ORGANIC CHEMISTRY

INTRODUCTION

Organic compounds are those which are derived or originated from plants or animals i.e. from living beings and the chemistry of organic compounds is called organic chemistry. On the contrary, the substances derived from non-living matter like the metals and minerals are called inorganic substances. Urea, excreted in the urine of living beings is an organic matter while limestone, available as a mineral in rocks is an inorganic substance whose composition is calcium carbonate. The above definition of organic chemistry although proved elegant in the 18th century was however rejected in 1828 when Friedrich Wohler prepared (synthesised) the organic compound, urea in his laboratory by boiling ammonium cyanate (an inorganic compound) with water.

\[
\text{NH}_4\text{OCN} \xrightarrow{\Delta} \text{H}_2\text{O} \rightarrow \text{H}_2\text{NCONH}_2
\]

After this great discovery, the definition of organic compounds and hence organic chemistry were changed. Organic compounds may not always be obtained from the living substances, it could as well be synthesised in the laboratories. The only requirement was that the compound should be either identical or similar to the compounds derived from living beings. Organic compounds were then defined simply as the compounds of carbon. Of course, a few compounds of carbon like carbonates, carbides, cyanides etc. were excluded from the organic list because of their connection with inorganic minerals. During the last century, countless organic compounds have been synthesised in laboratories. They range from simple compound like urea to very complex compounds like alkaloids, steroids, vitamins and many others. Organic chemists have not only mimicked the nature by synthesising the natural compounds in the laboratory but also have synthesised innumerable other compounds which do not occur in nature and which are highly essential for the modern man such as medicines, drugs, solvents, plastics, rubber, fabrics and what not? Do you know, the starting materials from which these vast range of organic compounds are synthesised? They are petroleum oil and natural gas which are present in the oil wells. Now you can guess why Arabian countries are so rich although they have so much of desert. Petroleum oil and gas contain organic compounds called hydrocarbons. Then the question arises, what are these hydrocarbons? Hydrocarbons are compounds of two elements, hydrogen and carbon combined in different proportions. The enormous variety of other organic compounds which are now being synthesised are all obtained from these hydrocarbons. We can now redefine organic chemistry as the chemistry of hydrocarbons and their derivatives. Derivatives of a compound are the compounds which are derived or synthesized from the parent compound.
When two elements A and B can be linked or attached with each other by covalent bonds, they can do so in three ways.

(i) **Single bond**: represented by a single dash: \( \text{A} - \text{B} \)

(ii) **Double bond**: represented by double dash (two dashes kept parallel to each other)

\( \text{A} \equiv \text{B} \)

(iii) **Triple bond** represented by a triple dash (three dashes kept parallel to each other)

\( \text{A} \equiv \equiv \text{B} \).

We know that each "dash" or covalent bond is composed of two electrons contributed one each by the bonded atoms.

**Carbon atom has a valency of four.** Carbon has an atomic number 6. Its valency is 4. This means that carbon atom is connected with four covalent bonds or dashes belonging to the following possibilities.

(i) **Four single bonds**: \( \text{C} \)

(ii) **One double bond and two single bonds**: \( \text{C} \equiv \)

(iii) **One triple bond and one single bond**: \( \equiv \text{C} \equiv \)

(iv) **Two double bonds**: \( \equiv \text{C} \equiv \)

So, we find that in all the cases carbon atom has to be connected with four covalent bonds or dashes irrespective of whether by four single bonds OR two single bonds and one double bond OR one single and one triple OR two double bonds. A beginner in organic chemistry is advised to count the number of dashes connected to each carbon atom of an organic structure. **If the number of dashes connected to a carbon atom is other than four, it is wrong.**

**UNIQUE PROPERTY OF CARBON:**

**CATENATION:**

Carbon shows a special property called catenation. This is a property by which carbon atoms are linked to one another repeatedly by single bonds to form a chain. Carbon shows high degree of catenation.

\[ \text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \]

This repetition can continue to a very large number of carbon atoms, sometimes exceeding one thousand carbon atoms in case of substances called polymers. Broadly, the organic compounds can be divided into two types.

(A) Aliphatic or open chain or acyclic compounds

(B) Cyclic or ring compounds
**Nomenclature of Organic Compounds**

(A) **ALIPHATIC OR OPEN CHAIN OR ACYCLIC COMPOUNDS**

Aliphatic compounds have two open ends or terminals in its structure as shown.

```
\[
\text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C}
\]
```

These compounds are obtained from the petroleum oil and gas.

(B) **CYCLIC OR RING COMPOUNDS**

Cyclic or ring compounds do not have open ends like the aliphatic compounds. The carbon atoms are connected with each other forming a cycle or a ring as follows.

There are two major types of cyclic compounds namely

(a) homocyclic or carbocyclic  
(b) heterocyclic

(a) **HOMOCYCLIC OR CARBOCYCLIC COMPOUNDS:**

If all the atoms present in the main chain of the ring are carbon atoms, it is called a homocyclic or carbocyclic ring. Carbocyclic compounds are further divided into two types.

(i) **Aromatic compounds**  
(ii) **Alicyclic compounds**

(i) **Aromatic compounds** are compounds of aromatic hydrocarbons, the simplest of which is **benzene**. Benzene is a ring of six carbon atoms with alternate carbon-carbon single and double bonds. Each carbon is attached to one hydrogen atom.

```
\[
\text{H} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{H}
\]
```

(benzene)

(ii) **Alicyclic compounds** are cyclic compounds which resemble aliphatic compounds. Each carbon atom is attached with two hydrogen atoms in an alicyclic ring.

```
\[
\text{CH}_2 - \text{CH}_2  \\
\text{CH}_2 - \text{CH}_2  \\
\text{CH}_2 - \text{CH}_2  \\
\text{CH}_2
\]
```
cyclopropane  
```
\[
\text{CH}_2 - \text{CH}_2  \\
\text{CH}_2 - \text{CH}_2  \\
\text{CH}_2 - \text{CH}_2  \\
\text{CH}_2 - \text{CH}_2  \\
\text{CH}_2
\]
```
cyclobutane  
```
\[
\text{CH}_2 - \text{CH}_2  \\
\text{CH}_2 - \text{CH}_2  \\
\text{CH}_2 - \text{CH}_2  \\
\text{CH}_2 - \text{CH}_2  \\
\text{CH}_2 - \text{CH}_2
\]
```
cyclopentane  
```
\[
\text{CH}_2 - \text{CH}_2  \\
\text{CH}_2 - \text{CH}_2  \\
\text{CH}_2 - \text{CH}_2  \\
\text{CH}_2 - \text{CH}_2  \\
\text{CH}_2 - \text{CH}_2
\]
```
cyclohexane

(b) **HETEROCYCLIC COMPOUNDS:**

If one or more atoms present in the main chain of the ring are atoms other than carbon atom (such as N, O, S etc.) and all other atoms are carbon atoms, it is called a heterocyclic compound.

```
\[
\text{CH} - \text{N} - \text{H}
\]
```
pyrrole  
```
\[
\text{CH} - \text{N} - \text{CH}
\]
```
pyridine  
```
\[
\text{CH} - \text{O}
\]
```
furan  
```
\[
\text{CH} - \text{S}
\]
```
thiophene  
```
\[
\text{CH}_2 - \text{CH}_2
\]
```
oxirane
There are nine main varieties or classes of aliphatic compounds which are listed below.

1. hydrocarbons
2. halogenated hydrocarbons
3. alcohols
4. ketones
5. aldehydes
6. carboxylic acids
7. derivatives of carboxylic acids
   (a) esters
   (b) acid amides
   (c) acid halides
   (d) salts of carboxylic acid
   (e) acid anhydrides
   (f) alkanenitriles (alkyl cyanides)
8. ethers
9. amines
10. nitrohydrocarbons (nitroalkanes)

In this chapter an introduction of these nine classes of aliphatic compounds will be made to a beginner who will be acquainting with their structures and basic names. The names are given according to IUPAC (International Union for Pure and Applied Chemistry) rules. IUPAC is an international organization which formulates rules for naming chemical compounds.

1. **HYDROCARBONS:**
   From the very name hydrocarbon one can guess that these are the compounds which contain only hydrogen and carbon. Many of these are available in nature in the petroleum oil and gas. Hydrocarbons again are of two types.
   (a) saturated hydrocarbons (alkanes or paraffins)
   (b) unsaturated hydrocarbons

(A) **SATURATED HYDROCARBONS (ALKANES)**
These were formerly called paraffins. These compounds have only single bonds in their structures.

<table>
<thead>
<tr>
<th>Structural formula</th>
<th>Condensed Structural formula</th>
<th>Molecular Formula</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₄</td>
<td>CH₄</td>
<td>C₄H₁₀</td>
<td>methane</td>
</tr>
<tr>
<td>CH₃–CH₃</td>
<td>C₂H₆</td>
<td>ethane</td>
<td></td>
</tr>
<tr>
<td>CH₃–CH₂–CH₃</td>
<td>C₃H₈</td>
<td>propane</td>
<td></td>
</tr>
<tr>
<td>CH₃–CH₂–CH₂–CH₃</td>
<td>C₄H₁₀</td>
<td>butane</td>
<td></td>
</tr>
</tbody>
</table>

and so on...
You are now required to write similar structures for higher alkanes containing 5, 6, 7, 8, 9, 10 and more number of carbon atoms and name them as pentane($C_5$), hexane($C_6$), heptane($C_7$), octane($C_8$), nonane($C_9$), decane($C_{10}$) and so on respectively. In all these structures, each carbon atom is attached to four single bonds. Keep on writing the structural formula as well as the condensed structural formula like those given in the first and second columns of the above table. After a few practice sessions you can stop writing the structural formula (showing all the bonds) and only write the condensed structural formula showing only the C-C bonds such as

$$
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3
$$

Never write the molecular formulae like $C_4H_{10}$ while representing a structure. Remember that in the condensed structural formula suggested above, customarily hydrogen(H) atoms are placed at the right or left side of carbon(C). Only the C-C bonds are shown (not the C-H bonds) so that the structure looks clean.

**Root words for aliphatic compounds:**

All organic compounds start with a root word which indicates the number of carbon atoms in the longest continuous chain of carbon atoms in the molecule. Thus, the root name is a code which tells the number of carbon atoms.

**Root names in the IUPAC nomenclature system.**

<table>
<thead>
<tr>
<th>No. of Carbon Atoms</th>
<th>Root Name</th>
<th>No. of Carbon Atoms</th>
<th>Root Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>meth</td>
<td>12</td>
<td>dodec</td>
</tr>
<tr>
<td>2</td>
<td>eth</td>
<td>13</td>
<td>tridec</td>
</tr>
<tr>
<td>3</td>
<td>prop</td>
<td>14</td>
<td>tetradec</td>
</tr>
<tr>
<td>4</td>
<td>but</td>
<td>15</td>
<td>pentadec</td>
</tr>
<tr>
<td>5</td>
<td>pent</td>
<td>20</td>
<td>icos</td>
</tr>
<tr>
<td>6</td>
<td>hex</td>
<td>21</td>
<td>henicos</td>
</tr>
<tr>
<td>7</td>
<td>hept</td>
<td>22</td>
<td>docos</td>
</tr>
<tr>
<td>8</td>
<td>oct</td>
<td>30</td>
<td>triacont</td>
</tr>
<tr>
<td>9</td>
<td>non</td>
<td>31</td>
<td>hentriacont</td>
</tr>
<tr>
<td>10</td>
<td>dec</td>
<td>40</td>
<td>tetracont</td>
</tr>
<tr>
<td>11</td>
<td>undec</td>
<td>50</td>
<td>pentacont</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100</td>
<td>hectane</td>
</tr>
</tbody>
</table>

**SUFFIX:**

If the suffix -ane is attached to the root word we get the name of alkane.

**Example:** The name of alkanes having the number of carbon atoms in the chain written against their names are

- nonane - $C_9$
- undecane - $C_{11}$
- icosane - $C_{20}$

For other classes of aliphatic compounds the suffixes are different.

**General Formula of Alkanes:** $C_nH_{2n+2}$

where $n$ is whole number 1, 2, 3 and so on. But you never give any importance to the general formula and always write the carbon chain (skeleton) first, then attach the required number of hydrogen atoms to each carbon atom. While doing so, do not forget that each carbon
has a valency equal to four i.e the number of bonds connected to each carbon should be four. A C-C single bond is counted for both the carbon atoms sharing a common bond between them. Let us take the skeleton as follows: \[ \text{C-C-C} \]

In order to make the valency four, the first carbon atom in the left needs three H atoms, second(middle) carbon atom needs two and last atom in the right needs three H atoms. So by placing the required number of H atoms we get the condensed structural formula. If we connect the H atoms by single bonds then we get the structural formula.

\[
\text{CH}_3 \text{CH}_2 \text{CH}_3 \quad \text{(condensed structural formula)} \quad \text{H-C-CH} = \text{H} \quad \text{(structural formula)}
\]

You also see here that the terminal carbon atoms(first and last) will always be \( \text{CH}_3 \) while all the internal carbon atoms will be \( \text{CH}_2 \) in simple(unbranched) alkanes.

<table>
<thead>
<tr>
<th>SAQ I.1</th>
<th>Draw the structural formula and also the condensed structural formula of the following compounds whose carbon chains have been given. Also name the alkanes. In bit (d) there is only one carbon atom(not a chain).</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)C-C-C-C</td>
<td>(b)C-C-C-C-C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SAQ I.2</th>
<th>Point out the mistakes in the following structures. Correct them also.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>(b)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SAQ I.3</th>
<th>Write down the structural, condensed structural formula and molecular formula for the following.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)nonane</td>
<td>(b)ethane</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SAQ I.4</th>
<th>Write the molecular formula of the following</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)heptane</td>
<td>(b)propane</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SAQ I.5</th>
<th>Write the names of the alkanes having the following numbers of carbon atoms in the continuous chain.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)C-12</td>
<td>(b)C-7</td>
</tr>
</tbody>
</table>

**LINE DRAWINGS OF ALKANES**

- **CH\textsubscript{4}** methane
- **CH\textsubscript{3}-CH\textsubscript{3}** ethane
- **CH\textsubscript{3}** propane
- **CH\textsubscript{2}** butane
- **pentane**
- **hexane**
- **heptane**
- **octane**
- **nonane**
- **decane**
Nomenclature of Organic Compounds

Excepting methane and ethane which do not have line drawings, the alkanes from propane onwards can be conveniently shown by line drawings. A line structure consists of a series of zig-zag lines connected with each other. The two terminal points and the bent points at which two lines meet carry one carbon atom each. Each carbon atom is attached with required number of H atoms to make it tetravalent. The C and H atoms are not shown in these drawings.

For example, in butane, the two terminal positions carry one carbon atom each and two internal bent points (where lines meet) also carry one carbon atom each. Each carbon is attached with required number of H atoms— the terminal carbons with 3 H atoms each and the internal carbons with 2 H atoms each.

To save time, you can write the line drawings of organic molecules instead of their structural formula.

**CAUTION**: The students are advised not to write the line drawings of any organic molecule in the examinations. They should convert the line structure to the condensed structural formula by placing carbon atoms at each terminal points and bent points and attaching required number of H atoms.

**SAQ I.6**: Draw the line drawings of the following alkanes.

(a) pentane  (b) undecane  (c) propane  (d) ethane

(B) UNSATURATED HYDROCARBONS:

This class of aliphatic organic compounds has two sub classes.

(i) alkenes or olefins   and   (ii) alkynes or acetylenes

(I) ALKENES OR OLEFINS:

If the hydrocarbon contains one C=C (carbon carbon double bond) and rest are single bonds, it is called an alkene, formerly called olefin. The first member of the alkene family must contain two carbon atoms. The following table gives the conceptual picture of the individual alkenes. Remember that the H atoms are connected to the carbon atoms by single bonds and each carbon atom has to satisfy a valency of four including the carbon-carbon double bond. The name of the alkene is obtained by using the suffix *ene* in the root *alk* in stead of *ane*.

<table>
<thead>
<tr>
<th>Structure formula</th>
<th>Condensed Structural Formula</th>
<th>Molecular Formula</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>H(=)C(=)H</td>
<td>CH(_2)(=)CH(_2)</td>
<td>C(_2)H(_4)</td>
<td>ethene or ethylene</td>
</tr>
<tr>
<td>H(=)C(=)H</td>
<td>CH(_3)(=)CH(_3)</td>
<td>C(_3)H(_6)</td>
<td>propene</td>
</tr>
<tr>
<td>H(=)C(=)H</td>
<td>CH(_2)(=)CH(_2)(=)CH(_3)</td>
<td>C(_4)H(_8)</td>
<td>butene</td>
</tr>
<tr>
<td>and so on.........</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The reader is advised to draw similar structures for alkenes containing more carbon atoms like five (pentene), six (hexene), seven (heptene), eight (octene), nine (nonene), ten (decene) and so on. Note that 'ethylene' is the preferred IUPAC name for $\text{C}_2\text{H}_4$ although it is traditional in origin. Remember that you can put a double bond between any two adjacent carbon atoms and not necessarily always between the first and second carbon atoms as given in the above table which has been given only for the sake of simplicity. The basic name of alkene will be same wherever be the position of C=C. But their specific names will be different. This aspect of naming will be taken up in the next chapter.

**General formula for alkenes**: $\text{C}_n\text{H}_{2n}$

### Line Drawings of Alkenes:

Like alkanes, alkenes can also be conveniently represented by line drawings. Some examples are given below.

\[
\text{propene} \quad \text{pentene} \quad \text{butene}
\]

<table>
<thead>
<tr>
<th>SAQ I.7:</th>
<th>Attach the required number of H atoms and write the structural and condensed structural formula of the following. Also give the basic names of each alkene.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) C-C=C</td>
<td>(b) C-C=C-C</td>
</tr>
<tr>
<td>(e)</td>
<td><img src="image" alt="Line drawing for SAQ I.7 (e)" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SAQ I.8:</th>
<th>Correct the following structures. Also give their basic names.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td><img src="image" alt="Line drawing for SAQ I.8 (a)" /></td>
</tr>
<tr>
<td>(b)</td>
<td><img src="image" alt="Line drawing for SAQ I.8 (b)" /></td>
</tr>
<tr>
<td>(c)</td>
<td><img src="image" alt="Line drawing for SAQ I.8 (c)" /></td>
</tr>
<tr>
<td>(d) $\text{CH}_3=\text{CH}_3$</td>
<td><img src="image" alt="Line drawing for SAQ I.8 (d)" /></td>
</tr>
</tbody>
</table>

| SAQ I.9: | An alkene has 8 carbon atoms. What will be its formula? Does an alkene having formula $\text{CH}_2$ exist? Explain. |

### (II) ALKYNES OR ACETYLENES:

If the unsaturated hydrocarbon contains one $\text{C}≡\text{C}$ (triple bond) and the rest single bonds, it is called an alkyne. The name of the alkyne is obtained by using the suffix *yne* with the root word *alk* in stead of *ane* or *ene*. Obviously, the first member of the alkyne family must contain two carbon atoms. This is called *ethyne* or *acetylene* from which all other alkynes can be obtained. Look at the following table.
### Nomenclature of Organic Compounds

<table>
<thead>
<tr>
<th>Structural formula</th>
<th>Condensed Structural formula</th>
<th>Molecular Formula</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>H(\equiv)C(\equiv)C(\equiv)H</td>
<td>CH(\equiv)CH</td>
<td>C(_2)H(_2)</td>
<td>ethyne or acetylene</td>
</tr>
<tr>
<td>H(\equiv)C(\equiv)C(\equiv)CH(\equiv)C(\equiv)H</td>
<td>CH(\equiv)CH(_3)</td>
<td>C(_3)H(_4)</td>
<td>propyne</td>
</tr>
<tr>
<td>H(\equiv)C(\equiv)C(\equiv)CH(\equiv)CH(\equiv)H</td>
<td>CH(\equiv)CH(_2)(\equiv)CH(_3)</td>
<td>C(_4)H(_6)</td>
<td>butyne</td>
</tr>
</tbody>
</table>

and so on...........

The reader is advised to build up similar structures for alkynes containing five(pentyne), six(hexyne),seven(septyne), eight(octyne), nine(nonyne), ten(decyne) carbon atoms and so on by placing the triple bond at any position as the basic name of alkyne does not change by changing the position of triple bond. Note that acetylene is the preferred IUPAC name for C\(_2\)H\(_2\) although it is traditional in origin. In all the structures that you write, every time ensure that the valency(number of bonds) of each carbon atom including the triple bond is four.

**General Formula for Alkynes:** C\(_n\)H\(_{2n-2}\)

### SAQ I.10
Write the structural, condensed structural formula and basic names from the following carbon chain skeletons.

(a) C\(\equiv\)C\(\equiv\)C\(\equiv\)C

(b) C\(\equiv\)C\(\equiv\)C

(c) C\(\equiv\)C\(\equiv\)C\(\equiv\)C

### SAQ I.11
Correct the following structures and give the basic names of each.

(a) H\(\equiv\)C\(\equiv\)C\(\equiv\)C\(\equiv\)H

(b) H\(\equiv\)C\(\equiv\)C\(\equiv\)C\(\equiv\)H

(c) CH\(\equiv\)CH\(\equiv\)CH\(\equiv\)CH\(\equiv\)CH\(_2\)

### 2. HALOGENATED HYDROCARBONS

Fluorine(F), Chlorine(Cl),Bromine(Br) and Iodine(I) are commonly called halogens(represented by general symbol X). If one hydrogen atom of a hydrocarbon(alkane, alkene or alkyne) is substituted by one halogen atom, the resulting compound is called a halogenated hydrocarbon(i.e. a haloalkane, haloalkene or a haloalkyne as the case may be). We shall study only about haloalkanes now.
**Haloalkanes**:

Haloalkanes are commonly called *alkyl halides*.

<table>
<thead>
<tr>
<th>Structural formula</th>
<th>Condensed Structural formula</th>
<th>Molecular Formula</th>
<th>Name</th>
</tr>
</thead>
</table>
| \[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{Cl}
\end{array}
\] | \[
\text{CH}_3\text{Cl}
\] | \[
\text{CH}_3\text{Cl}
\] | chloromethane |
| \[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{Br}
\end{array}
\] | \[
\text{CH}_3\text{CH}_2\text{Br}
\] | \[
\text{C}_2\text{H}_5\text{Br}
\] | bromoethane |
| \[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H}
\end{array}
\] | \[
\text{CH}_3\text{CH}_2\text{CH}_2\text{I}
\] | \[
\text{C}_3\text{H}_7\text{I}
\] | iodopropane |

and so on........

The readers are advised to write similar structures of haloalkanes with greater number of carbon atoms than three. Bear it in mind that you can substitute any hydrogen of the alkane by halogen atom, not necessarily the terminal (extreme right) H atom as done in the above table for the sake of simplicity. The basic names will remain the same irrespective of the position of halogen. The word halo (fluoro, chloro, bromo, iodo) should be prefixed to the name of the alkane. The SAQs below will give more clarification on this point.

**SAQ I.12**: Write down the condensed structural formula and give the basic names of the following haloalkanes.

(a) \[
\begin{array}{c}
\text{Br}
\end{array}
\] (b) \[
\begin{array}{c}
\text{H} \\
\text{Br}
\end{array}
\] (c) \[
\begin{array}{c}
\text{C} \\
\text{F}
\end{array}
\] (d) \[
\begin{array}{c}
\text{Cl}
\end{array}
\]

**SAQ I.13**: Write down the structures of the following

(a) iodomethane  (b) fluorobutane  (c) chlorohexane  (d) bromopentane

**3. ALCOHOLS**:

We know that -OH group is called the *hydroxyl* group and when one -OH group substitutes one H atom of an alkane we get simple alcohols.

\[
\begin{array}{c}
\text{H} \\
\text{C} \\
\text{H}
\end{array}
\] alkane

\[
\begin{array}{c}
\text{H} \\
\text{C} \\
\text{OH}
\end{array}
\] alcohol

The IUPAC name of alcohol is obtained by replacing 'e' of alkane by 'ol', i.e. *alkanol*.

It may be remembered here that the hydroxyl group (-OH) can substitute any H atom of the alkane and not necessarily the extreme right H as shown in the following table.
Nomenclature of Organic Compounds

<table>
<thead>
<tr>
<th>Structural formula</th>
<th>Condensed Structural formula</th>
<th>Molecular Formula</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CH₃—OH</td>
<td>CH₄O</td>
<td>methanol</td>
</tr>
<tr>
<td></td>
<td>CH₃—CH₂—OH</td>
<td>C₂H₆O</td>
<td>ethanol</td>
</tr>
<tr>
<td></td>
<td>CH₃—CH₂—CH₂—OH</td>
<td>C₃H₈O</td>
<td>propanol</td>
</tr>
</tbody>
</table>

You practise the structures of alcohols containing four (butanol), five (pentanol), six (hexanol), seven (heptanol), eight (octanol), nine (nonanol) and ten (decanol) carbon atoms. Place -OH group anywhere you like at this stage and accordingly adjust H atoms. The basic names alcohols will remain the same irrespective of the position of the -OH group.

**General Formula for alcohols:** CₙH₂ₙ₊₂O

**SAQ I.14:** Write the complete structure and basic names for the following skeletons.

(a) HO-C-C  (b) \(\text{OH} \quad \text{C} \rightarrow \text{C} \)  (c) C-C-C-C-C-C-OH  (d) HO-C-C-C-C

**SAQ I.15:** Correct the following.

(a) H—C—C—O—H  (b) H—O—C—H

**PRIMARY AND SECONDARY SUFFIXES**

The root word for all aliphatic compounds is 'alk'. There are two types of suffixes which follow the root word.

(a) **primary suffix**:

'ane' used for saturated hydrocarbons.
'ene' used for unsaturated hydrocarbons containing C=C.
'yne' used for unsaturated hydrocarbons containing \(\text{C} \equiv \text{C}\).

Primary suffix is used after the root word.

alk + ane = alkane;    alk + ene = alkene;    alk + yne = alkyne
(b) secondary suffix:

Secondary suffix is used after the primary suffix (ane, ene and yne) for compounds containing functional groups such as -OH, -CO-, -CHO, -COOH etc. The last letter 'e' of the primary suffix (ane, ene and yne) is omitted when it faces a vowel in the secondary suffix. The vowels considered for the purpose are a, y, i, o, u. The letter 'y' is taken as vowel in place of 'e'. This last letter 'e' is not omitted when it faces a consonant.

Example:

**Alcohol:** \[\text{alk} + \text{ane} + \text{ol} = \text{alkanol}\]

**Alkanenitrile:** \[\text{alk} + \text{ane} + \text{nitrile} = \text{alkanenitrile}\]

The following table gives the secondary suffixes used for different functional groups.

<table>
<thead>
<tr>
<th>Class of Compound</th>
<th>Functional Group</th>
<th>Secondary Suffix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td>OH</td>
<td>ol</td>
</tr>
<tr>
<td>Aldehyde</td>
<td>C=H</td>
<td>al</td>
</tr>
<tr>
<td>Ketone</td>
<td>CO</td>
<td>one</td>
</tr>
<tr>
<td>Carboxylic acid</td>
<td>COOH</td>
<td>oic acid</td>
</tr>
<tr>
<td>Ester</td>
<td>C=OR'</td>
<td>oate</td>
</tr>
<tr>
<td>Acid amide</td>
<td>C=NH₂</td>
<td>amide</td>
</tr>
<tr>
<td>Acid chloride</td>
<td>C=Cl</td>
<td>oyl chloride</td>
</tr>
<tr>
<td>Alkanenitrile</td>
<td>CN</td>
<td>nitrile</td>
</tr>
</tbody>
</table>

**Ketone:** \[\text{alk} + \text{ane} + \text{one} = \text{alkanone}\]; **Aldehyde:** \[\text{alk} + \text{ane} + \text{al} = \text{alkanal}\]

**Carboxylic acid:** \[\text{alk} + \text{ane} + \text{oic acid} = \text{alkanoic acid}\]; **Ester:** \[\text{alk} + \text{one} + \text{oate} = \text{alkanoate}\]; **Acid amide:** \[\text{alk} + \text{ane} + \text{amide} = \text{alkanamide}\]

**Acid chloride:** \[\text{alk} + \text{ane} + \text{oyl chloride} = \text{alkanoyl chloride}\]

In all these cases the last letter 'e' of the primary suffix has been omitted as it faces a vowel. However in alkanenitrile the letter 'e' has not been omitted as it faces a consonant. All these things will be more clear when you read the individual classes of compounds below.

**HOMOLOGOUS SERIES:** Compounds belonging to the same organic class in which each member differs from the previous lower member by a CH₄ unit (14 mass units) form a homologous series. For example: \(\text{CH}_4, \text{CH}_3\text{CH}_3, \text{CH}_2\text{CH}_2\text{CH}_3, \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3\) and so on form a homologous series of alkanes. Similarly homologous series for alkenes, alkynes, alcohols, ketones etc. can be obtained.
Nomenclature of Organic Compounds

4. KETONES:
The group is called a carbonyl group in which a divalent oxygen atom is connected to the carbon atom by a double bond. Carbonyl group is divalent which means that two free single bonds are available to bond with other atoms or groups. A ketone is formed when two H atoms attached to one internal carbon atom of an alkane are replaced by one divalent oxygen atom.

\[ \text{Replaced by one Oxygen} \]

In other words, a ketone contains carbon atoms on either side of the carbonyl(C=O) group.

\[ R - C - R' \]

The IUPAC name of ketone is ALKANONE, the 'e' of alkane being replaced by 'one' to name a ketone (alk + ane + one).

General Formula: \( C_nH_{2n}O \)

Remember that in a ketone the carbony group (\( \text{O} \)) cannot remain at the terminal (i.e. first or last) position. It will always remain anywhere inside the carbon chain (in an internal position). Hence, the first member of the ketone family must contain three carbon atoms. The convenient method to write the structure of a ketone is to draw the carbon skeleton and put an oxygen atom above an internal carbon atom and connect the two (C and O) with a double bond. Then attach the required number of H atoms with other carbon atoms to build the structure of the ketone. The following table will give a better idea on ketones.

<table>
<thead>
<tr>
<th>Structural formula</th>
<th>Condensed Structural Formula</th>
<th>Molecular Formula</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>( H - C - C - C - H )</td>
<td>( \text{CH}_3 - \text{CH}_3 )</td>
<td>( C_3H_6O )</td>
<td>propanone / acetone</td>
</tr>
<tr>
<td>( H - C - C - C - H )</td>
<td>( \text{CH}_3 - \text{CH}_2 - \text{CH}_3 )</td>
<td>( C_4H_8O )</td>
<td>butanone</td>
</tr>
<tr>
<td>( H - C - C - C - H )</td>
<td>( \text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 )</td>
<td>( C_5H_{10}O )</td>
<td>pentanone</td>
</tr>
</tbody>
</table>

and so on........
Practise the structures of ketones containing six(hexanone), seven(heptanone), eight(octanone), nine(nonanone), ten(decanone) carbon atoms. Keep the carbonyl group(C=O) at any internal position(not necessarily the second carbon atom always)  and draw the structures.

**SAQ I.16:** Write down the condensed structural formula and basic names of the ketones from the following skeletons.

(a) \( \text{C} \equiv \text{C} \equiv \text{C} \equiv \text{C} \equiv \text{O} \)  
(b) \( \text{C} \equiv \text{C} \equiv \text{C} \equiv \text{C} \equiv \text{O} \)

(c) \( \text{C} \equiv \text{C} \equiv \text{C} \equiv \text{C} \equiv \text{C} \equiv \text{C} \equiv \text{C} \equiv \text{O} \)

**SAQ I.17:** Are the following structures represent ketones, if not why?

(a) \( \text{H} \equiv \text{H} \equiv \text{H} \equiv \text{O} \equiv \text{C} \equiv \text{H} \)
(b) \( \text{H} \equiv \text{H} \equiv \text{H} \equiv \text{H} \equiv \text{H} \equiv \text{O} \equiv \text{C} \equiv \text{H} \)

**SAQ I.18:** Write down the condensed structural formula of the following. Place the carbonyl group at any internal position you like.

(a) hexanone (b)propanone (c)heptanone

5. ALDEHYDES:
If two hydrogen atoms from a terminal(first or last) carbon atom of an alkane is replaced by one oxygen atom connected by a double bond, we get an aldehyde.

![Aldehyde structure](image)

In otherwords, if the carbonyl group (\( \text{C} \equiv \text{O} \)) remains in the terminal position, it becomes an aldehyde group(\( \text{H} \equiv \text{C} \equiv \text{O} \)). We have already seen before that when the carbonyl group remains in any internal position, it is a ketone.

Let us see the difference between a terminal and an internal carbon atom. The carbon atom which is connected with only one other carbon atom is a terminal carbon. On the other hand, if the carbon atom is connected with atleast two carbon atoms on two sides, it is called an internal carbon atom.

![Terminal and Internal Carbon atom](image)
If the group is present in the terminal position, it becomes an aldehyde group and it is represented shortly by the formula -CHO (and not -COH). Both ketones and aldehydes contain carbonyl (\( \text{C} = \text{O} \)) group, but the difference is that, in ketone it is present in any of the internal positions while in aldehyde, it is present in the terminal position. Both aldehydes and ketones are commonly called carbonyl compounds.

The IUPAC name of aldehyde is ALKANAL. The 'e' of alkane being replaced by 'al' to become alkanal (alk + ane + al).

**General Formula:** \( \text{C}_n\text{H}_{2n}\text{O} \)

The molecular formula of aldehydes and ketones are same.

<table>
<thead>
<tr>
<th>Structural Formula</th>
<th>Condensed Structural formula</th>
<th>Molecular Formula</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{H} - \text{C} = \text{H} )</td>
<td>HCHO</td>
<td>( \text{CH}_2\text{O} )</td>
<td>methanal or formaldehyde</td>
</tr>
<tr>
<td>( \text{H} - \text{C} - \text{C} = \text{H} )</td>
<td>( \text{CH}_2 - \text{C} = \text{H} )</td>
<td>( \text{C}_2\text{H}_4\text{O} )</td>
<td>ethanal or acetaldehyde</td>
</tr>
<tr>
<td>( \text{H} - \text{C} - \text{C} - \text{H} )</td>
<td>( \text{CH}_3 - \text{C} - \text{C} = \text{H} )</td>
<td>( \text{C}_3\text{H}_6\text{O} )</td>
<td>propanal or propionaldehyde</td>
</tr>
<tr>
<td>( \text{H} - \text{C} - \text{C} - \text{C} = \text{H} )</td>
<td>( \text{H}_3\text{C} - \text{C} - \text{C} - \text{C} = \text{H} )</td>
<td>( \text{C}_4\text{H}_8\text{O} )</td>
<td>butanal or butyraldehyde</td>
</tr>
</tbody>
</table>

The names formaldehyde, acetaldehyde, propionaldehyde and butyraldehyde are preferred IUPAC names although traditional in origin. You can familiarise the structures of aldehydes containing five(pentanal), six(hexanal), seven(septanal), eight(octanal), nine(nonanal) and ten(decanal) carbon atoms. Remember that while writing the structure of an aldehyde, first write the carbon chain. Convert any one terminal carbon(first or last) into an aldehyde group by placing an oxygen atom above that carbon connected with it by a double bond and then attaching one H atom with it. Then attach required number of H atoms to the other carbon atoms.

**General Formula:** \( \text{C}_n\text{H}_{2n}\text{O} \) (same as ketones)

**SAQ I.19:** Write down the structural formula and names of the following aldehydes

(a) \( \text{C} - \text{C} - \text{C} - \text{C} - \text{H} \)

(b) \( \text{H} - \text{C} - \text{C} - \text{C} - \text{C} - \text{H} \)

(c) \( \text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{H} \)
SAQ I.20: Correct the following structures and indicate the class to which they belong.

(a) \( \text{H-C-C} \) \( \text{H} \)
(b) \( \text{O-H-C-C} \) \( \text{H} \)
(c) \( \text{CH}_3\text{-CH} \text{-CH}_2 \)

SAQ I.21: Identify ketones and aldehydes from the following and name each of them.

(a) \( \text{O-H-C-CH}_3 \)
(b) \( \text{O-C-CH}_2\text{-CH}_3 \)
(c) \( \text{O-C-CH}_2\text{-CH}_2\text{-CH}_3 \)
(d) \( \text{O-H-C-H} \)

6. CARBOXYLIC ACIDS

These are the organic acids formerly called the fatty acids because they were first obtained from natural fats. In ketones and aldehydes, we know that there is a carbonyl group. In carboxylic acid, there is however another group called carboxyl group represented as \( \text{C} = \text{O} \) or shortly as -COOH which is situated at the terminal position like the aldehyde group, discussed earlier. There is one additional O atom in carboxylic acid as compared to aldehyde. Carboxylic acids (R-COOH) are entirely different from the carbonyl compounds i.e aldehydes and ketones in their properties.

IUPAC Name: ALKANOIC ACID, (R-COOH)

the 'e' of alkane is replaced by 'oic' followed by the term 'acid' to get the name of carboxylic acid (alk + ane + oic acid). Look at the following table.

<table>
<thead>
<tr>
<th>Structural formula</th>
<th>Condensed formula</th>
<th>Molecular formula</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{O-H-C-OH} )</td>
<td>( \text{H-C-OH} )</td>
<td>( \text{CH}_2\text{O}_2 )</td>
<td>methanoic or formic acid</td>
</tr>
<tr>
<td>( \text{H-C-OH} )</td>
<td>( \text{H-C-OH} )</td>
<td>( \text{CH}_3\text{O}_2 )</td>
<td>ethanoic or acetic acid</td>
</tr>
<tr>
<td>( \text{C-H-OH} )</td>
<td>( \text{H-C-OH} )</td>
<td>( \text{C}_3\text{H}_6\text{O}_2 )</td>
<td>propanoic or propionic acid</td>
</tr>
<tr>
<td>( \text{H-C-C-OH} )</td>
<td>( \text{H-C-C-OH} )</td>
<td>( \text{C}_4\text{H}_8\text{O}_2 )</td>
<td>butanoic or butyric acid</td>
</tr>
</tbody>
</table>
The names formic acid, acetic acid, propionic acid and butyric acid are preferred IUPAC names although traditional in origin.

Practise the structures of pentanoic acid ($C_5$), hexanoic acid ($C_6$), heptanoic acid ($C_7$), octanoic acid ($C_8$), nonanoic acid ($C_9$) and decanoic acid ($C_{10}$).

**General formula of Carboxylic Acids** $: C_nH_{2n}O_2$

**SAQ I.22:** Write down the condensed structural formula and names from the following skeletons.

(a) \[ C\overset{\cdot}\text{C}\overset{\cdot}\text{C}\rightarrow\overset{\cdot}\text{OH} \]
(b) \[ HO\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C} \]
(c) \[ HO\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C} \]

**SAQ I.23:** Correct the following structures and name them.

(a) \[ H\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{OH} \]
(b) \[ H\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{OH} \]
(c) \[ H\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{C}\overset{\cdot}\text{OH} \]

Before knowing about the derivatives of carboxylic acids, let us know what is an alkyl group.

**ALKYL GROUP(R-):**

Alkyl group is generally represented by symbol R-. When one H atom is removed from an alkane, an alkyl group results. It is a group i.e. a part of a molecule and not a complete molecule. Alkyl group has a valency equal to one (shown by one dash sign) and it can bond to any monovalent group like -X, -OH, -NH\textsubscript{2} etc. Look at the following table.

<table>
<thead>
<tr>
<th>Structural formula of Alkane</th>
<th>Structural formula of Alkyl group</th>
<th>Condensed Part formula</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ \text{H--C--H} ] (methane)</td>
<td>[ \text{H--C} ]</td>
<td>CH\textsubscript{3}−</td>
<td>methyl</td>
</tr>
<tr>
<td>[ \text{H--C--C--H} ] (ethane)</td>
<td>[ \text{H--C--C} ]</td>
<td>CH\textsubscript{3}−CH\textsubscript{2}−</td>
<td>ethyl</td>
</tr>
<tr>
<td>[ \text{H--C--C--C--H} ] (propane)</td>
<td>[ \text{H--C--C--C} ]</td>
<td>CH\textsubscript{3}−CH\textsubscript{2}−CH\textsubscript{2}−</td>
<td>propyl</td>
</tr>
</tbody>
</table>

and so on......
In the same manner you can write the structures of other alkyl groups such as butyl\( (C_4) \), penty l\( (C_5) \), hexyl\( (C_6) \), heptyl\( (C_7) \), octyl\( (C_8) \), nonyl\( (C_9) \) and decyl\( (C_{10}) \) derived from butane, pentane, hexane, heptane, octane, nonane and decane respectively. Since an alkyl group is conventionally represented by \( R- \) symbol, the alkane therefore, can be represented by \( R-H \). Remember that while removing the H atom from an alkane to get an alkyl group, you can remove the H atom from any carbon atom and not always from the terminal carbon atom as shown in the previous table. As a beginner, let us remove H atom from terminal carbon to get simple alkyl groups. Details of naming a complex alkyl group obtained by removing H atom from internal positions will be discussed in the next section.

**SAQ I.24:** Remove one H atom from the positions indicated in the following alkane structures and write the condensed structural formula and names of the resulting alkyl groups.

(a)  
\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array}
\]

(b)  
\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array}
\]

(c)  
\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array}
\]

**SAQ I.25:** Write the structural formula and names of the alkyl groups derived from the following alkanes. Remove H atom from the terminal carbon atom.

(a) hexane  
(b) undecane  
(c) butane

**SAQ I.26:** Name and write the part formula of the alkyl groups containing the following number of carbon atoms.

(a) 12  
(b) 17  
(c) 21  
(d) 30

After having discussed about alkyl group\( (R-) \), let us write the simple general formula of different classes of compounds that we have studied so far in terms of alkyl group\( (R) \).

<table>
<thead>
<tr>
<th>ALKANE:</th>
<th>( R-H )</th>
</tr>
</thead>
<tbody>
<tr>
<td>HALOGENATED ALKANES:</td>
<td>( R-X )</td>
</tr>
<tr>
<td>ALCOHOLS:</td>
<td>( R-OH )</td>
</tr>
<tr>
<td>KETONES:</td>
<td>( R\overset{\circ}{\text{C}} \text{R'} )</td>
</tr>
<tr>
<td>ALDEHYDES:</td>
<td>( R\overset{\circ}{\text{C}} \text{-H} )</td>
</tr>
<tr>
<td>CARBOXYLIC ACIDS:</td>
<td>( R\overset{\circ}{\text{C}} \text{-OH} )</td>
</tr>
</tbody>
</table>

In all these cases, \( R- \) group is an alkyl group which is nothing but a carbon chain. \( R \) and \( R' \) in the structure of ketones may be same or different alkyl groups.
SAQ I.27: Write the structural formula and IUPAC names of the following with the name of alkyl groups given inside parenthesis for each.

(i)  \( R-\text{OH} \) (R= ethyl)  
(ii)  \( \text{O} \quad R-C-R' \) (R= methyl and R'= ethyl)  
(iii)  \( R-C-H \) (R= butyl),  
(iv)  \( \text{O} \quad R-C-\text{OH} \) (R= propyl)  
(v)  \( \text{R-H} \) (R= hexyl)  
(vi)  \( \text{R-Br} \) (R= pentyl)

7. DERIVATIVES OF CARBOXYLIC ACIDS

There are six derivatives of carboxylic acids which are as follows.

(a) ester  
(b) salt of carboxylic acids  
(c) acid anhydride  
(d) acid amide  
(e) acid halide  
(f) alkanenitrile (alkyl cyanides)

It may be pointed out once again here that derivative of a compound is another compound which is derived or obtained from the original (parent) compound. The derivatives are closely related to the original compound from which they have been derived. Let us know each of the six derivatives of carboxylic acid.

(a) **ESTER:**

If the H atom of carboxyl group (-COOH) is replaced by a carbon chain (-COOC-), the resulting compound is called an ester.

In other words, when the H atom of carboxyl group of a carboxylic acid, is replaced by an alkyl group (R') or carbon chain, an ester results. So, an ester is represented as follows.

The \( \text{O} \quad \text{C} \quad \text{O} \) \( \text{R} \quad \text{O} \quad \text{R'} \) written inside the box is called the **ester group**. There is another alkyl group (R), attached to the left of this group in the ester. The naming of ester is done in a different way. Look at the structure below.

The **alkyl** group (R') attached to O atom is written first followed by the term **alkanoate** (alk + ane + oate). The number of carbon atoms inclusive of the carboxyl carbon placed inside the marked box are counted for naming the alkanoate. Between alkyl and alkanoate there has to be a single space.

**IUPAC name of ester:** alkyl alkanoate
Look at the following example.

![Methyl propanoate structure](image)

The alkyl group ($R'$) attached to O atom is **methyl** here and so it is to be written first and then alkanoate (shown inside the box) is to be written. Here, there are three carbon atoms inside the box, so the name of the alkanoate is **propanoate**. Hence, the name of the ester is **methyl propanoate**. While naming an ester you are advised to follow this method to separate the alkanoate part from the alkyl part before writing the name. For alkyl part and alkanoate part you have to count the number of carbon atoms separately.

<table>
<thead>
<tr>
<th>Expanded Structure</th>
<th>Simplified structure</th>
<th>Formula</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Expanded Structure" /></td>
<td><img src="image" alt="Simplified structure" /></td>
<td>$C_2H_6O_2$</td>
<td>methyl methanoate</td>
</tr>
<tr>
<td><img src="image" alt="Expanded Structure" /></td>
<td><img src="image" alt="Simplified structure" /></td>
<td>$C_3H_6O_2$</td>
<td>methyl ethanoate</td>
</tr>
<tr>
<td><img src="image" alt="Expanded Structure" /></td>
<td><img src="image" alt="Simplified structure" /></td>
<td>$C_4H_{10}O_2$</td>
<td>ethyl propanoate</td>
</tr>
</tbody>
</table>

The names **formate** for methanoate, **acetate** for ethanoate, **propionate** for propanoate, **butyrate** for butanoate are used as preferred IUPAC names which originate from common names of the corresponding acids namely formic, acetic, propionic and butyric acid respectively. The suffix -ic of alkanoic has been replaced by -ate.

**General Formula of Esters:** $C_nH_{2n}O_2$

**SAQ I.28:** Write down the names of the following esters.

(a) $H_3C-CH_2CH_2CH_2-\text{O-CH}_2-\text{CH}_3$  (b) $H-\text{O-CH}_2\text{CH}_2-\text{H}$

(c) $H_3C-\text{O-CH}_2-\text{CH}_2$  (d) $H_3C-\text{CH}_2-\text{O-CH}$

(e) $H_3C-\text{CH}_2\text{CH}_2\text{CH}_2-\text{O-CH}_3$
Nomenclature of Organic Compounds

SAQ I.29: Write down the structure of the following.
(i) propyl formate  (ii)methyl propionate  (iii)ethyl butyrate  (iv)butyl acetate

Remember that in whichever way the structure is written\(\text{O} \quad \text{C} \quad \text{O}\) or \(\text{O} \quad \text{C} \quad \text{O}\), while naming an ester, the alkyl group directly attached to \(-\text{O}-\) atom is written first followed by the term alkanoate for the other part with a space in between(no comma or semicolon).

(b) SALT OF CARBOXYLIC ACID:

This derivative is very similar to ester. The group \(\text{R} \quad \text{C} \quad \text{O}\) is called the alkanoate(carboxylate) group which is obtained by deleting the H atom of \(\text{R-COOH}\) (carboxylic acid). It is a monovalent group or radical. If this is attached with a metal(instead of an alkyl group), we get a salt of carboxylic acid.

So the name of the salt is \textit{metal alkanoate}

Let us take an example of a monovalent metal like Na. Since both the alkanoate and Na radicals are monovalent, the condensed structural formula of the salt will be

\[
\text{CH}_3 \quad \text{C} \quad \text{O} \quad \text{O} \quad \text{Na}^+ \quad (\text{sodium ethanoate or sodium acetate}).
\]

Here, the bond between Na and O is ionic. Sodium and potassium salts are ionic. Calcium is divalent while alkanoate is monovalent, so that calcium salt will have the structure

\[
\begin{align*}
\text{H}_3\text{C} & \quad \text{C} \quad \text{O} \\
\text{Ca}^{2+}
\end{align*}
\]

(calcium ethanoate or calcium acetate)

Note that the names formate, acetate, propionate and butyrate are preferred IUPAC names for methanoate, ethanoate, propanoate and butanoate respectively.

SAQ I.30: Write down the names of the following.

(i) \(\text{H}_3\text{C}-\text{CH}_2\text{CH}_2\text{CH}_2\text{C} \quad \text{O} \quad \text{K}^+ \)

(ii) \(\text{H} \quad \text{C} \quad \text{O} \quad \text{Na}^+\)

(iii) \(\left[\text{H}_3\text{C}-\text{CH}_2-\text{C} \quad \text{O}\right]_2\text{Ca}\)

SAQ I.31: Write the structures of the following.

(i) potassium pentanoate  (ii)sodium formate  (iii)calcium butyrate  (iv)aluminium acetate  (v)potassium propionate
(c) **ACID AMIDE:**

When the -OH group of carboxyl group (COOH) is replaced by NH\(_2\) group, the amide group (-CONH\(_2\)) results.

IUPAC Name: \(alk + ane + amide = alkanamide\)

The e of alkane is replaced by amide to give the name alkanamide.

SAQ I.32: Write down the structures and names of the amides from the following skeleton.

(i) \(\text{C} - \text{C} - \text{C} - \text{C} - \text{NH}_2\)  (ii) \(\text{H}_2\text{N} - \text{C} - \text{C} - \text{C}\)

SAQ I.33: Write down the structures of the following amides: (i) hexanamide (ii) nonanamide

(d) **ACID HALIDE:**

When -OH group of carboxyl group is replaced by halogen group (X = F, Cl, Br, I), we get acid halide (RCOX). Among the acid halides, **acid chloride** is most common.

IUPAC Name: \(alk + ane + oyl\) chloride = alkanoyl chloride

The e of alkane is replaced by -oyl followed by chloride.

SAQ I.34: Write down the structures of (i) pentanoyl chloride (ii) hexanoyl chloride
**Nomenclature of Organic Compounds**

(e) **ACID ANHYDRIDE:**

Acid anhydride results when a molecule of water is removed from two molecules of carboxylic acid.

\[
\text{RCOOH} + \text{RCOOH} \rightarrow \text{RC\(\_\)OCO\(\_\)RC} \\
\text{(acid anhydride)}
\]

Acid anhydride is characterized by the group \(\text{R-C\(\_\)O\(\_\)C-R}\) and there are two types of anhydrides.

(i) **Symmetrical anhydride:** If the two R groups are same i.e when the anhydride is prepared from one acid, it is called a symmetrical anhydride. In this case, put a dividing line passing through the middle O atom. The two halves are identical with respect to the this dividing line in case of symmetrical anhydride. Disregard one half and name with the number of carbon atoms present in the other half as follows.

\[
\begin{align*}
\text{RC} & \quad \text{O} & \quad \text{OC} & \quad \text{R} \\
\text{(symmetrical anhydride)}
\end{align*}
\]

Name: \(\text{alk+ ane+ oic anhydride} = \text{alkanoic anhydride}\)

The word acid is replaced by anhydride in this case.

Example:

\[
\text{H}_3\text{C}-\text{C} \quad \text{O} \quad \text{O} \quad \text{CH}_3 \quad (\text{ethanoic anhydride or acetic anhydride})
\]

\[
\text{H}_3\text{C}-\text{CH}_2\text{C} \quad \text{O} \quad \text{O} \quad \text{CH}_2\text{CH}_3 \quad (\text{propanoic anhydride})
\]

(ii) **Unsymmetrical or mixed anhydride:** If the two alkyl groups are different i.e when the anhydride is prepared from two different carboxylic acids, it is called unsymmetrical anhydride. In this case the two halves with respect to the dividing line are different and the carbon atoms are separately counted in each half and named as \(\text{alkanoic alkanoic anhydride}\) and the two alkanoic terms are arranged in alphabetical order. There is a space after each part.

\[
\begin{align*}
\text{RC} & \quad \text{O} & \quad \text{O} & \quad \text{CH}_3 \quad \text{R'} \\
\text{(unsymmetrical anhydride)}
\end{align*}
\]

On one side of the dividing line there are two carbon atoms, hence ethanoic(or acetic) and on the other side there are three carbon atoms, hence propanoic. Hence the above name. Note that the term acetic can be used for ethanoic, but the terms propionic and butyric for propanoic and butanoic respectively cannot be used in IUPAC naming of anhydrides although they are used for naming carboxylic acids. Note also that since formic anhydride does not exist, no discussion has been done about it.
SAQ I.35: Write the structures of (i) butanoic anhydride (ii) propanoic anhydride (iii) acetic butanoic anhydride (iv) hexanoic pentanoic anydride. Indicate which is a symmetrical and which an unsymmetrical anhydride.

(F) ALKANENITRILE:
When alkyl group(R) is attached to a cyanide group(-CN), it is called alkanenitrile.

\[
R - C\equiv N
\]

The IUPAC name is *alkanenitrile* (alk + ane + nitrile) and while counting the number of carbon atoms, the cyanide carbon is included. Note that there is no space between the terms *alkane* and *nitrile*.

\[
\text{H}_3\text{C} - \text{C}\equiv \text{N} \quad \text{(ethanenitrile or acetonitrile)},
\]

\[
\text{H}_3\text{C} - \text{CH}_2\text{-C}\equiv \text{N} \quad \text{(propanenitrile or propiononitrile)}
\]

\[
\text{CH}_3\text{CH}_2\text{CH}_2\text{-CN} \quad \text{butanenitrile or butyronitrile)
\]

The names acetonitrile, propiononitrile, butyronitrile for ethanenitrile, propanenitrile and butanenitrile respectively have been derived from the corresponding acids namely acetic, propionic and butyric acids. Although trivial in origin, they are used as preferred IUPAC names.

SAQ I.36: (a) Write the structure of (i) octanenitrile (ii) pentanenitrile

8. ETHERS
Ethers are derivatives of alcohols. When the H atom of the OH group of alcohol is replaced by an alkyl group(R'), an ether results. In other words, ether contains two same or different alkyl groups on either side of oxygen atom.

\[
R - O - R \quad \text{symmetrical ether}
\]

\[
R - O - R' \quad \text{unsymmetrical ether}
\]

IUPAC name: *alkoxyalkane*

Alkox group: -O-R is called alkox group:

-\[
\text{-OCH}_3 \quad \text{(methoxy), -OCH}_2\text{CH}_3 \quad \text{(ethoxy), -OCH}_3\text{CH}_2\text{CH}_3 \quad \text{(propoxy),}
\]

-\[
\text{-OCH}_3\text{CH}_2\text{CH}_2\text{CH}_3 \quad \text{(butoxy), -OCH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \quad \text{(pentyloxy)}
\]

Ex. \[
\text{CH}_3\text{CH}_2\text{O} - \text{CH}_2\text{-CH}_3 \quad \text{CH}_3\text{-CH}_2\text{-O} - \text{CH}_2\text{-CH}_2\text{-CH}_3
\]

methoxyethane (not ethoxymethane) ethoxypropane (not propoxyethan)

In symmetrical ether, one alkyl group is regarded as parent alkane and the other alkyl group along with O atom makes the alkoxy group.
Nomenclature of Organic Compounds

Example:

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

SAQ I.37: Write the structural formula of the following, (i) ethoxybutane  
(ii) methoxypentane  (iii) propoxyprapane

SAQ I.38: Below find a set of incorrect names. Write the structures and give their correct names.

(i) ethoxymethane  (ii) propoxymethane  (iii) butoxypropane

(9) AMINES:
Amines are derivatives of NH\textsubscript{3}. There are three types of amines.

(a) primary amine: (1\textsuperscript{st} amine)
(b) secondary amine (2\textsuperscript{nd} amine)
(c) tertiary amine (3\textsuperscript{rd} amine)

(a) Primary amine:
If one H atom of ammonia is replaced by an alkyl group, we get a primary or 1\textsuperscript{st} amine.

\[\text{Alk}+\text{ NH}_2 = \text{R-NH}_2\]

Ex.: CH\textsubscript{3}NH\textsubscript{2} (methanamine), CH\textsubscript{3}CH\textsubscript{2}NH\textsubscript{2} (ethanamine), CH\textsubscript{3}CH\textsubscript{2}CH\textsubscript{2}NH\textsubscript{2} (propanamine)

SAQ I.39: Write down the structures of the following primary amines.

(i) butanamine  (ii) pentanamine

(b) Secondary amine:
When two H atoms of NH\textsubscript{3} are replaced by two same or different alkyl groups, we get a secondary(2\textsuperscript{nd}) amine. In sec-amine, there is NH group (not NH\textsubscript{2} group which is present in primary amine).

\[\text{Alk}_1+\text{ NH}_2 = \text{N-alkylalkanamine}\]

Ex.: \(\text{CH}_3-\text{NH}-\text{CH}_2-\text{CH}_3\) (N-methylethanamine, not N-ethylmethanamine)  
\(\text{CH}_3-\text{CH}_2-\text{NH}-\text{CH}_2-\text{CH}_3\) (N-methylpropanamine, not N-propylmethanamine)

If the two alkyl groups are identical, any one group becomes N-alkyl and the other becomes alkanamine. \(\text{CH}_3-\text{CH}_2-\text{NH}-\text{CH}_2-\text{CH}_3\) (N-ethylethanamine).

SAQ I.40: Write the structures of the following:

(i) N-ethylbutanamine  (ii) N-methylmethanamine  (iii) N-propylpentanamine
(c) **Tertiary** (3°) **amine:**
When three H atoms are replaced by three same or different alkyl groups, we get a tert-amine.

\[
N^\text{R} \quad N^\text{R'} \quad N^\text{R''}
\]

In tert-amine there is N group (not NH or NH₂).

(i) If the three alkyl groups are different, the name is **N-alkyl-N-alkylalkanamine**

*The alkyl group containing the greatest number of carbon atoms becomes the parent alkanamine and the alkyl groups containing lesser number of carbon atoms become the two N-alkyl groups arranged in alphabetical order.*

\[
\begin{align*}
\text{H}_3\text{C} & \text{N} \quad \text{CH}_2\text{CH}_3 \\
\quad & \text{CH}_2\text{CH}_3 \\
\text{CH}_2\text{CH}_3 &
\end{align*}
\]

(N-ethyl-N-methylpropanamine)

(ii) If two alkyl groups containing less number of carbon atoms are identical, the name is **N,N-dialkylalkanamine**

\[
\begin{align*}
\text{H}_3\text{C} & \quad \text{N} \quad \text{CH}_2 \quad \text{CH}_3 \\
\quad & \quad \text{CH}_3
\end{align*}
\]

(N, N-dimethylethanamine)

Note that if two alkyl groups containing larger number of carbon atoms are identical, one of the groups is taken as N-alkyl group and the other as parent alkanamine.

\[
\begin{align*}
\text{H}_3\text{C} & \quad \text{N} \quad \text{CH}_2 \quad \text{CH}_3 \\
\quad & \quad \text{CH}_3
\end{align*}
\]

(N-ethyl-N-methylethanamine)

(iii) If all the three alkyl groups are same, then one of them is taken as parent alkanamine and the other two as N, N-dialkyl groups.

\[
\begin{align*}
\text{CH}_3 & \quad \quad \text{CH}_3 \\
\quad & \quad \quad \text{CH}_3
\end{align*}
\]

(N,N-diethylethanamine)

Note that in sec- and tert- amines, no space is to given between N-alkyl group(s) and the parent alkanamine. Since N is the locant of alkyl group, it is prefixed and suffixed by hyphens if it remains internally while the terminal N is only suffixed by hyphen.

**SAQ I.41:** Write the structural formula of the following
(i) N,N-diethylbutanamine
(ii) N-ethyl-N-methylpentanamine

**SAQ I.42:** Identify which is 1°, 2° and 3° amine. Also name them.
(i) CH₃CH₂NHCH₂CH₃ (ii) CH₃CH₂CH₂NH₂ (iii) CH₃CH₂N(CH₃)CH₂CH₂CH₃

(10) **Nitrohydrocarbons (Nitroalkanes)**
When H atom of an alkane is replaced by a nitro(-NO₂) group, a nitroalkane results. The IUPAC name of such compounds is **NITROALKANE**.

eg. CH₃-NO₂ (nitromethane), CH₃-CH₂-NO₂ (nitroethane), CH₃-CH₂-CH₂-NO₂ (nitropropane) and so on. **R-ONO** is called alkyl nitrite which is a structural isomer of nitroalkane.
SAQ I.1:  
(a) CH₃−CH₂−CH₂−CH₃ (butane)  
(b) CH₃−CH₂−CH₂−CH₂−CH₃ (pentane)  
(c) CH₃−CH₂−CH₂−CH₂−CH₂−CH₃ (hexane)  
(d) CH₄ (methane)  

SAQ I.2:  
(a) H,C−C−C−C−H  
(b) H,C−C−C−C−H  
(c) CH₃−CH₂−CH₂−CH₂−CH₃  

Valencies of carbon atoms were not satisfied at some places due to want of required number of H atoms.  

SAQ I.3:  
(a) CH₃−CH₂−CH₂−CH₂−CH₂−CH₂−CH₂−CH₃ (cyclohexane)  
(b) CH₃−CH₂−CH₂−CH₂−CH₂−CH₃ (dodecane)  

(c) CH₃−CH₂−CH₂−CH₂−CH₂−CH₃ (pentane)  
(d) CH₂−CH₃ (there is no line structure for methane and ethane)  

SAQ I.4:  
(a) C₇H₁₆  
(b) C₃H₈  
(c) C₁₁H₂₄  
(d) C₄₀H₈₂  

SAQ I.5:  
(a) dodecane  
(b) heptane  
(c) henticosane  
(d) hexacosane  
(e) triacontane  

SAQ I.6:  
(a)  
(b)  
(c)  
(d) CH₃−CH₃ (there is no line structure for methane and ethane)  

SAQ I.7:  
(a) CH₃−CH=CH₂ (propene)  
(b) CH₃−CH=CH−CH₃ (butene)  

(c) CH₃−CH=CH−CH₂−CH₃ (pentene)  
(d) CH₃−CH₂−CH=CH₂ (butene)  

SAQ I.8:  
(a) H,C−C−C−C−H (propene)  
(b) H,C−C−C−C−H (butene)  

(c) CH₃−CH₃−CH=CH−CH₂−CH₃ (hexene)  
(d) CH₂−CH₃ (ethene or ethylene)  

There were mistakes at different carbon atoms in the number of carbon atoms attached. Each carbon should satisfy a valency of 4. Accordingly the required number of H atoms are to be attached.  

SAQ I.9: C₆H₁₂. No, the alkene having formula CH₂ does not exist, because the valency of carbon is not satisfied.  

SAQ I.10:  
(a) CH₂−C≡C−CH₃ (butyne)  
(b) CH₃−C≡CH (propyne)  

(c) H₃C−CH₂−C≡C−CH₂−CH₃ (hexyne)  

SAQ I.11:  
(a) H−C≡C−C−C−H (butyne)  
(b) H−C≡C−C−C−H (pentyne)  

(c) CH₃−CH₃−C≡C−CH₃ (pentyne)
SAQ I.12:  
(a) \( \text{CH}_3-\text{C}-\text{CH}_2-\text{CH}_3 \) (bromobutane)  
(b) \( 1-\text{CH}_2-\text{CH}_2-\text{CH}_3 \) (iodopropane)  
(c) \( \text{CH}_3-\text{F} \) (fluoromethane)  
(d) \( \text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{Cl} \) (chloropentane)

SAQ I.13:  
(a) \( \text{CH}_3-\text{I} \)  
(b) \( \text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{F} \)  
(c) \( \text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{Cl} \)  
(d) \( \text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{Br} \)  
(Note that X atom can be attached with any carbon atom and accordingly H atoms adjusted)

SAQ I.14:  
(a) \( \text{HO-CH}_2-\text{CH}_3 \) (ethanol)  
(b) \( \text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{F} \) (propanol)  
(c) \( \text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{OH} \) (hexanol)  
(d) \( \text{HO-CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_3 \) (butanol)

SAQ I.15:  
(a) \( \text{H-C-O-H} \) (ethanol)  
(b) \( \text{H-O-C-H} \) (methanol)

SAQ I.16:  
(a) \( \text{CH}_3-\text{CH}-\text{C}-\text{CH}_3 \) (butanone)  
(b) \( \text{CH}_3-\text{CH}_2-\text{C}-\text{CH}_2-\text{CH}_3 \) (pentanone)  
(c) \( \text{H}_3\text{C-CH}_2-\text{CH}_2-\text{C}-\text{CH}_3 \) (hexanone)

SAQ I.17: They are not ketones because the carbonyl group (C=O) is located at the terminal positions (first and last).

SAQ I.18:  
(a) \( \text{H}_3\text{C-CH}_2-\text{CH}_2-\text{CH}_2-\text{C}-\text{CH}_3 \)  
(b) \( \text{CH}_3-\text{C}-\text{CH}_3 \)  
(c) \( \text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{C}-\text{CH}_2-\text{CH}_3 \)  
(In (a) and (c) you can put =O at any position and accordingly H atoms adjusted.)

SAQ I.19:  
(a) \( \text{CH}_3-\text{CH}-\text{C}-\text{H} \) (propanal or propionaldehyde)  
(b) \( \text{H-C-CH}_2-\text{CH}_2-\text{CH}_3 \) (butanal or butyraldehyde)  
(c) \( \text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{C}-\text{H} \) (pentanal)

SAQ I.20:  
(a) \( \text{it is a ketone as the carbonyl group is in an internal position} \)  
(b) \( \text{it is an aldehyde as the carbonyl group is in a terminal position} \)
Nomenclature of Organic Compounds

(c) $\text{CH}_3 \overset{\text{C}}{-} \text{H}_2 \overset{\text{O}}{-} \text{C}$ (it is an aldehyde as the carbonyl group is in a terminal position).

SAQ I.21:  
(a) aldehyde(propanal or propionadehyde)  
(b) ketone(butanone)  
(c) ketone(pentanone)  
(d) aldehyde(methanal or formaldehyde)

SAQ I.22:  
(a) $\text{CH}_3\text{CH}_2\text{C} \overset{\text{O}}{-}$ (propanoic acid or propionic acid)

(b) $\text{HO} \overset{\text{C}}{-} \text{CH}_2\text{CH}_2 \overset{\text{O}}{-} \text{CH}_3$ (butanoic acid or butyric acid)

(c) $\text{HO} \overset{\text{C}}{-} \text{CH}_3$ (ethanoic acid or acetic acid)

SAQ I.23:  
(a)  

(b)  

(c) $\text{O} \overset{\text{C}}{-} \text{CH}_3$ (methanoic or formic acid)

SAQ I.24:  
(a) $\text{CH}_3\text{CH}_2 :$ ethyl  
(b) $\text{CH}_2\text{CH}_2\text{CH}_3 :$ propyl  
(c) $\text{CH}_3 :$ methyl

SAQ I.25:  
(a) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2 \overset{\text{O}}{-}$ (hexyl)  
(b) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2 \overset{\text{O}}{-}$ (undecyl)  
(c) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2 \overset{\text{O}}{-}$ (butyl)

SAQ I.26:  
(a) dodecyl  
(b) heptadecyl  
(c) henicosyl  
(d) triacontyl

SAQ I.27:  
(i) $\text{CH}_3\text{CH}_2\text{OH}$ (ethanol)  
(ii) $\text{CH}_3 \overset{\text{O}}{-} \text{C} \overset{\text{O}}{-} \text{CH}_2\text{CH}_3$ (butanone)  
(iii) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CHO}$ (pentanal)  
(iv) $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$ (butanoic acid or butyric acid)

Aldehyde and carboxylic acid groups have been written shortly as $\text{-CHO}$ and $\text{-COOH}$ respectively.

(v) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$ (hexane)

SAQ I.28:  
(a) ethyl pentanoate  
(b) propyl methanoate(propyl formate)  
(c) methyl propanoate or ethyl propionate (here alkyl part attached to O atom is written in LHS).

(d) ethyl methanoate or ethyl formate (here also the alkyl part is in LHS).  
(e) methyl hexanoate

SAQ I.29:  
(i) $\text{H} \overset{\text{O}}{-} \text{C} \overset{\text{O}}{-} \text{C} \overset{\text{O}}{-} \text{CH}_2\text{CH}_2\text{CH}_3$  
(ii) $\text{CH}_3\text{CH}_2\text{COOCH}_2\text{CH}_3$

(Shortly the ester group is written as $\text{-COOR'}$, the C=O double bond is not shown)

(iii) $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOCH}_2\text{CH}_3$  
(iv) $\text{CH}_3\text{COOCH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
SAQ I.30: (i) potassium pentanoate (ii) sodium methanoate (sodium formate) (iii) calcium butanoate (calcium butyrate)

SAQ I.31: (i) CH₃CH₂CH₂CH₂COO⁻K⁺ (ii) H-COONa (iii) (CH₃CH₂CH₂COO)₂Ca (iv) (CH₃COO)₃Al (v) CH₃CH₂COOK

SAQ I.32: (i) CH₃CH₂CH₂CONH₂ (butanamide or butyramide) (ii) H₂NOC-CH₂CH₃ (propanamide or propionamide)

The amide group is shortly written as -CONH₂. The C=O double bond is not shown.

SAQ I.33: (i) CH₃CH₂CH₂CH₂CH₂CONH₂ (ii) CH₃CH₂CH₂CH₂CH₂CONH₂

SAQ I.34: (i) CH₃CH₂CH₂CH₂COCl (ii) CH₃CH₂CH₂CH₂COCl

SAQ I.35: (i) CH₃CH₂CH₃CO-O-CO-CH₂CH₂CH₃ (sym.) (ii) CH₃CH₂CO-O-CO-CH₂CH₂CH₃ (sym. anhydride) (iii) CH₃CO-O-CO-CH₂CH₂CH₃ (unsym.) (iv) CH₃CH₂CH₃CO-O-CO-CH₂CH₂CH₂CH₂CH₃ (unsym.)

Note that CO has been shortly written as CO in the above structures.

SAQ I.36: (i) CH₃CH₂CH₂CH₂CH₂CN (ii) CH₃CH₂CH₂CN

SAQ I.37: (i) CH₃O-CH₂CH₂CH₂CH₃ (ii) CH₃-CH₂O-CH₂CH₂CH₂CH₃ (iii) CH₃CH₂CH₂O-CH₂CH₂CH₃

SAQ I.38: (i) CH₃CH₂O-CH₃ (methoxy ethane); (ii) CH₃CH₂CH₂O-CH₃ (methoxypropane) (iii) CH₃CH₂CH₂CH₂O-CH₂CH₃ (prooxybutane)

SAQ I.39: (a) CH₃CH₂CH₂CH₂CH₂NH₂ (b) CH₃CH₂CH₂CH₂CH₂NH₂

SAQ I.40: (i) CH₃CH₂NHCH₂CH₂CH₂CH₃ (ii) CH₃NHCH₂CH₂CH₃ (iii) CH₃CH₂CH₂NHCH₂CH₂CH₂CH₂CH₂CH₃

SAQ I.41: (i) CH₂=CH₂ CH₃

   N
   CH₂=CH₂ CH₂=CH₂

   (two ethyl groups are attached to N and one butyl group is attached to N).

(ii) CH₃ CH₂=CH₂

   N
   CH₂=CH₂ CH₂=CH₂

   (One methyl, one ethyl and one pentyl group are attached to N)

SAQ I.42: (i) ²⁰ amine: N-ethylethanamine (ii) ¹⁰ Amine: propanamine (iii) ³⁰ amine: N-ethyl-N-methylpropanamine (the CH₃ group written within parenthesis is attached to N separately)