<table>
<thead>
<tr>
<th>Compound</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₄</td>
<td>Methane</td>
</tr>
<tr>
<td>H₃CCH₂CH₂CH₃</td>
<td>n-Butane</td>
</tr>
<tr>
<td>(H₃C)₂CHCH₃</td>
<td>Isobutane</td>
</tr>
<tr>
<td>(H₃C)₄C</td>
<td>Neopentane</td>
</tr>
<tr>
<td>H₃CCH₂CH₂OH</td>
<td>n-Propyl alcohol</td>
</tr>
<tr>
<td>HCHO</td>
<td>Formaldehyde</td>
</tr>
<tr>
<td>(H₃C)₂CO</td>
<td>Acetone</td>
</tr>
<tr>
<td>CHCl₃</td>
<td>Chloroform</td>
</tr>
<tr>
<td>CH₃COOH</td>
<td>Acetic acid</td>
</tr>
<tr>
<td>C₆H₆</td>
<td>Benzene</td>
</tr>
<tr>
<td>C₆H₅OCH₃</td>
<td>Anisole</td>
</tr>
<tr>
<td>C₆H₅NH₂</td>
<td>Aniline</td>
</tr>
<tr>
<td>C₆H₅COCH₃</td>
<td>Acetophenone</td>
</tr>
<tr>
<td>CH₃OCH₂CH₃</td>
<td>Ethyl methyl ether</td>
</tr>
</tbody>
</table>

**The IUPAC System of Nomenclature**

A systematic name of an organic compound is generally derived by identifying the parent hydrocarbon and the functional group(s) attached to it. See the example given below. By further using prefixes and suffixes, the parent name can be modified to obtain the actual name. Compounds containing carbon and hydrogen only are called hydrocarbons. A hydrocarbon is termed saturated if it contains only carbon-carbon single bonds. The IUPAC name for a homologous series of such compounds is alkane. Unsaturated hydrocarbons are those, which contain at least one carbon-carbon double or triple bond.
Straight chain hydrocarbons: The names of such compounds are based on their chain structure, and end with suffix ‘-ane’ and carry a prefix indicating the number of carbon atoms present in the chain (except from CH\textsubscript{4} to C\textsubscript{4}H\textsubscript{10}, where the prefixes are derived from trivial names). The IUPAC names of some straight chain saturated hydrocarbons are given in Table. The alkanes in Table differ from each other by merely the number of -CH\textsubscript{2} groups in the chain. They are homologues of alkane series.

<table>
<thead>
<tr>
<th>Name</th>
<th>Molecular formula</th>
<th>Name</th>
<th>Molecular formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane</td>
<td>CH\textsubscript{4}</td>
<td>Heptane</td>
<td>C\textsubscript{2}H\textsubscript{6}</td>
</tr>
<tr>
<td>Ethane</td>
<td>C\textsubscript{2}H\textsubscript{8}</td>
<td>Octane</td>
<td>C\textsubscript{8}H\textsubscript{18}</td>
</tr>
<tr>
<td>Propane</td>
<td>C\textsubscript{3}H\textsubscript{8}</td>
<td>Nonane</td>
<td>C\textsubscript{9}H\textsubscript{20}</td>
</tr>
<tr>
<td>Butane</td>
<td>C\textsubscript{4}H\textsubscript{10}</td>
<td>Decane</td>
<td>C\textsubscript{10}H\textsubscript{22}</td>
</tr>
<tr>
<td>Pentane</td>
<td>C\textsubscript{5}H\textsubscript{12}</td>
<td>Icosane</td>
<td>C\textsubscript{20}H\textsubscript{42}</td>
</tr>
<tr>
<td>Hexane</td>
<td>C\textsubscript{6}H\textsubscript{14}</td>
<td>Triacontane</td>
<td>C\textsubscript{30}H\textsubscript{62}</td>
</tr>
</tbody>
</table>

Branched chain hydrocarbons:

In a branched chain compound small chains of carbon atoms are attached at one or more carbon atoms of the parent chain. The small carbon chains (branches) are called alkyl groups.

In order to name such compounds, the names of alkyl groups are prefixed to the name of parent alkane. An alkyl group is derived from a saturated hydrocarbon by removing a hydrogen atom from carbon. Thus, CH\textsubscript{4} becomes -CH\textsubscript{3} and is called methyl group. An alkyl group is named by substituting ‘yl’ for ‘ane’ in the corresponding alkane. Some alkyl groups are listed in Table.

**Some Alkyl Groups**

<table>
<thead>
<tr>
<th>Molecular formula</th>
<th>Name of alkane</th>
<th>Structural formula</th>
<th>Name of alkyl group</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH\textsubscript{4}</td>
<td>Methane</td>
<td>CH\textsubscript{3}</td>
<td>Methyl</td>
</tr>
<tr>
<td>C\textsubscript{2}H\textsubscript{6}</td>
<td>Ethane</td>
<td>-CH\textsubscript{2}CH\textsubscript{3}</td>
<td>Ethyl</td>
</tr>
<tr>
<td>C\textsubscript{3}H\textsubscript{8}</td>
<td>Propane</td>
<td>-CH\textsubscript{2}CH\textsubscript{2}CH\textsubscript{3}</td>
<td>Propyl</td>
</tr>
<tr>
<td>C\textsubscript{4}H\textsubscript{10}</td>
<td>Butane</td>
<td>-CH\textsubscript{2}CH\textsubscript{2}CH\textsubscript{2}CH\textsubscript{3}</td>
<td>Butyl</td>
</tr>
<tr>
<td>C\textsubscript{10}H\textsubscript{22}</td>
<td>Decane</td>
<td>-CH\textsubscript{2}(CH\textsubscript{2})\textsubscript{8}CH\textsubscript{3}</td>
<td>Decyl</td>
</tr>
</tbody>
</table>

Abbreviations are used for some alkyl groups. For example, methyl is abbreviated as Me, ethyl as Et, propyl as Pr and butyl as Bu. The alkyl groups can be branched also. Thus, propyl and butyl groups can have
branched structures as shown below.

\[
\begin{align*}
\text{Isopropyl} & : & \text{CH}_3-\text{CH}-\text{CH}_3 \\
\text{sec-Butyl} & : & \text{CH}_3-\text{C}-\text{CH}_2- \\
\text{Isobutyl} & : & \text{CH}_3-\text{C}-\text{CH}_2- \\
\text{tert-Butyl} & : & \text{CH}_3-\text{C}-\text{CH}_2- \\
\text{Neopentyl} & : & \text{CH}_3-\text{C}-\text{CH}_2- \\
\end{align*}
\]

Common branched groups have specific trivial names. For example, the propyl groups can either be n-propyl group or isopropyl group. The branched butyl groups are called sec-butyl, isobutyl and tert-butyl group. We also encounter the structural unit, \(-\text{CH}_2\text{C}((\text{CH}_3)_3)\), which is called neopentyl group.

### Nomenclature of branched chain alkanes:

We encounter a number of branched chain alkanes. The rules for naming them are given below.

- First of all, the longest carbon chain in the molecule is identified. In the example (I) given below, the longest chain has nine carbons and it is considered as the parent or root chain. Selection of parent chain as shown in (II) is not correct because it has only eight carbons.

\[
\begin{align*}
\text{I} & : & \text{CH}_3-\text{CH}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}-\text{CH}_2-\text{CH}_3 \\
& & | \\
& & | \\
& & \text{CH}_3 & \text{CH}_3 \\
\text{II} & : & \text{CH}_3-\text{CH}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}-\text{CH}_2-\text{CH}_3 \\
& & | \\
& & | \\
& & \text{CH}_3 & \text{CH}_3 \\
\end{align*}
\]

- The carbon atoms of the parent chain are numbered to identify the parent alkane and to locate the positions of the carbon atoms at which branching takes place due to the substitution of alkyl group in place of hydrogen atoms. The numbering is done in such a way that the branched carbon atoms get the lowest possible numbers. Thus, the numbering in the above example should be from left to right (branching at carbon atoms 2 and 6) and not from right to left (giving numbers 4 and 8 to the carbon atoms at which
The names of alkyl groups attached as a branch are then prefixed to the name of the parent alkane and position of the substituents is indicated by the appropriate numbers. If different alkyl groups are present, they are listed in alphabetical order. Thus, name for the compound shown above is: 6-ethyl-2-methylnonane. [Note: the numbers are separated from the groups by hyphens and there is no break between methyl and nonane.]

**Basic Example:**

*Write structures of all the alkenes which on hydrogenation give 2-methylbutane.*

**Solution.** Alkenes having the following carbon chain skeleton would give 2-methylbutane on hydrogenation.

Following alkenes are possible for this carbon chain skeleton.

1. \( \text{CH}_3-\text{CH} = \text{CH} = \text{CH}_2 \)
2. \( \text{CH}_3-\text{C} = \text{CH} - \text{CH}_3 \), cis as well as trans
3. \( \text{CH}_2 = \text{C} - \text{CH}_2 - \text{CH}_3 \)

If two or more identical substituent groups are present then the numbers are separated by commas. The names of identical substituents are not repeated, instead prefixes such as di (for 2), tri (for 3), tetra (for 4), penta (for 5), hexa (for 6) etc. are used. While writing the name of the substituents in alphabetical order, these prefixes, however, are not considered. Thus, the following compounds are named as:

- 2,4-Dimethylpentane
- 2,2,4-Trimethylpentane
- 3-Ethyl-4,4-dimethylheptane
• Basic Example: Write IUPAC name

(i) \(\text{CH}_2\text{CHO} \quad \text{Br}\)
(ii) \(\text{CH}_3\text{COCH} \quad \text{CH}_2\quad \text{CH}_2\text{Cl}\)
\(\text{C}_2\text{H}_5\)
(iii) \(\text{CH}_3\quad \text{O} \quad \text{COCH}_3\)
(iv) \(\text{O} \quad \text{CO} \quad \text{C} \quad \text{O} \quad \text{C}\)

Solution. (i) \(\text{Br}\)

2-(2-bromophenyl) ethanal. It can also be named as 2-(o-bromophenyl) ethanal.
(ii) 5-chloro-3-ethyl-2-pentanone.
(iii) 3,5-dimethyl phenyl ethanoate
(iv) Cis-di-isopropyl -2,3-dimethyl -2-buten 1, 4-dioate.

- If the two substituents are found in equivalent positions, the lower number is given to the one coming first in the alphabetical listing. Thus, the following compound is 3-ethyl-6-methyloctane and not 6-ethyl-3-methyloctane.

\[
\begin{array}{cccccccc}
1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \\
\text{CH}_3 & \text{CH}_2 & \text{CH} & \text{CH}_2 & \text{CH}_2 & \text{CH} & \text{CH}_2 & \text{CH}_3 \\
& & & & \text{CH}_2\text{CH}_3 & & \text{CH}_3 \\
\end{array}
\]

- The branched alkyl groups can be named by following the above mentioned procedures. However, the carbon atom of the branch that attaches to the root alkane is numbered 1 as exemplified below.

\[
\begin{array}{ccccccc}
4 & 3 & 2 & 1 \\
\text{CH}_3 & \text{CH} & \text{CH}_2 & \text{CH} & \text{CH}_3 & \text{CH}_3 \\
& & & & \text{CH}_2 & \text{CH}_3 \\
1,3\text{-Dimethylbutyl}
\end{array}
\]

The name of such branched chain alkyl group is placed in parenthesis while naming the compound. While writing the trivial names of substituents’ in alphabetical order, the prefixes iso- and neo- are considered to be
the part of the fundamental name of alkyl group. The prefixes sec- and tert- are not considered to be the part of the fundamental name. The use of iso and related common prefixes for naming alkyl groups is also allowed by the IUPAC nomenclature as long as these are not further substituted. In multisubstituted compounds, the following rules may also be remembered:

- If there happens to be two chains of equal size, then that chain is to be selected which contains more number of side chains.
- After selection of the chain, numbering is to be done from the end closer to the substituent.

\[ 
\text{CH(CH}_3\text{)}_2 \\
\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_3 \\
\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_3 \\
\text{5-sec-Butyl 4-isopropyldecane} \\
\]

\[ 
\begin{array}{c}
\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_3 \\
\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_3 \\
\text{5-(2,2-Dimethylpropyl)nonane} \\
\end{array} \\
\]

Cyclic Compounds:

A saturated monocyclic compound is named by prefixing ‘cyclo’ to the corresponding straight chain alkane. If side chains are present, then the rules given above are applied. Names of some cyclic compounds are
Structures and IUPAC names of some hydrocarbons are given below. Explain why the names given in the parentheses are incorrect.

Solution
(a) Lowest locant number, 2,5,6 is lower than 3,5,7, (b) substituents are in equivalent position; lower number is given to the one that comes first in the name according to alphabetical order.

Nomenclature of Organic Compounds having Functional Group(s)

A functional group, as defined earlier, is an atom or a group of atoms bonded together in a unique manner which is usually the site of chemical reactivity in an organic molecule. Compounds having the same functional group undergo similar reactions. For example, CH₃OH, CH₃CH₂OH, and (CH₃)₂CHOH- all having -OH functional group liberate hydrogen on reaction with sodium metal. The presence of functional groups enables systematisation of organic compounds into different classes. Examples of some functional groups with their prefixes and suffixes along with some examples of organic compounds possessing these are given in Table:

<table>
<thead>
<tr>
<th>Some Functional Groups and Classes of Organic Compounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class of compounds</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Alkanes</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Alkenes</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Alkyenes</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Arenes</td>
</tr>
<tr>
<td>Halides</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Alcohols</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Aldehydes</td>
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<tr>
<td></td>
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<tr>
<td>Ketones</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Nitriles</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Ethers</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Carboxylic acids</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Carboxylate ions</td>
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<tr>
<td></td>
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<tr>
<td>Esters</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Acyl halides</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Amines</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Amides</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
### Nomenclature of Substituted Benzene Compounds

For IUPAC nomenclature of substituted benzene compounds, the substituent is placed as prefix to the word benzene as shown in the following examples. However, common names (written in bracket below) of many substituted benzene compounds are also universally used.

Methylibenzene (Toluene)  
 Methoxybenzene (Anisole)  
 Aminobenzene (Aniline)  
 Nitrobenzene  
 Bromobenzene

If benzene ring is disubstituted, the position of substituents is defined by numbering the carbon atoms of the ring such that the substituents are located at the lowest numbers possible. For example, the compound (b) is
named as 1,3-dibromobenzene and not as 1,5-dibromobenzene.

In the trivial system of nomenclature the terms ortho (o), meta (m) and para (p) are used as prefixes to indicate the relative positions 1,2-, 1,3- and 1,4- respectively. Thus, 1,3-dibromobenzene (b) is named as m-dibromobenzene (meta is abbreviated as m-) and the other isomers of dibromobenzene 1,2-(a) and 1,4-(c), are named as ortho (or just o-) and para (or just p-) dibromobenzene, respectively.

For tri- or higher substituted benzene derivatives, these prefixes cannot be used and the compounds are named by identifying substituent positions on the ring by following the lowest locant rule. In some cases, common name of benzene derivatives is taken as the base compound.

Substituent of the base compound is assigned number1 and then the direction of numbering is chosen such that the next substituent gets the lowest number. The substituents appear in the name in alphabetical order.
Some examples are given below.

1-Chloro-2,4-dinitrobenzene
(not 4-chloro,1,3-dinitrobenzene)

2-Chloro-1-methyl-4-nitrobenzene
(not 4-methyl-5-chloro-nitrobenzene)

2-Chloro-4-methylanisole 4-Ethyl-2-methylaniline

3,4-Dimethylphenol

When a benzene ring is attached to an alkane with a functional group, it is considered as substituent, instead of a parent. The name for benzene as substituent is phenyl (C₆H₅⁻, also abbreviated as Ph).

• Solved Problem:
Write the structural formula of: (a) o-Ethylanisole, (b) p-Nitroaniline, (c) 2,3 - Dibromo -1- phenylpentane, (d) 4-Ethyl-1-fluoro-2-nitrobenzene.

Solution

- (a) o-Ethylanisole
- (b) p-Nitroaniline
- (c) 2,3-Dibromo-1-phenylpentane
- (d) 4-Ethyl-1-fluoro-2-nitrobenzene

Solved Problem:

Write IUPAC name of following

(i) \( \text{CH}_3\text{COCH} - \text{CH}_2\text{CH}_2\text{Cl} \)

(ii) \( \text{CH}_2\text{CHO} \)

(iii) \( \text{CH}_2\text{COO} \)

(iv) \( \text{CH}_3\text{CHO} \)

(v) \( \text{CH}_3\text{CO-CH-CH-CH}_{2}\text{Cl} \)

Solution. (i) 5-chloro-3-ethyl pentan-2-one
(ii) 2-(2-bromophenyl) ethanal.
(iii) Phenyl-2-(phenyl) ethanoate
(iv) 2-phenyl propanal
(v) 5-chloro-3-methyl pentan-2-one

Solved Problem:
Give structures and IUPAC names of all the open chain structural isomers having molecular formula $C_4H_{10}O$.

**Solution.**

1. CH$_3$CH$_2$CH$_2$CH$_2$OH
   - Butan-1-ol

2. CH$_3$CH$_2$CH CH$_3$
   - Butan-2-ol

3. CH$_3$–CH–CH$_2$OH
   - 2-Methylpropan-1-ol

4. CH$_3$–C–OH
   - 2-Methylpropan-2-ol

5. CH$_3$CH$_2$O–CH$_2$CH$_3$
   - Ethoxyethane

6. CH$_3$CH$_2$CH$_2$O–CH$_3$
   - 1-Methoxypropane

7. CH$_3$–CH–CH$_3$
   - 2-Methoxypropane

- Solved Problem: Draw the structure of following compounds

(a) 3-Methylbutanal  
(b) p-Methylbenzaldehyde  
(c) 4-Chloropentan-2-one  
(d) p,p-Dihydroxybenzophenone  
(e) p-Nitropropiophenone

**Solution.** The correct structures are:

(a) \[
\text{CH}_3 - \text{CH} = \text{CH}_2 - \text{C} = \text{H}
\]

(b) \[
\text{H}_3\text{C} - \text{O} \text{C} = \text{H}
\]

(c) \[
\text{CH}_3 - \text{C} = \text{CH}_2 - \text{CH} - \text{CH}_3
\]

(d) \[
\text{HO} - \text{C} = \text{C} \text{H}_2 - \text{OH}
\]

(e) \[
\text{O}_2\text{N} - \text{C} = \text{CH}_2\text{CH}_3
\]
Solved Problem: Draw the structure of the following:

(a) 2, 4-Dimethylpentanoyl chloride
(b) Formic acetic anhydride
(c) Methyl 1-methylcyclohexanecarboxylate
(d) N-Ethyl-N-methylbenzamide
(e) N, 2-Dimethylpropanamide

Solution. (a) \[ \text{CH}_3 - \text{CH} - \text{CH}_2 - \text{CH} - \text{C} = \text{Cl} \]

(b) \[ \text{H} - \text{C} = \text{O} - \text{C} - \text{CH}_3 \]

(c) \[ \text{CH}_3 \text{COOCH}_3 \]

(d) \[ \text{H}_2\text{C} = \text{CH} - \text{C} = \text{N} - \text{CH}_3 \]

(e) \[ \text{CH}_3 - \text{CH} - \text{C} = \text{NHCH}_3 \]

Solved Problem: Write the IUPAC name of the following:

(a) \[ \text{OH} \]

(b) \[ \text{NH}_2 \text{CO}_2\text{H} \]

(c) \[ \text{H} - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{OCH}_3 \]

(d) \[ \text{CN} \]

(e) \[ \text{Ph} \text{O} - \text{O} - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CO}_2\text{H} \]
Solution. (a) 4-Hydroxy cyclo hex-2-one.
(b) 2-Amino pent-3-en-1-0ic acid
(c) Methyl 5-oxo pentanoate
(d) 3-Aldo benzene carbonitrile
(e) Isopropyl 3-keto-4-phenyl hexanoate

Solved Problem: Write the IUPAC name of the following

(a) \(\text{CH}_3\text{CH(CH}_3\text{)}_2\text{CH}_2\text{CHO}\)
(b) \(\text{CH}_3\text{CH} = \text{CHCHO}\)
(c) \(\text{CH}_3\text{CH(CH}_3\text{)}_2\text{CH}_2\text{C(CH}_3\text{)}_2\text{COCH}_3\)
(d) \(\text{OHCC}_6\text{H}_4\text{CHO-p}\)
(e) \(\text{CH}_3\text{CH}_2\text{COCH(C}_2\text{H}_5\text{)}\text{CH}_2\text{CH}_2\text{Cl}\)