Classification of organic compounds

Organic compounds constitute about 90% of all organic compounds. In order to study such a vast number of compounds, it is necessary to classify them into categories.

- Classification of organic compounds.

A) Depending upon the arrangement of carbon atoms in their structure. Organic compound classified as follows:

a) **Aliphatic compounds**

   Compounds which consist of open chain of carbon atoms are called aliphatic compounds. There is no limit to the number of atoms involved.

   Examples:
   i) $\text{CH}_3 - \text{CH}_3 \rightarrow \text{Ethane}$
   ii) $\text{CH}_3 - \text{CH}_2 - \text{CH}_3 \rightarrow \text{Propane}$
   iii) $\text{CH}_3 - \text{CH}_2 - \text{OH} \rightarrow \text{Ethyl alcohol}$

b) **Saturated compounds**:

   Compound is said to be saturated, if it contains only C-C single bonds.

   Examples:
   i) $\text{CH}_3 - \text{CH}_3 \rightarrow \text{Ethane}$
   ii) $\text{CH}_3 - \text{CH}_2 - \text{CH}_3 \rightarrow \text{Propane}$

c) **Unsaturated compounds**:

   Compounds is said to be unsaturated, if it contain C = C or C ≡ C multiple bonds.

   Examples:
   i) $\text{CH}_2 = \text{CH}_2 \rightarrow \text{Ethylene}$
   ii) $\text{CH} \equiv \text{CH} \rightarrow \text{Acetylene}$
d) Aromatic compounds

Benzene and all compounds that have structures and chemical properties resembling benzene are called aromatic compounds.

Examples:

- i) Benzene
- ii) Aniline

e) Alicyclic compounds:

Cyclic compounds which consist only of carbon atoms are called alicyclic or carbo cyclic compounds.

Examples:

- i) Cyclopropane
- ii) Cyclohexane

f) Heterocyclic compounds:

Cyclic compounds in which the ring atoms are of carbon and some other element (For example N, S or O) are called heterocyclic compounds.

Examples:

- i) Oxirane (ethylene oxide)
- ii) Pyridine
B) Depending upon type of elements. Organic compounds are classified as follows.

**a) Compounds containing C,H,O elements only -**

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Examples</th>
</tr>
</thead>
</table>
| Carbohydrate  | i) \[\text{H}_2\text{C}_\text{O}\]  
|               | H—C—OH                   
|               | HO—C—H                   
|               | H—C—OH                   
|               | CH$_2$OH                  
|               | Glucose                   
|               | ii) \[\text{CH}_2\text{OH}\]  
|               | C=O                      
|               | HO—C—H                   
|               | H—C—OH                   
|               | CH$_2$OH                  
|               | Fructose                  |
| Carboxylic acid| i) \[\text{CH}_3\text{—C—OH}\]  
|              | Acetic acid               |
|              | ii) \[\text{CH}_3\text{—CH}_2\text{—C—OH}\]  
|              | Propanoic acid            |
| Phenols       | i) \[\text{Phenol}\]      
|              | \[\alpha\text{-naphthol}\] |
|              | ii) \[\text{Phenol}\]     
<p>|              | [\beta\text{-naphthol}] |</p>
<table>
<thead>
<tr>
<th>Alcohol</th>
<th>i) $C_2H_5-OH$ Ethanol</th>
<th>ii) $CH_2OH$ Benzyl alcohol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Esters</td>
<td>i) $CH_3-C-O-C_2H_2$ Ethylacetate</td>
<td>ii) $\text{C}-O-\text{CH}_3$ Methylbenzoate</td>
</tr>
<tr>
<td>Anhydride</td>
<td>i) $\text{Pthalic anhydride}$</td>
<td>ii) $\text{Acetic anhydride}$</td>
</tr>
<tr>
<td>Ethers</td>
<td>i) $CH_3-O-CH_3$ Dimethyl ether</td>
<td>ii) $\text{Anisole}$</td>
</tr>
<tr>
<td>Hydrocarbon</td>
<td>i) $CH_4$ Methane</td>
<td>ii) $CH_3-CH_3$ Ethane</td>
</tr>
<tr>
<td>Aldehydes</td>
<td>i) $\text{Acetaldehyde}$</td>
<td>ii) $\text{Benzaldehyde}$</td>
</tr>
<tr>
<td>Ketones</td>
<td>i) $\text{Acetone}$</td>
<td>ii) $\text{Acetophenone}$</td>
</tr>
<tr>
<td>Compound</td>
<td>Examples</td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td>Amines</td>
<td>i) $\text{CH}_3\text{NH}_2$&lt;br&gt; Methylamine</td>
<td>ii) $\text{NH}_2$&lt;br&gt; Aniline</td>
</tr>
<tr>
<td>Amide</td>
<td>i) $\text{CH}_3\text{C}\text{NH}_2$&lt;br&gt; Acetamide</td>
<td>ii) $\text{C}\text{NH}_2$&lt;br&gt; Benzamide</td>
</tr>
<tr>
<td>Imides</td>
<td>i) Pthalimide</td>
<td>ii) Succinimide</td>
</tr>
<tr>
<td>Compounds</td>
<td>Structure 1</td>
<td>Structure 2</td>
</tr>
<tr>
<td>--------------------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Nitriles</td>
<td>CH₃CN</td>
<td>CH₃CH₂CN</td>
</tr>
<tr>
<td>Methyldicyanide</td>
<td>m-Dinitrobenzene</td>
<td>o-Nitrotoluene</td>
</tr>
<tr>
<td>Nitro-hydrocarbon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitroacids</td>
<td>COOH</td>
<td>COOH</td>
</tr>
<tr>
<td>O-Nitrobenzoic acid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrophenols</td>
<td>OH</td>
<td>O₂N</td>
</tr>
<tr>
<td>o-Nitrophenol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anilides</td>
<td>C₅H₅CONH₂H₅</td>
<td>NH₂CaCH₃</td>
</tr>
<tr>
<td>Benzanilide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amino acids</td>
<td>COOH</td>
<td>COOH</td>
</tr>
<tr>
<td>o-Aminobenzoic acid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-Aminobenzoic acid</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
c) Compounds containing C, H, [O] N and S elements only

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphonic acid</td>
<td>i) CH₃CH₂CH₂SO₃H</td>
</tr>
<tr>
<td></td>
<td>Propane sulphonic acid</td>
</tr>
<tr>
<td>ii) SO₃H</td>
<td>Benzene sulphonic acid</td>
</tr>
<tr>
<td>Thiols</td>
<td>i) CH₃SH</td>
</tr>
<tr>
<td></td>
<td>Methanethiol</td>
</tr>
<tr>
<td>ii) SH</td>
<td>Thiophenol</td>
</tr>
<tr>
<td>Sulphanamides</td>
<td>i) SO₂NH₂</td>
</tr>
<tr>
<td></td>
<td>Benzene Sulphanamide</td>
</tr>
<tr>
<td>ii) SO₂NH₂</td>
<td>p - toluene sulphonamide</td>
</tr>
</tbody>
</table>

d) Compounds containing C, H, [O] and halogens elements only

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkyl halides</td>
<td>i) CH₃—Cl</td>
</tr>
<tr>
<td></td>
<td>Methylchloride</td>
</tr>
<tr>
<td>ii) CH₃—CH₂—Br</td>
<td>Ethylbromide</td>
</tr>
<tr>
<td>Aryl halides</td>
<td>i) Cl</td>
</tr>
<tr>
<td></td>
<td>Chlorobenzene</td>
</tr>
<tr>
<td>ii) I</td>
<td>Iodobenzene</td>
</tr>
</tbody>
</table>
Common and IUPAC system of nomenclature in alkanes

**Alkanes:** Alkanes are hydrocarbons that contain only single bonds.

**Common name system:**
In the common system all isomeric alkanes have the same parent name. The names of various isomers are distinguished by prefixes. The prefix indicates the types of branching present in the molecule.

1) **Prefix n:** Prefix n is used for those alkanes in which all carbons are in one continuous chain. The prefix ‘n-’ stands for normal or straight chain.

   e.g.:
   i) \( \text{CH}_3 - \text{CH}_2 - \text{CH}_3 \)  
   ii) \( \text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \)
   n-Propane  
   n-Butane

2) **Prefix Iso:** Prefix Iso is used for those alkanes which have a methyl group \((\text{CH}_3 -)\) attached to the second last carbon atom of the continuous chain.

   e.g.:
   \[
   \begin{array}{c}
   \text{CH}_3 \\
   \text{CH}_3 - \text{CH} - \text{CH}_3 \\
   \end{array}
   \]
   Isobutane

3) **Prefix Neo:** Prefix Neo - is used for those alkanes which have two methyl group attached to the second last carbon atom of the continuous chain.

   e.g.:
   \[
   \begin{array}{c}
   \text{CH}_3 \\
   \text{H}_3\text{C} - \text{C} - \text{CH}_3 \\
   \text{CH}_3 \\
   \end{array}
   \]
   Neopentane
• IUPAC rules for naming alkanes:

**Rule 1**: Select the longest continuous carbon chain.

**Rule 2**: Name the longest chain. The names are those that give the parent names.

\begin{align*}
\text{CH}_3 & - \text{CH}_2 - \text{CH}_2 - \text{CH} - \text{CH}_3 \\
\end{align*}

The longest continuous chain has five carbon atoms. Thus, the compound is named as a pentane.

**Rule 3**: Number the longest chain. The carbon atoms in the longest chain are numbered. The numbering is started from that end which will give numbers having the lowest value to carbons carrying substituents.

\begin{align*}
\text{CH}_3 & - \text{CH}_2 - \text{CH}_2 - \text{CH} - \text{CH}_3 \\
\end{align*}

**Rule 4**: Identify the substituent. Name the substituent. Indicate its position by the number of the carbon atom to which it is attached.

The attached group is located or carbon 2 of the chain and it is a methyl group.

\begin{align*}
\text{CH}_3 & - \text{CH}_2 - \text{CH}_2 - \text{CH} - \text{CH}_3 \\
\end{align*}

**Rule 5**: Prefix the position number and name of the substituent onto the parent name. The whole name is written as one-word. The number and name of the substituent are separated by a hyphen.

\begin{align*}
\text{CH}_3 & - \text{CH}_2 - \text{CH}_2 - \text{CH} - \text{CH}_3 \\
\end{align*}

**Rule 6**: Identify the substituents by names an position numbers. When the same substituent is present two or more times in the molecule, prefixes di, tri-, tetra-, penta-, etc. are used. Position of each substituent is indicated by a separated number.

These position numbers, separated by commas, are put just before the name of the substituent, with the hyphen before and after the numbers when necessary.

\begin{align*}
i) & 1 \text{CH}_3 - 2 \text{CH} - 3 \text{CH} - 4 \text{CH}_3 \\
\text{CH}_3 & - \text{CH}_3 \\
\text{2,3 - Dimethylbutane} & \\

\text{ii) } & 1 \text{CH}_3 - 2 \text{CH}_2 - 3 \text{CH} - 4 \text{CH}_2 - 5 \text{CH}_3 \\
\text{CH}_3 & - \text{CH}_3 \\
\text{3,3 - Dimethylpentane} & \\
\end{align*}
**Rule 7**: When two or more different substituents are present, their names are arranged in alphabetic order and added to the name of the parent alkane, again as one word.

\[
\begin{array}{ccccccc}
1 & 2 & 3 & 4 & 5 & 6 & 7 \\
\text{CH}_3 & \text{CH}_2 & \text{CH} & \text{CH}_2 & \text{CH} & \text{CH}_2 & \text{CH}_3 \\
\text{CH}_3 & \text{CH}_2 & \text{CH} & \text{CH}_2 & \text{CH}_3 & \\
\end{array}
\]

5 - Ethyl - 3 - Methylheptane

Common and IUPAC system of nomenclature in alkenes

**Alkenes**: Alkenes are hydrocarbons that contain a carbon-carbon double bond. Their common and IUPAC names are as follows.

- **Common name**:
  Their common names are obtained by changing the ending one of the corresponding alkane to -ylene.

  Example:

  i) \( \text{CH}_2=\text{CH}_2 \) \quad \text{Ethylene} \\
  ii) \( \text{CH}_3-\text{CH}=\text{CH}_2 \) \quad \text{Propylene} \\
  iii) \( \text{CH}_3-\text{C}=\text{CH}_2 \) \quad \text{Isobutylene}

- **IUPAC rules for naming Alkenes**:
  The IUPAC rules for naming alkenes are given below:

  **Rule 1**: Select the longest carbon chain. Containing the double bond. This is parent chain

  **Rule 2**: Name the longest chain. The name is obtained by dropping the final -ane from the name of the corresponding alkane and adding the ending -ene

  **Rule 3**: Number the chain from the end closer to the double bond.

  **Rule 4**: Indicate the position of the double bond by the number of first carbon atom involved in double bond.

  **Rule 5**: Alkyl groups and other substituents are numbered, named and placed as prefixes in alphabetic order.

  For example

  i) \( \text{CH}_2=\text{CH}_2 \) \quad \text{Ethene} \\
  ii) \( \text{CH}_3-\text{CH}=\text{CH}_2 \) \quad \text{Propene} \\
  iii) \( \text{CH}_3-\text{C}=\text{CH}_2 \) \quad 2 - Methylpropene

  iv) \( \text{CH}_3-\text{CH}_2-\text{CH}=\text{CH}_2 \) \quad 4 - 3 - 2 - 1 - Butene

  v) \( \text{CH}_3-\text{C}=\text{CH}-\text{CH}_2-\text{CH}_3 \) \quad 1 - 2 - 3 - 4 - 5 - Pentene
**Rule 6** : Alkenes containing two double bonds are named as alkadienes.

\[
\begin{align*}
\text{CH}_2=\text{C} \equiv \text{CH}_2 \\
1 & \quad 2 \\
\text{CH}_2=\text{CH} \equiv \text{CH} \equiv \text{CH}_2 \\
1 & \quad 2 & \quad 3 & \quad 4 \\
1,2 \text{- Propadiene} & & 1,3 \text{- Butadiene}
\end{align*}
\]

**Rule 7** : In naming cycloalkenes, number the ring to give the double bonded carbons the number 1 and 2 choose the direction of numbering so that the substituents get the lowest numbers. The position of the double bond is not indicated because it is known to be between C-1 and C-2.

![Methylcyclopentene](image)

**IUPAC system of nomenclature of alcohols.**

- **Alcohols** : Alcohols are compounds in which a hydroxyl group (\(-\text{OH}\)) is bounded to a saturated carbon.

- **IUPAC rules for naming alcohols** : In the IUPAC system, alcohols are named as alkanols.

**Rule 1** : Select the longest chain to which the hydroxyl group is attached.

**Rule 2** : Name the longest chain. The name is obtained by dropping the final -e from the name of the alkane that contains the some number of carbon atoms and adding the ending -ol.

**Rule 3** : Number the chain to give the lowest number to carbon attached to the hydroxyl group.

**Rule 4** : Indicate the position of the hydroxyl group by the number of the carbon attached to the hydroxyl group.
Rule 5: Other substituents are numbered, named and placed as prefixes in alphabetic order.

For example:

i) \( \text{CH}_3\text{OH} \) (Methanol)  
ii) \( \text{CH}_3\text{CH}\text{CH}_3 \)  
iii) \( \text{CH}_3\text{CHCH}_2\text{OH} \) (2-Methyl-1-Propanol)

Rule 6: Alcohols containing two or three \(-\text{OH}\) groups are named as Alkanediols and Alkanetriol respectively. ‘-e’ of the corresponding alkane name is retained.

i) \( \text{CH}_2\text{OH} \)  
ii) \( \text{CH}_2\text{CH}_2\text{OH} \)  

1,3 – Propanediol  
1,2,3 – Propanetriol

IUPAC system of nomenclature in aldehyde and ketone

Alcohols: Alcohols are compounds in which a carbonyl group \((\text{C} = \text{O})\) is bounded to an organic group and hydrogen. Their common names are related to those of carboxylic acid.

<table>
<thead>
<tr>
<th>Formula</th>
<th>Common name</th>
<th>IUPAC name</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{O} ) ( \text{H} ) ( \text{C} - \text{H} )</td>
<td>Formaldehyde</td>
<td>Methanal</td>
</tr>
<tr>
<td>( \text{CH}_3\text{C} \text{H} )</td>
<td>Acetaldehyde</td>
<td>Ethanal</td>
</tr>
<tr>
<td>( \text{CH}_3\text{CH}_2\text{C} \text{H} )</td>
<td>Propionaldehyde</td>
<td>Propanal</td>
</tr>
<tr>
<td>( \text{CH}_3\text{CH}_2\text{CH}_2\text{C} \text{H} )</td>
<td>Butyraldehyde</td>
<td>Butanal</td>
</tr>
</tbody>
</table>

- IUPAC rules for naming aldehyde:
  
  In IUPAC system, aldehyde are named as alkanols
  
  Rule 1: Select the longest chain containing the aldehyde group.
Rule 2: Name the longest chain. The name is obtained by dropping the final -e from the name of the corresponding alkane and adding the ending -al.

Rule 3: Number the chain by assigning the number 1 to the aldehyde carbon. The number 1 is not used to indicate the position of the carbonyl carbon, since it is always located at the end of the chain.

Rule 4: Other substituents are numbered, named and placed as prefixes in alphabetic order.

For example,

1) \( \text{CH}_3 - \text{CH} = \text{CH}_2 - \text{C} = \text{H} \) (3-Methylbutanal)

2) \( \text{CH}_3 - \text{CH} = \text{CH} - \text{CH}_2 - \text{C} = \text{H} \) (4-Chloropentanal)

Rule 5: When there are two aldehyde groups in a molecule, it is named as alkanedial "-e" of alkane name is retained

\[ \text{H} - \text{C} = \text{CH}_2 - \text{CH}_2 - \text{C} = \text{H} \] (1,4-Butanediol)

- Ketones: Ketones are compounds in which the carbonyl group (C = O) is bonded to two organic groups.

Their common names are obtained by naming the alkyl groups attached to the carbonyl group and adding the word ketone.

<table>
<thead>
<tr>
<th>Formula</th>
<th>Common name</th>
<th>IUPAC name</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{CH}_3 - \text{C} = \text{CH}_3 )</td>
<td>Dimethyl ketone (acetone)</td>
<td>Propanone</td>
</tr>
<tr>
<td>( \text{H}_3\text{C} - \text{CH}_2 - \text{C} = \text{CH}_2 - \text{CH}_3 )</td>
<td>Diethyl ketone</td>
<td>Pentanone</td>
</tr>
</tbody>
</table>

- IUPAC rules for naming ketones:

In the IUPAC system ketones are named as Alkanones.

Rule 1: Select the longest chain containing the carbonyl carbon atom.
**Rule 2**: Name the longest chain. The name is obtained by dropping the final –e from the name of the corresponding alkane and adding the ending one.

**Rule 3**: Number the chain to give the lowest number to the carbonyl carbon.

**Rule 4**: Other substituents are numbered, named and placed as prefixes in alphabetic order.

For examples:

i)\[
\text{CH}_3\text{CH}-\text{C}-\text{CH}_2\text{-CH}_3
\]
3 – Pentaone

ii)\[
5\text{CH}_3\text{CH}-\text{C}-\text{CH}_2\text{-C}-\text{CH}_3
\]
4 – Methyl-2-Pentaone

**Rule 5**: When there are two carbonyl group in a molecule it is named as Alkanedione ‘-e’ of the corresponding alkane name is retained.

\[
\text{CH}_3\text{C}-\text{C}-\text{CH}_2\text{C}-\text{CH}_3
\]
2,4 – Pentanediene

**IUPAC rules for naming Alkynes, Alkyl halides and ethers**

**a) Alkynes**: Alkynes are hydrocarbons that contain a carbon-carbon triple bond.

**IUPAC rules**:

**Rule 1**: Select the longest carbon chain containing the triple bond. This is the parent chain.

**Rule 2**: Name the longest chain. The name is obtained by dropping final –ane from the name of corresponding alkane and adding the ending –yne.

**Rule 3**: Number the chain from the end closer to the triple bond.

**Rule 4**: Indicate the position of the triple bond by the number of the first (lowest numbered) carbon atom involved in the triple bond.
**Rule 5**: Alkyl groups and other substituents are numbered, named and placed as prefixes in alphabetic order.

For example:

\[
\begin{align*}
&\text{HC} \equiv \text{CH} & \text{CH}_3 \equiv \text{C} \equiv \text{CH} \\
&\text{Ethyne} & \text{Propyne}
\end{align*}
\]

**Rule 6**: Alkynes containing two triple bonds are named as Alkadiynes.

\[
\begin{align*}
&\text{HC} \equiv \text{C} \equiv \text{CH} \\
&\text{1,3-Butadiyne}
\end{align*}
\]

b) **Alkyl halides**

Alkyl halides are compound which contain carbon-halogen bonds.

**IUPAC rules**:

**Rule 1**: Select the longest chain to which the halogen is attached and give it the name of the corresponding alkane.

**Rule 2**: Prefix the name of the alkane by chloro, bromo, iodo or fluoro.

**Rule 3**: Number the chain so as to give the carbon carrying halogen atom the lowest possible number.

**Rule 4**: Other substituents are numbered, named and placed as prefixes in alphabetic order. If there are two or more identical halogen substituents, the prefixes – di-, tri-, tetra- etc. are used.

For example:

\[
\begin{align*}
&\text{Br} \\
&\text{CH}_3-\text{CH}-\text{CH}_3 \\
&\text{1-2-3} \\
&\text{2-Bromopropane}
\end{align*}
\]

\[
\begin{align*}
&\text{C}_2\text{H}_5 \\
&\text{CH}_3-\text{CH}-\text{CH}_2-\text{Cl} \\
&\text{4-3-2-1} \\
&\text{C}_2\text{H}_5 \\
&\text{1-Chloro-2,3-Diethylbutane}
\end{align*}
\]
c) Ethers:

Ethers are compounds in which an oxygen atom is bonded to two organic groups (R – O – R).

**IUPAC rule:**

In the IUPAC system, ethers are named as Alkoxyalkanes. The smaller alkyl group plus the oxygen atom is called an alkoxy substituent.

![Methoxy group]

\[
\begin{align*}
\text{CH}_3 & \quad \text{CH}_2 \quad \text{O} \quad \text{CH}_3 \\
1 & \quad \text{- Methoxyethane}
\end{align*}
\]

![Ethoxy group]

\[
\begin{align*}
\text{CH}_3 & \quad \text{CH} \quad \text{CH}_2 \quad \text{O} \quad \text{CH}_2 \quad \text{CH}_3 \\
5 & \quad 4 \quad 3 \quad 2 \quad 1 \\
2 & \quad \text{- Ethoxy - 4 - methylpentane}
\end{align*}
\]

**IUPAC system of nomenclature of carboxylic acid derivatives.**

Carboxylic acid derivatives are compounds in which the hydroxyl part of the carboxyl group is replaced by various other groups.

**a) Acid chloride:**

Acid chlorides are derived from acids by replacing OH group by Cl atom. They are named by changing the ending –ic acid of the corresponding carboxylic acid to –yl chloride.

<table>
<thead>
<tr>
<th>Examples</th>
<th>Common Name</th>
<th>IUPAC Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\text{CH}_3 \quad \text{C} \quad \text{Cl})</td>
<td>Acetyl chloride</td>
<td>Ethanoyl chloride</td>
</tr>
<tr>
<td>(\text{CH}_3 \quad \text{CH}_2 \quad \text{C} \quad \text{Cl})</td>
<td>Propionyl chloride</td>
<td>Propanoyl chloride</td>
</tr>
</tbody>
</table>
b) **Esters**: Esters are derived from acids by replacing the OH group by OR group. Their names consist of two words. The first word is the name of the alkyl group attached to the oxygen atom. The second word is derived from the carboxylic acid name with -ic acid changed to -ate.

<table>
<thead>
<tr>
<th>Examples</th>
<th>Common Name</th>
<th>IUPAC Name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Methyl formate</td>
<td>Methyl methanoate</td>
</tr>
<tr>
<td></td>
<td>Methyl acetate</td>
<td>Methyl methanoate</td>
</tr>
</tbody>
</table>

c) **Anhydrides**: Anhydrides are derived from acids by replacing OH by OCOR. They are named by changing the suffix acid of the parent acid to anhydride.

<table>
<thead>
<tr>
<th>Example</th>
<th>Common Name</th>
<th>IUPAC Name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Acetic Anhydride</td>
<td>Ethanoic Anhydride</td>
</tr>
</tbody>
</table>

d) **Amides**: Amides are derived from acids by replacing OH by NH₂. They are named by replacing the ending -oic acid (of the IUPAC name) or -ic acid (of the common name) of the corresponding carboxylic acid with the ending -amide.

<table>
<thead>
<tr>
<th>Examples</th>
<th>Common Name</th>
<th>IUPAC Name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Formamide</td>
<td>Methnamide</td>
</tr>
<tr>
<td></td>
<td>Acetamide</td>
<td>Ethanamide</td>
</tr>
</tbody>
</table>
IUPAC naming of sulfonic acids, Nitro compounds and cyanides

: a) Sulfonic acids: Sulfonic acids are compounds which contain the sulfo group (– SO$_3$H). Their IUPAC names are obtained by adding the suffix – sulfonic acid to the alkane name.

\[
\text{CH}_3\text{CH}_2\text{SO}_3\text{H} \\
\text{Ethane sulphonie acid}
\]

b) Nitro compounds:
Nitro compounds are compounds which contain the nitro group (– NO$_2$). Their IUPAC names are obtained by adding the prefix nitro– to the alkane name.

\[
\text{CH}_3\text{NO}_2 \\
\text{Nitromethane}
\]

c) Cyanides or Nitriles:
Cyanides are compounds which contain the nitrile group (– CN). In the common system, they are named as alkyl cyanides. In the IUPAC system they are named as Alkanenitriles. Numbering includes the nitrile carbon atom.

\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{CH}_2\text{CN} & \quad \text{Ethenenitrile} \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH} & \quad \text{3- cyanobutanoic acid}
\end{align*}
\]

Nomenclature of polyfunctional compounds

When a compound contains two or more different types of functional groups, it is called as polyfunctional compound, in which the functional group which specifies its class is called the **Principal Functional Group**.

The other functional groups are referred to as substituents.

**Selection of the Principal Functional Group**

The IUPAC system has laid down the priority of the functional groups for determining the class of a polyfunctional compound. Following table gives a list of functional groups in **decreasing** order of priority for citation as the principal functional group.
<table>
<thead>
<tr>
<th>Class</th>
<th>Functional group</th>
<th>Suffix used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carboxylic acid</td>
<td>(-\text{C}OH)</td>
<td>–oic acid</td>
</tr>
<tr>
<td>Sulfonic acid</td>
<td>(-\text{SO}_3\text{H})</td>
<td>–Sulfonic acid</td>
</tr>
<tr>
<td>Ester</td>
<td>(-\text{C}O)</td>
<td>alkyl –oate</td>
</tr>
<tr>
<td>Acid halide</td>
<td>(-\text{C}X)</td>
<td>–oyl halide</td>
</tr>
<tr>
<td>Amide</td>
<td>(-\text{C}NH}_2)</td>
<td>– amide</td>
</tr>
<tr>
<td>Nitrile</td>
<td>(-\text{CN})</td>
<td>– nitrile</td>
</tr>
<tr>
<td>Aldehyde</td>
<td>(-\text{C}H)</td>
<td>– al</td>
</tr>
<tr>
<td>Ketone</td>
<td>(-\text{C})</td>
<td>– one</td>
</tr>
<tr>
<td>Alcohol</td>
<td>(-\text{OH})</td>
<td>–ol</td>
</tr>
<tr>
<td>Amine</td>
<td>(-\text{N})</td>
<td>– amine</td>
</tr>
<tr>
<td>Ethers</td>
<td>(-\text{O})</td>
<td>ether</td>
</tr>
<tr>
<td>Alkenes</td>
<td>(-\text{C}\equiv\text{C})</td>
<td>–ene</td>
</tr>
<tr>
<td>Alkyne</td>
<td>(-\text{C}≡\text{C})</td>
<td>–yne</td>
</tr>
</tbody>
</table>

Following table gives the list of prefixes used for functional groups

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Functional group</th>
<th>Suffix used</th>
</tr>
</thead>
<tbody>
<tr>
<td>– Br</td>
<td>Bromo</td>
<td>– R Alkyl</td>
</tr>
<tr>
<td>– Cl</td>
<td>Chloro</td>
<td>– OR Alkoxy</td>
</tr>
<tr>
<td>– F</td>
<td>Fluoro</td>
<td>– OH Hydroxy</td>
</tr>
<tr>
<td>– I</td>
<td>Iodo</td>
<td>– NH\textsubscript{2} Amino</td>
</tr>
</tbody>
</table>

\[ \text{Ox} \quad \text{Oxo} \]
\[ \text{NO}_2 \quad \text{Nitro} \]
\[ \text{NO} \quad \text{Nitroso} \]
\[ \text{CN} \quad \text{Cyano} \]
IUPAC rules

**Rule 1**: Identify the principal functional group. This gives the class name of the structure.

For example:

```
  O
CH₃—CH—CH₂—CH₂—COOH
```

Two functional groups –OH and –COOH are present in above structure since –COOH ranks higher in priority table, the structure is named as a carboxylic acid.

**Rule 2**: Number the longest chain containing the principal functional group from the end closer to it.

**Rule 3**: Write the parent name corresponding to the number of carbons in the longest chain.

**Rule 4**: Arrange the substituent names with position numbers in alphabetic order.

**Rule 5**: Prefix substituent names with the parent name.

**Rule 6**: Following functional groups are always named as substituents.

<table>
<thead>
<tr>
<th>Functional Group</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cl</td>
<td>Chloro</td>
</tr>
<tr>
<td>Br</td>
<td>Bromo</td>
</tr>
<tr>
<td>I</td>
<td>Iodo</td>
</tr>
<tr>
<td>F</td>
<td>Fluoro</td>
</tr>
<tr>
<td>CN</td>
<td>Cyano</td>
</tr>
<tr>
<td>R</td>
<td>Alkyl</td>
</tr>
<tr>
<td>OR</td>
<td>Alkoxo</td>
</tr>
<tr>
<td>NH₂</td>
<td>Amine</td>
</tr>
<tr>
<td>NO₂</td>
<td>Nitro</td>
</tr>
<tr>
<td>NO</td>
<td>Nitroso</td>
</tr>
</tbody>
</table>

**Rule 7**: Carbon-carbon double or triple bonds are usually indicated by integrating –en– or –yn– into the suffix, as in –enoic acid or –ynol

**Rule 8**: Compounds containing a double bond and a triple bond in the main chain are named as alkenynes. The position number of the double bond is inserted before –alkene– and that of triple bond before –yne.

**Examples**:

1)

```
  O
CH₃—CH=CH—CH₂—CH₂—CH₃
  3 - Pentenal
```

2)

```
CH₃—CH₂—CH=CH₂—CH₂—CH＝CH₂
  4 - Oxohexenal
```

3)

```
CH₃—CH—CH—CH=CH
  3 - Penten - 1 - yne
```

4)

```
CH₃—CH=CH—CH=CH₂—CH₂—CH₃
  6 - Bromo - 3 - Oxo - 4 - heptenal
```

IUPAC name for following structure

a) Alkanes:
   i) \( \text{CH}_3-\text{CH}-\text{CH}_2-\text{CH}_2-\text{CH}_3 \)
   2,3 - Dimethylhexane

   ii) \( \text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_3 \)
   2 - Methylbutane

   iii) \( \text{CH}_3 \)
   1,2 - Dimethylcyclobutane

   iv) \( \text{H}_3\text{C} - \text{C}_\text{H}_3 \)
   1,1 - Dimethylcyclohexane

b) Alkenes:
   i) \( \text{CH}_3-\text{CH}=\text{CH}-\text{CH}_2-\text{CH}_3 \)
   2 - Pentene

   ii) \( \text{Br} \)
   3 - Bromo-1 - butene

   iii) \( \text{CH}_3-\text{C} \equiv \text{C}-\text{CH}_2-\text{CH}_3 \)
   2 - Methyl-2 hexene

   iv) \( \text{Cl} \)
   1,4 - Dichloro-2 - pentene

c) Alkynes:
   i) \( \text{HC} \equiv \text{C}-\text{CH}_2-\text{CH}_3 \)
   1 - Butyne

   ii) \( \text{C}_2\text{H}_5 \)
   3,3 - Dimethyl-1 - Pentyne

   iii) \( \text{CH}_3-\text{C} \equiv \text{C}-\text{CH}_2-\text{CH}_3 \)
   2 - Hexyne

   iv) \( \text{CH}_3-\text{CH} \equiv \text{C} \equiv \text{CH} \)
   3 - Bromo-1 - butyne

d) Alcohols:
   i) \( \text{Cl} \)
   2 - Chloro-2 - propanal

   ii) \( \text{OH} \)
   1,5 - Pentanediol

   iii) \( \text{C}_2\text{H}_4\text{OH} \)
   2 - Cyclopropylethanol

   iv) \( \text{CH}_3\text{OH} \)
   1 - Methylcyclohexanol
e) Aldehyde:

i) $\text{CH}_3\text{-CH}═\text{CH}-\text{C}=\text{H}$

2-Butanal

ii) $\text{CH}_3\text{-CH-CH}_2\text{-CH}_2\text{-CH-CH}=\text{H}$

2-Chloro-5-Methylhexanal

iii) $\text{H-CH-C-CH}_2\text{-CH-C}=\text{H}$

2-Methyl-1,5-Pentadienal

iv) $\text{CH}_3\text{-CH}_2\text{-C}=\text{H}$

1-Propanal

f) Ketones:

i) $\text{CH}_3\text{-CH}_2\text{-C}=\text{H-CH}_3$

2-Methyl-3-Pentanone

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

2,4-Pentanedione

iii) Cyclohexanone

iv) $\text{CH}_3\text{-CH-CH}_2\text{-C-CH}_2\text{-CH}_3$

5-Chloro-3-hexanone

g) Carboxylic Acids:

i) $\text{CH}_3\text{-CH-CH}_2\text{-CH}_2\text{-COOH}$

Br

4-Bromopentanoic acid

ii) $\text{HO-C-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-C}=\text{O}$

3-Ethyl-6-Methyloctanedioic acid

iii) 2,4-Dinitrobenzoic acid

iv) $\text{CH}_3\text{-CH}_2\text{-CH-COOH}$

2-Methyl butanoic acid
h) Cyanides or Nitriles:
   i) \( \text{CH}_3-\text{CH}_2-\text{CH}==\text{CN} \)  
      2—Methylbutanenitrile
   ii) \( \text{CH}_3-\text{C}==\text{CH}_2-\text{CH}_2-\text{CH}_3 \)  
        4,4—Dimethylbutanitrile
   iii) \( \text{CH}_3-\text{CH}_2-\text{CH}-\text{CH}_2-\text{CH}_2-\text{CN} \)  
        3—Chloropentanitrile

i) Amines:
   i) \( \text{CH}_3-\text{CH}_2-\text{N}==\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_3 \)  
      N—Ethyl—Methylbutanamine
   ii) \( \text{NH}_2-\text{CH}_2-\text{CH}-\text{CH}-\text{CH}_2-\text{CH}_3 \)  
        4—Methyl—3—hexamine
   iii) \( \text{NH}_2-\text{CH}_3-\text{CH}-\text{CH}-\text{CH}_3 \)  
        3—Chlorol—2—butamine
   iv) \( \text{CH}_3-\text{CH}_2-\text{CH}_2-\text{NH}==\text{CH}_3 \)  
       N—Methylpropanamine
1. Propanamine
   \[\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{NH}_2\]

2. Ethyl butanoate
   \[\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{C}(-\text{OC}_2\text{H}_5)\]

3. 3, 3 dichloropentane
   \[\text{CH}_3-\text{CH}_2-\text{C}-\text{CH}_2-\text{CH}_3\]

4. 2-bromo-2-methylbutane
   \[\text{CH}_3-\text{CH}_2-\text{C}-\text{CH}_3\]

5. 2 ethoxy - 5-methyl hexane
   \[\text{CH}_3-\text{CH}-\text{CH}_2-\text{CH}_2-\text{CH}-\text{CH}_3\]

6. 3 - Cyanobutanoic acid
   \[\text{CN}-\text{CH}-\text{CH}_2-\text{C(OH)}\]

7. Methyl cyclopentane
   \[\text{H}_3\text{C}\]

8. 3 Chlorophenol
   \[\text{OH}\]

9. 1, 4 - Pentadiene
   \[\text{CH}_2=\text{CH}-\text{CH}_2-\text{CH}=\text{CH}_2\]
10. 2, 2 - Dimethylcyclopentanol

![Chemical structure of 2, 2 - Dimethylcyclopentanol]

11. Propanoyl chloride

![Chemical structure of Propanoyl chloride]

12. Phenylacetic acid

![Chemical structure of Phenylacetic acid]

13. 4 - Pentenamide

![Chemical structure of 4 - Pentenamide]

14. 3 - Methyl - 2 butenoic acid

![Chemical structure of 3 - Methyl - 2 butenoic acid]

15. 3 - Hydroxyproanoic acid

![Chemical structure of 3 - Hydroxyproanoic acid]
**Structural isomerism**: When the isomerism is due to difference in the arrangement of atoms within the molecule, without any reference to space, the phenomenon is called structural isomerism.

In other words, structural isomers are compounds that have the same molecular formula but different structural formulas.

- Structural isomerism is of five types:
  a. Chain isomerism
  b. Position isomerism
  c. Functional isomerism
  d. Metamerism
  e. Toutomerism

**a) Chain isomerism**

Chain isomers have the same molecular formula but differ in the order, in which the carbon atoms are bonded to each other.

Examples:

i) n-Butane and Isobutane

\[
\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_3 \quad \text{CH}_3-\text{CH}-(\text{CH}_3) \quad \text{n-Butane} \quad \text{Isobutane}
\]

ii) 2-Methylbutane and 2, 2-Dimethyl propane

\[
\text{CH}_3-\text{CH}_2-\text{CH}-(\text{CH}_3) \quad \text{CH}_3-\text{C}-(\text{CH}_3) \\
\text{2-Methylbutane} \quad \text{2,2-Dimethyl propane}
\]

**b) Position isomerism**:

Position isomers have the same molecular formula but different in the position of a functional group on the carbon chain.

Examples:

i) 1-Bromobutane and 2-Bromobutane

\[
\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_2\text{Br} \quad \text{CH}_3-\text{CH}-(\text{CH}_2-\text{CH}_3) \\
\text{1-Bromobutane} \quad \text{2-Bromobutane}
\]
ii) n-Propyl alcohol and isopropyl alcohol

\[
\text{CH}_3\text{−CH}_2\text{−CH}_2\text{−OH} \quad \text{CH}_3\text{−CH}\text{−CH}_3
\]

n-Propyl alcohol \hspace{1cm} \text{Isopropyl alcohol}

iii) 1-Butene and 2-Butene

\[
\text{CH}_3\text{−CH}_2\text{−CH}=\text{CH}_2 \quad \text{CH}_3\text{−CH}=\text{CH}−\text{CH}_3
\]

1-Butene \hspace{1cm} 2-Butene

c) **Functional isomerism**

Functional isomers have the same molecular formula but different functional groups.

**Examples:**

i) Ethyl alcohol and Dimethyl ether

\[
\text{CH}_3\text{−CH}_2\text{−OH} \quad \text{CH}_3\text{−O−CH}_3
\]

Ethyl alcohol \hspace{1cm} Dimethyl ether

ii) Acetone and propionaldehyde

\[
\text{CH}_3\text{−C}−\text{CH}_3 \quad \text{CH}_3\text{−CH}_2−\text{C}−\text{H}
\]

Acetone \hspace{1cm} Propionaldehyde

iii) Acetic acid and Methyl formate

\[
\text{CH}_3\text{−C}−\text{O}−\text{H} \quad \text{H}−\text{C}−\text{OCH}_3
\]

Acetic acid \hspace{1cm} Methyl formate

d) **Metamerism**

This type of isomerism is due to the unequal distribution of carbon atoms on either side of the functional group. Members belong to the same homologous series.

**Examples:**

i) Diethyl ether and Methyl propyl ether

\[
\text{CH}_3\text{−CH}_2−\text{O−CH}_2−\text{CH}_3 \quad \text{CH}_3\text{−O−CH}_2−\text{CH}_2−\text{CH}_3
\]

Diethyl ether \hspace{1cm} Methyl propylether
ii) Diethylamine and Methylpropylamine

\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{NHCH}_2\text{CH}_3 & \quad \text{Diethylamine} \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{NHCH}_3 & \quad \text{Methylpropylamine}
\end{align*}
\]

**e) Tautomerism**

It is a special type of functional isomerism in which the isomers are in dynamic equilibrium with each other.

For example, ethyl acetoacetate is an equilibrium mixture of the following two forms. At room temperature, the mixture contains 93% of Keto-form plus 6% of the enol-form.

\[
\begin{align*}
\text{CH}_3\text{C}==\text{CHCO}_2\text{C}_2\text{H}_5 & \quad \text{Keto form} \\
\text{CH}_3\text{C}==\text{CH}\text{CO}_2\text{C}_2\text{H}_5 & \quad \text{Enol form}
\end{align*}
\]