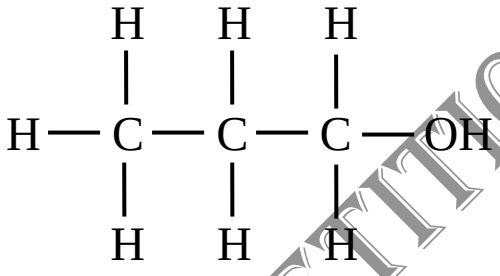
or



Ethanol

Here, if n = 3, then formula of alcohol = $C_3H_{2\times3+1}OH$ = C_3H_7OH

or



Propanol

(2)Two consecutive members of a homologous series differ by -CH_2- group (methylene) group. Thus, there is a difference of 14 units in molecular masses of two consecutive members of a homologous series.

(3)All the members of a homologous series have same functional group and therefore, they resemble in their chemical properties.

(4)Different members of a homologous series differ in their hydrocarbon part and therefore, they differ in their physical properties.

(5) All the members of a homologous series can be prepared by similar methods of preparation.

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IUPAC Nomenclature of Organic Compounds

IUPAC name of an organic compound, in general consist of following three parts-

(1) Word root-It represents the number of carbon atoms in longest continuous carbon chain of the compound. For example,

Number of carbon atoms	Word root	
1	Meth-	Special Word Roots
2	Eth-	
3	Prop-	
4	But-	
5	Pent-	Word Roots based on Greek Numeral System
6	Hex-	
7	Hept-	
8	Oct-	
9	Non-	
10	Dec-	

Here, first four word roots are special word roots which are not based on any numeral system. The other word roots are based upon Greek numeral system.

(2) Suffix- Suffixes are of following two types-

(i) Primary suffix-It represents nature of bonding between carbon atoms in longest continuous carbon chain of the compound. For example,

Nature of bonding	**Primary suffix**
C — C	-ane
C = C	-ene
C ≡ C	-yne

Primary suffix is always added with word root for IUPAC naming of the organic compound. For example,

CH_3— CH_3

Eth + ane = Ethane

CH_3— CH_2— CH_3

Prop + ane = Propane

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$$CH_2 = CH_2$$

Eth + ene = Ethene

$$CH_3 - CH = CH_2$$

Prop + ene = Propene

$$CH \equiv CH$$

Eth + yne = Ethyne

$$CH_3 - C \equiv CH$$

Prop + yne = Propyne

Word root and primary suffix are the essential part of the IUPAC name of an organic compound i.e. these two parts are always present in IUPAC name of an organic compound. Other parts may or not may be present in IUPAC name of the organic compounds.

(ii) Secondary suffix- It represents functional group present in the compound. For example,

Functional group	**Secondary suffix**
-OH (alcohol group)	-ol
-CHO (aldehyde group)	-al
> CO (ketone group)	-one
-COOH (carboxylic acid group)	-oic acid

Secondary suffix, if present is always added after primary suffix. For example,

$$CH_3 - OH$$

Meth + ane + ol = Methanol

$$CH_3 - CH_2 - OH$$

Eth + ane + ol = Ethanol

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HCOOH

Meth + ane + oic acid = Methanoic acid

CH_3 ─ COOH

Eth + ane + oic acid = Ethanoic acid

CH_3─ CH ─ COOH

Prop + ane + oic acid = Propanoic acid

(3)Prefix- There are certain atoms or groups which are not considered to be functional groups in IUPAC naming of the organic compounds. These atoms or groups are considered to be substituents in longest continuous carbon chain of the compound and are named as prefix. For example,

Atom/Group	**Prefix**
-Cl	chloro-
- Br	bromo-
- I	iodo-
- CH_3	methyl-
- CH_2-CH_3	ethyl-
- NH_2	amino-
- NO_2	nitro-

Prefixes if present, are always placed before the word root during IUPAC naming of the organic compounds.

Thus, the sequence of different parts in IUPAC name of an organic compound is as under-

Prefix + Word root + Primary suffix + Secondary suffix

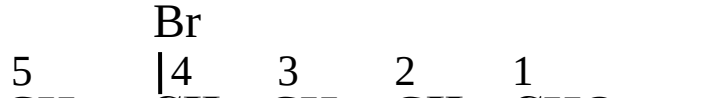
For example, for following compound-



3-Methyl + But + ane + oic acid

= 3-Methylbutanoic acid

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4-Bromo + Pent + 2-ene + al

= 4-Bromo pent-2-enal

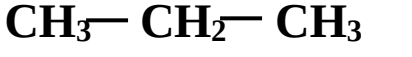
= 4-Bromo-2-pentenal

(I) Naming of Unbranched Alkanes

IUPAC name of the unbranched alkanes consist of only two parts-

Word root + Primary suffix (- ane)

For example,



Prop + ane = Propane



But + ane = Butane

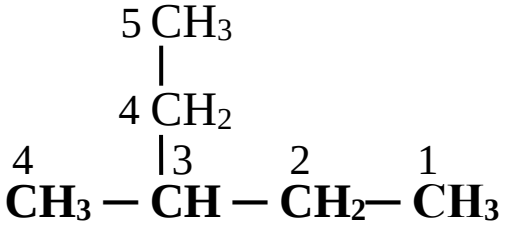


Pent + ane = Pentane

(II) Naming of branched chain alkanes

Naming of branched chain alkanes involves following steps-

(1) Selection of longest continuous carbon chain-First longest continuous carbon chain of the compound is selected. This chain may be straight or curved, but it must contain largest number of carbon atoms. The IUPAC name of the compound is derived from the word root corresponding to this carbon chain. For example,



Pentane derivative

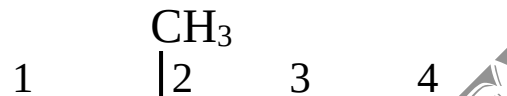
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Here, curved chain is longest carbon chain of the compound. It contains five carbon atoms. Hence, this compound will be pentane derivative.

(2)Numbering of carbon atoms of longest continuous carbon chain-

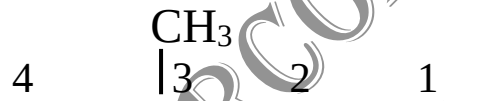
In order to give the position of substituent in longest continuous carbon chain, the carbon atoms of longest continuous carbon chain is numbered using following rules-

(i) If the compound contains only one substituent, then numbering is done from that end of longest continuous carbon chain, where from the substituent is nearest, so that the substituent should get lowest number. For example, in following compound-



2-Methylbutane

(Correct name)



3-Methylbutane

(Incorrect name)

Here, numbering will be done from left end of the longest continuous carbon chain, because it gives lowest possible number to the substituent. The numbering from right end of the longest continuous carbon chain gives bigger number to the substituent. Hence, it should be avoided.

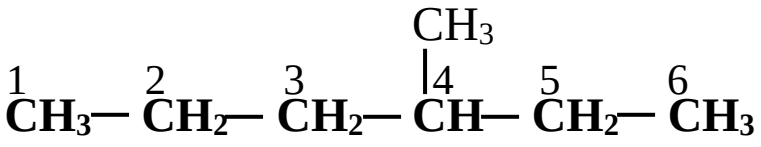
Similarly, in following compound-



3-Methylhexane

(Correct name)

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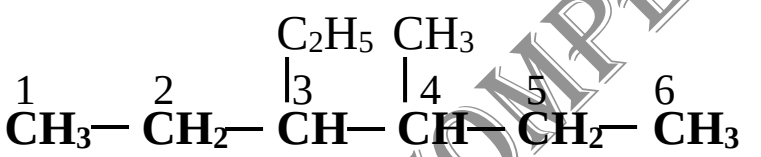


4-Methylhexane

(Incorrect name)

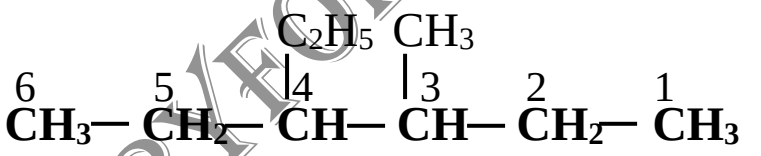
Here, numbering will be done from right end of the longest continuous carbon chain (here, straight chain), because it gives lowest possible number to the substituent. The numbering from left end of the longest continuous carbon chain gives bigger number to the substituent. Hence, it should be avoided.

(ii) If the compound contains two substituents on identical position from either of the ends, then numbering is done in such a way that the substituent coming first in alphabetical order should get lowest number. For example, in following compound-



3-Ethyl-4-methylhexane

(Correct name)



4-Ethyl-3-methylhexane

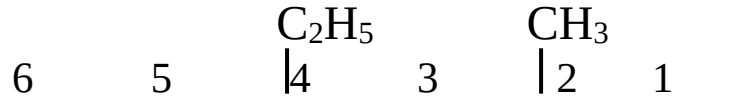
(Incorrect name)

Here, ethyl group comes first in alphabetical order between ethyl and methyl groups, hence, numbering of carbon atoms in longest continuous carbon chain should be done from that end where from ethyl group is nearest so that, ethyl group should get lowest number. Thus, numbering should be done from left end of longest continuous carbon chain.

The substituents are always named in alphabetical order irrespective of their numbers.

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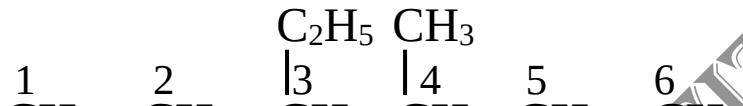
(iii)Lowest Sum Rule- If the compound contains two more substituents, then numbering is done in such a way that the sum of the numbers given to the substituents is the lowest. For example, in following compound-



4-Ethyl-2-methylhexane

[Sum of locants = 4 + 2 = 6]

(Correct name)



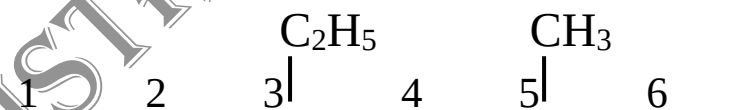
3-Ethyl-4-methylhexane

[Sum of locants = 3 + 4 = 7]

(Incorrect name)

Here, numbering of carbon atoms in longest continuous carbon chain should be done from right end because, it gives lowest sum of locants.

(iv)Lowest set of Locants rule- If the compound contains two more substituents, then numbering is done in such a way that the set of the numbers given to the substituents is the lowest i.e. numbering is done from that end which gives lowest set of locants. For example, in following compound-

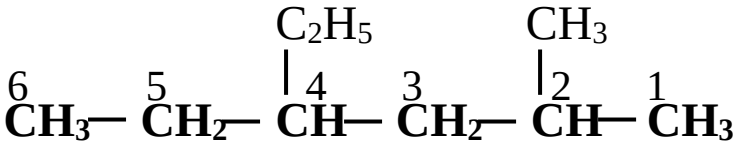


3-Ethyl-5-methylhexane

Set of locants = [3, 5]

(Incorrect name)

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4-Ethyl-2-methylhexane

Set of locants = [2, 4]

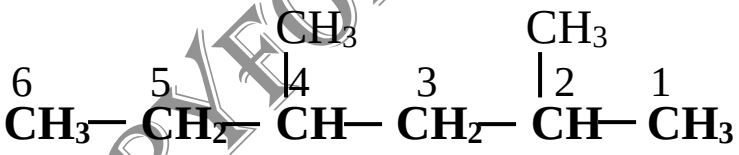
(Correct name)

Here, numbering of carbon atoms in longest continuous carbon chain should be done from left end because, it gives lowest set of locants.

Here, the set having lower number at first digit of difference is considered to be lowest set and the IUPAC name corresponding to this set is considered to be the correct IUPAC name of the compound. For example, amongst **[2, 4] and [3, 5]** set **[2, 4]** has lower number at first digit of difference. Hence, it is considered to be the lowest set and the IUPAC name corresponding to this set is considered to be the correct IUPAC name of the compound.

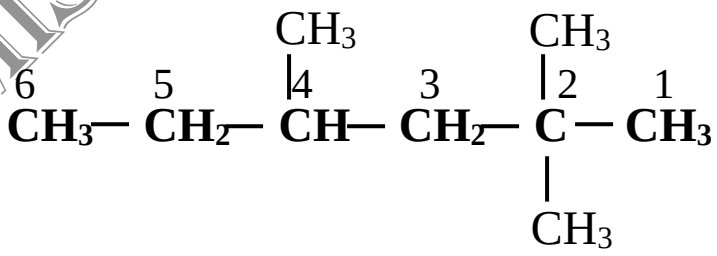
In general, lowest sum rule and lowest set rule do not violate each other, but in case of violation lowest set of locants rule got preference over lowest sum of locants rule.

(3) If the compound contains two or more same substituents, then they are named by prefixing di, tri, tetra etc. along with their position in the longest continuous carbon chain. For example, in following compound-



2,4-dimethylhexane

Similarly, for example, in following compound-

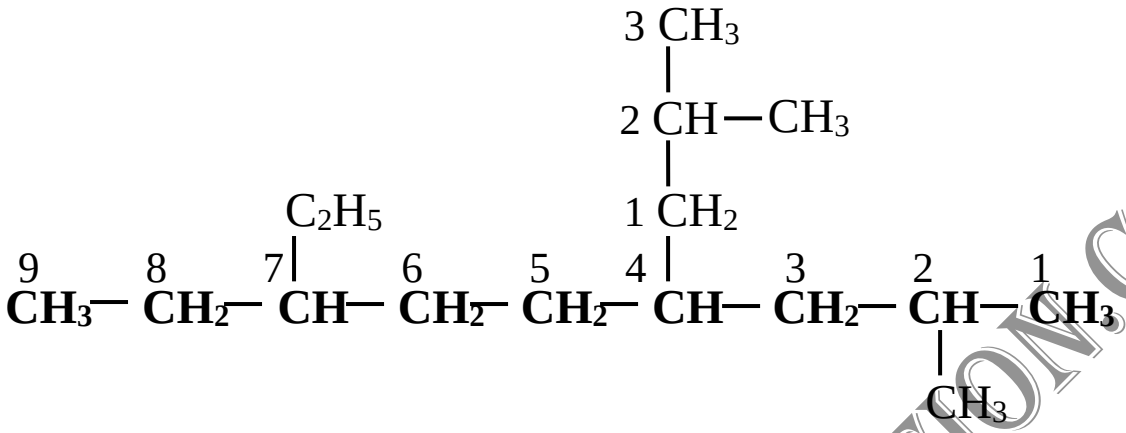


2,2,4-trimethylhexane

(4) If the compound contains branched substituents, then carbon atoms of these branches are also numbered. Here, carbon atom directly attached to the longest

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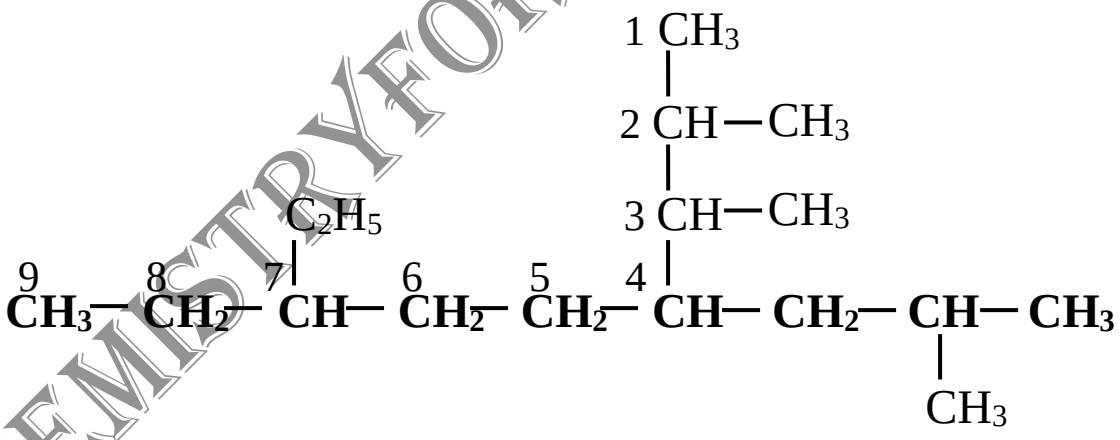
continuous carbon chain in always numbered 1. For example, in following compound-



7-Ethyl-2-methyl-4(2-methylpropyl) nonane

Here, a branched substituent is attached to the 4th carbon atom of longest carbon chain. Hence, carbon atoms of this substituent will also be numbered separately to give the position of substituent in this branched substituent.

(5) If the compound contains two or more longest continuous carbon chain of same length, then the chain having highest number of substituents is preferred for IUPAC naming of the compound. For example, in following compound-



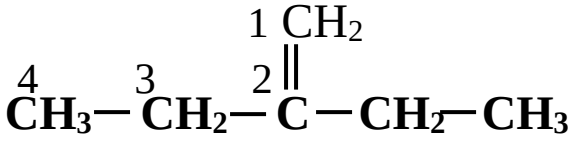
7-Ethyl-2,3-dimethyl-4(2-methylpropyl) nonane

Here, curved carbon chain contains highest number of substituents and therefore, it will be preferred for IUPAC naming of the compound.

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(III) Naming of Compounds containing multiple bonds

(1) First longest continuous carbon chain containing multiple bond is selected. This chain may or not may be longest carbon chain of the compound, but it must contain multiple bond. For example, in following compound-



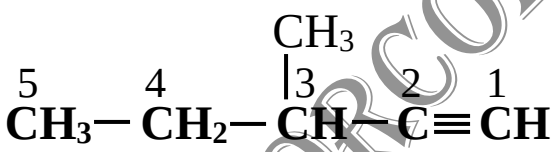
2-Ethylbut-1-ene

or

2-Ethyl-1-butene

Here, straight chain is longest continuous carbon chain of the compound but, it doesn't involve double bond. Hence, it will not be selected for IUPAC naming of the compound. The longest continuous carbon chain containing double bond is curved chain and is selected for IUPAC naming of the compound.

(2) Numbering of carbon atoms in longest continuous carbon chain is done from that end where from multiple bond is nearest, so that the multiple bond should get lowest number. For example, in following compound-



3-Methylpent-1-yne

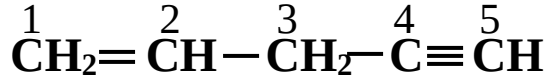
or

3-Methyl-1-pentyne

Here, numbering of carbon atoms is done from right end because it gives lowest number to the triple bond.

(IV)Naming of Compounds containing both double and triple bonds (Naming of ene-yne system).

(1) If double and triple bonds are present on identical positions from either of the end, then numbering is done from that end where from double bond is nearest, but the compound is considered to be of -yne family. For example,

(1) 

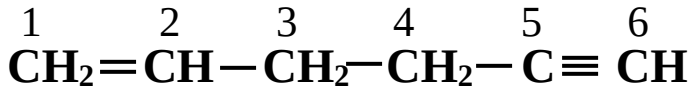
Pent-1-en-4-yne

or

1-Penten-4-yne

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(2)



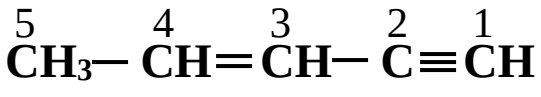
Hex-1-en-5-yne

or

1-Hexen-5-yne

(2) If double and triple bonds are not present on identical positions from either of the end, then numbering is done following lowest set of locants rule. For example,

(1)



Pent-3-en-1-yne

or

3-Penten-1-yne

(2)



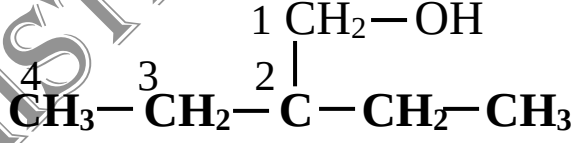
3-Methyl-hex-5-en-1-yne

or

3-Methyl-5-hexen-1-yne

(V) Naming of Compounds containing single functional group-

(1) First longest continuous carbon chain containing functional group is selected. This chain may or not may be longest carbon chain of the compound, but it must contain functional group. For example, in following compound-



2-Ethylbutan-1-ol

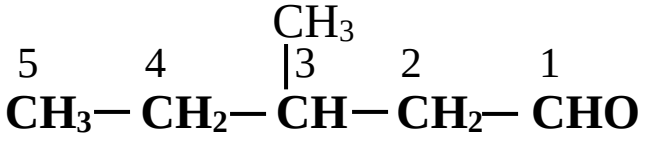
or

2-Ethyl-1-butanol

Here, straight chain is longest continuous carbon chain of the compound but, it doesn't involve functional group. Hence, it will not be selected for IUPAC naming of the compound. The longest continuous carbon chain containing functional group is curved chain and is selected for IUPAC naming of the compound.

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(2) Numbering of carbon atoms in longest continuous carbon chain is done from that end where from functional group is nearest, so that the functional group should get lowest number. For example, in following compound-



3-Methylpentan-1-al

or

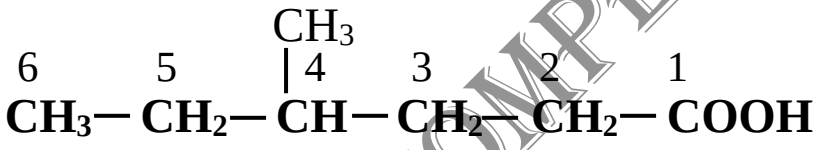
3-Methyl-1-pentanal

or

3-Methylpentanal

Here, numbering of carbon atoms is done from right end, because it gives lowest number to the functional group.

Similarly, for following compound-



4-Methylhexan-1-oic acid

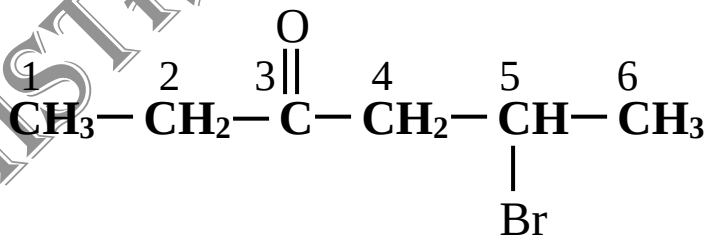
or

4-Methyl-1-hexanoic acid

or

4-Methylhexanoic acid

Similarly, for following compound-



5-Bromohexan-3-one

or

5-Bromo-3-hexanone

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(VI)Naming of Compounds containing more than one functional groups (Naming of Poly-functional Compounds)-

(1) If the compound contains two or more functional groups, then one of them is selected as principal functional group on the basis of the priority table of different functional groups.

The priority table of different functional groups with their respective secondary suffix and prefix are listed here-

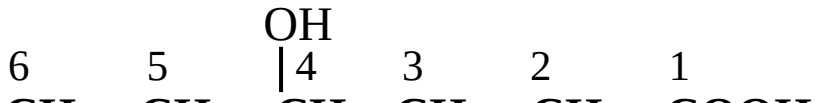
Functional group	Secondary suffix	Prefix
-COOH (Carboxylic acid group)	-oic acid	Carboxy-
$-SO_3H$ (Sulphonic acid group)	-sulphonic acid	Sulpho-
-COOR (Ester group)	-alkyl alkanoate	Alkoxycarbonyl-
-COX (Acid halide group)	-alkanoyl halide	Halocarbonyl-
$-CONH_2$ (Acid amide group)	-alkanamide	Carbamoyl-
-CHO (Aldehyde group)	-al	Formyl-
> CO (Ketone group)	-one	Oxo- or -keto-
-OH (Alcohol group)	-ol	Hydroxy-

(2)Numbering of carbon atoms in longest continuous carbon chain containing principal functional group is done from that end, where from principal functional group is nearest. Thus, numbering of carbon atoms in longest continuous carbon chain should be done in such a way that, the principal functional group should get lowest number.

(3)Other rules are identical to the naming of branched chain alkanes. For example,

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(1)



4-Hydroxyhexan-1-oic acid

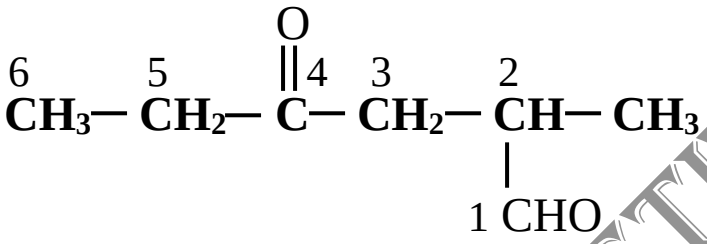
or

4-Hydroxy-1-hexanoic acid

or

4-Hydroxyhexanoic acid

(2)



2-Methyl-4-oxohexan-1-al

or

2-Methyl-4-oxohexanal

(3)



3-Carbamoyl-4-ethylpent-4-en-1-oic acid

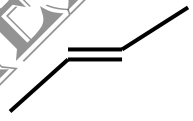
or

3-Carbamoyl-4-ethyl-4-penten-1-oic acid

or

3-Carbamoyl-4-ethyl-4-pentenoic acid

IUPAC naming based on Bond Line Notations-

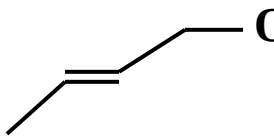
(1)  ≡ **$CH_3-CH=CH-CH_3$**

But-2-ene

or

2-Butene

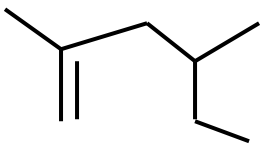
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(2)  ≡ $CH_3-CH=CH-CH_2-OH$

But-2-en-1-ol

or

2-Buten-1-ol

(3) 

$$\equiv CH_2=\underset{\displaystyle CH_2-CH_3}{\overset{\displaystyle CH_3}{\overset{|}{C}H}}-CH_2-\underset{\displaystyle CHO}{\overset{|}{C}H}$$

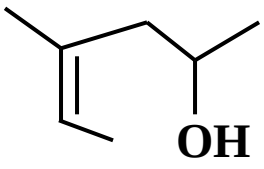
2-Ethyl-4-methylpent-4-en-1-al

or

2-Ethyl-4-methyl-4-penten-1-al

or

2-Ethyl-4-methyl-4-pentenal

(4) 

$$\equiv CH_3-CH=\underset{\displaystyle CH_2-CH-COOH}{\overset{\displaystyle CH_3}{\overset{|}{C}}}-\underset{\displaystyle OH}{\overset{|}{}}$$

2-Hydroxy-4-methylhex-4-en-1-oic acid

or

2-Hydroxy-4-methyl-4-hexen-1-oic acid

or

2-Hydroxy-4-methyl-4-hexenoic acid

- If –COOH, -CHO or –CN groups are present as principal functional group, then carbon atoms of these groups always carbon no. 1. Hence, there is no need to give the position of these groups.
- In determining alphabetical order of substituents, the prefixes iso- and neo- are considered to be the part of the name of respective alkyl groups, but sec- and tert- are not considered to be the part of the name of alkyl groups.
- Iso- and neo- alkyl groups (if not substituted further) are allowed to be used as substituent in IUPAC naming of the compounds.

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