Chapter 21

Organic Chemistry

Student Learning Outcomes

After studying this chapter, students will be able to:

- Describe organic molecules as either straight-chained, branched or cyclic.
- State that a structural formula is an unambiguous description of the way the atoms in molecules are arranged, including $CH_2=CH_2$, CH_3CH_2OH, CH_3COOCH_3
- Identify and draw structural formulae for molecules.
- Interpret general formulae of compounds in the same homologous series including alkanes, alkenes, alkynes, alcohols and carboxylic acids.
- Define structural isomers as compounds with the same molecular formula, but different structural formulae, including C_4H_{10} as $CH_3CH_2CH_2CH_3$ and $CH_3CH(CH_3)CH_3$ and C_4H_8 as $CH_3CH_2CH=CH_2$ and $CH_3CH=CHCH_3$.
- Identify a functional group as an atom or group of atoms that determine the chemical properties of a homologous series including that for alcohols, aldehydes, ketones, phenols, carboxylic acids, amine, esters, and amide.
- Describe the general characteristics of homologous series. These can include:
  a. Having the same functional group
  b. Having the same general formula
  c. Differing from one member to the next by a CH_2 – Unit.
  d. Displaying a trend in physical properties.
  e. Sharing similar chemical properties
- State that a saturated compound has molecules in which all carbon-carbon bonds are single bonds.
- State that an unsaturated compound has molecules in which one or more carbon-carbon bonds are not single bonds.
- Name and draw the structural and displayed formulae of unbranched alkanes, alkenes, alcohols, and carboxylic acids. (Include but-1-ene and but-2-ene, propan-1-ol, propan-2-ol, butan-1-ol and butan-2-ol.
- State the type of compound present given the chemical name ending in – ane, -ene, -yne, -ol, or -olc acid or from a molecular, structural or displayed formula.
- Name and draw the displayed formulae of the unbranched esters which can be made from unbranched alcohols and carboxylic acids, each containing up to four carbon atoms.

Organic Chemistry

An organic compound is a chemical compound primarily composed of carbon atoms that are covalently bonded to each other or to other elements. Apart from carbon, majority of organic compounds also contain hydrogen. Other elements which may also be present include oxygen, nitrogen, sulphur and halogens etc. For historical and conventional reasons a few of the carbon compounds such as its oxides, carbonates and hydrogen carbonates, etc. are studied as inorganic compounds. Organic chemistry is defined as that branch of chemistry in which we study compounds of carbon and hydrogen (hydrocarbons) and their derivatives.

21.1 Classifications of Organic Compounds

There are millions of organic compounds. It is practically not possible to study each individual compound. To facilitate their study, organic compounds are classified into various groups and sub-groups. They may be broadly classified into the following classes:

(i) Open chain or Acyclic compounds.

(ii) Closed chain or Cyclic (or ring) compounds

Interesting Information

Organic chemistry plays a vital role in developing new materials with specific properties, such as polymers and drugs.

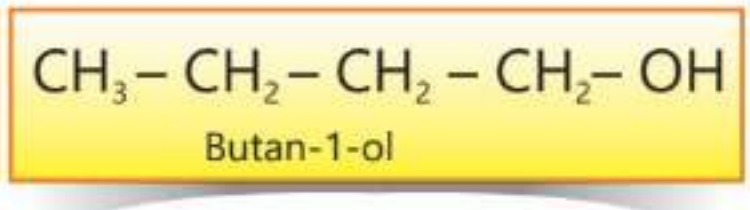
(i) Open Chain or Acyclic Compounds

This type of compounds contains an open chain of carbon atoms. The chains may be branched or non-branched (straight chain). Open chain compounds alongwith certain cyclic compounds are also called aliphatic compounds.

Straight chain (or non-branched) compounds

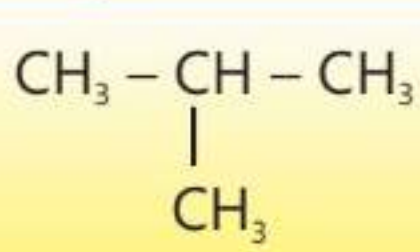
Butane

But-1-ene

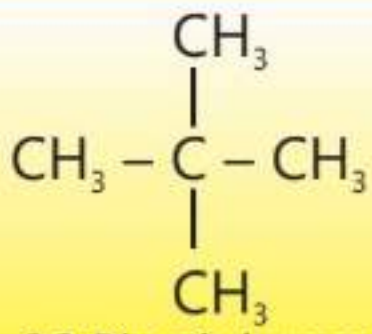


Butan-1-ol

Branched chain compounds



2-Methylpropane



2,2-Dimethylpropane

(ii) Closed Chain or cyclic Compounds

These compounds contain one or more closed chains (cyclic) of atoms and are known as closed chain or ring compounds.

Interesting Information

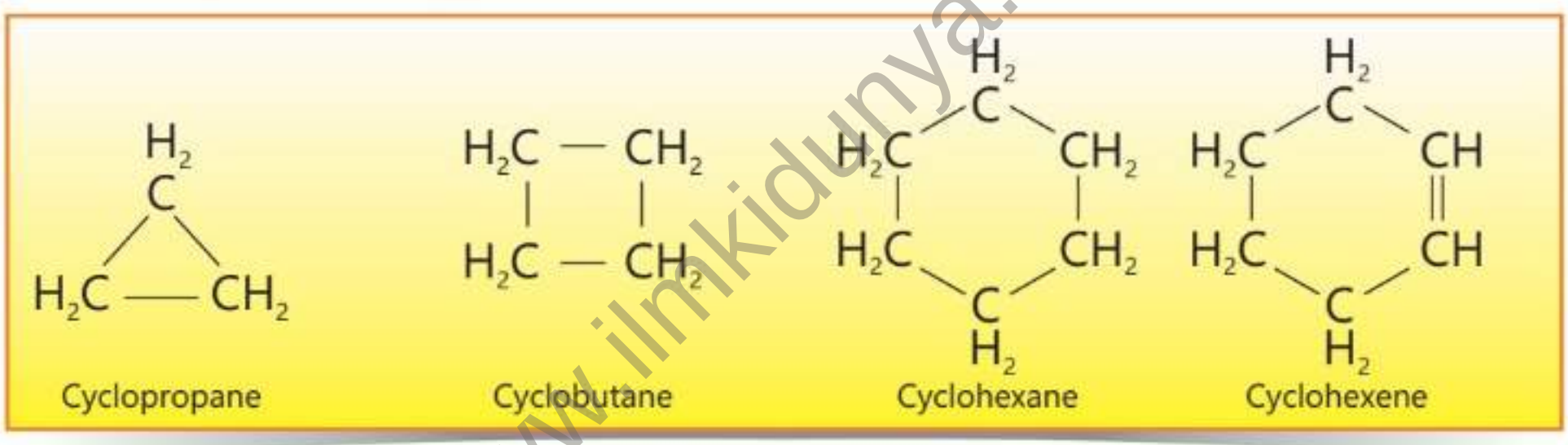
The ability of carbon atom to form four bonds creates an almost infinite variety of molecules which make organic chemistry very useful.

When the ring contains carbon atoms only, the compounds are called carbocylic compounds. However, if the ring contains other atoms alongwith carbon atoms, the compounds are called heterocyclic compounds. Carbocyclic compounds are further classified as;

(1) Alicyclic compounds (2) Aromatic compounds

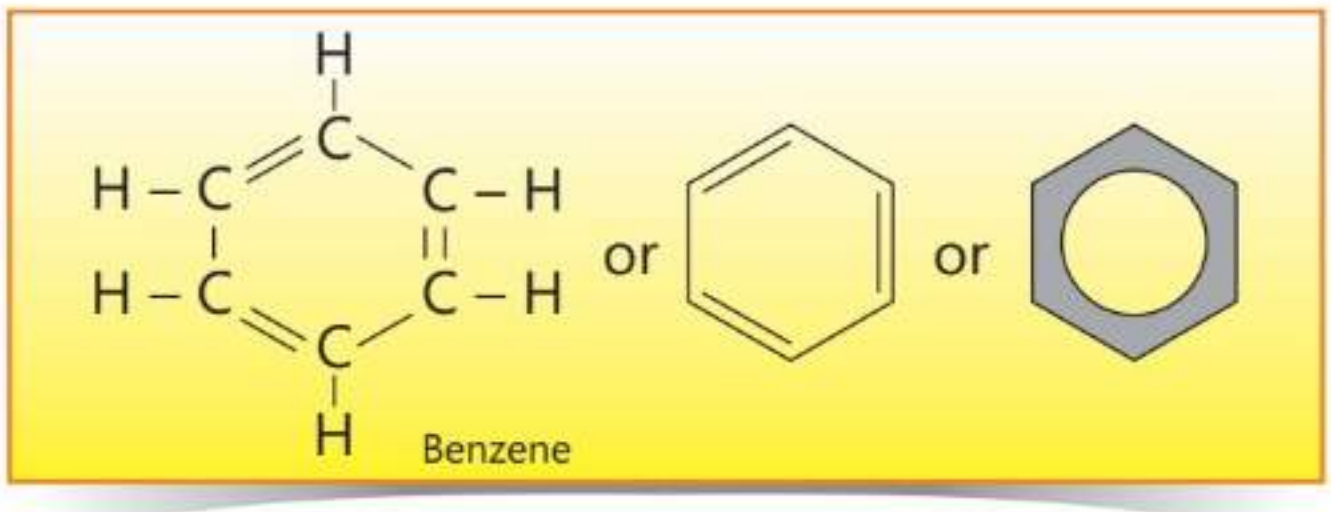
(1) Alicyclic compounds

The carbocyclic compounds which contain a ring of three or more carbon atoms and resemble aliphatic compounds are called alicyclic compounds. The saturated alicyclic hydrocarbons have the general formula C_nH_{2n}. A few typical alicyclic compounds are given below.



(2) Aromatic compounds

Aromatic compounds are of many types. The simplest among them are those which contain one benzene ring. A benzene ring has six carbon atoms with three alternate double and single bonds. These bonds are usually shown in the form of a circle. Some other cyclic compounds having alternate double bonds are also included in aromatic compounds.



21.1 Quick Check!

1. What is the difference between cyclohexane and benzene?
2. Give two examples of branched chain compounds.

21.2 Structural Formula

The structural formula of a compound shows the arrangement of atoms and bonds present in that compound. It gives enough information to understand the structure of a molecule clearly. While showing the arrangement of atoms in a molecule, it is usual to omit most of the single covalent bonds present in the molecule. Only important bonds such as double and triple bonds are shown. Identical groups present in the molecules can be bracketed together while some other groups are also shown using brackets.

There are various ways of drawing the structural formula of organic compounds and the students should familiarize with all of them.

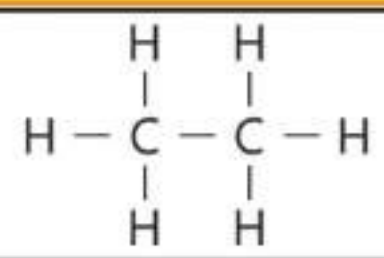
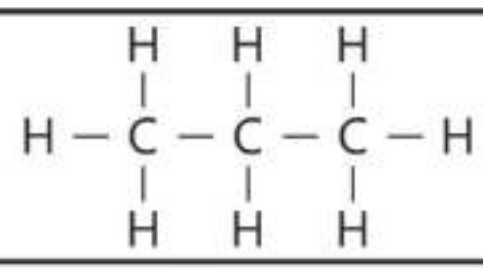
Displayed Formula or Full Structural Formula

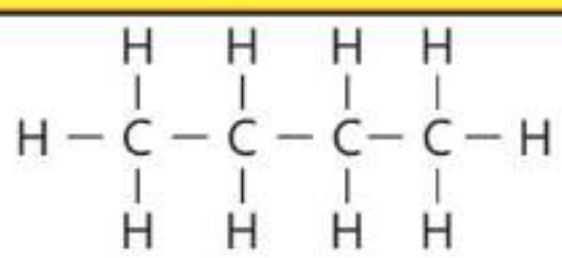
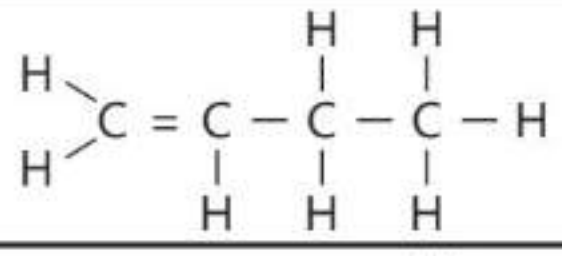
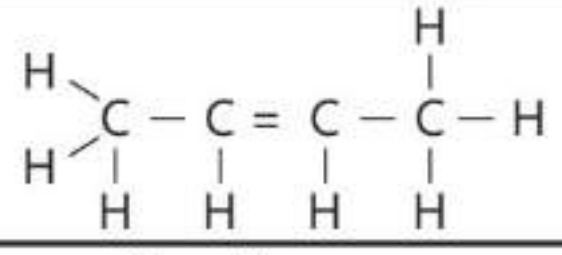
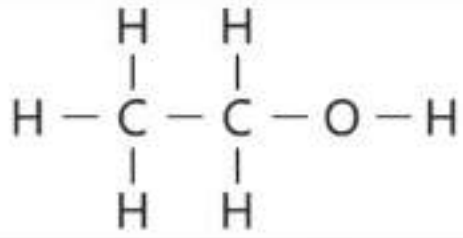
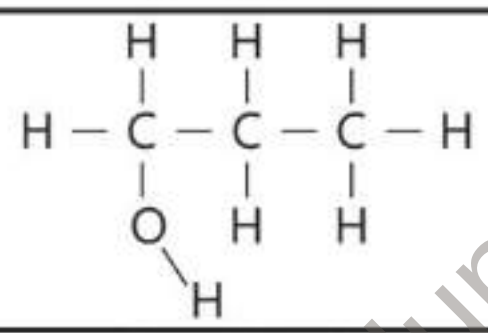
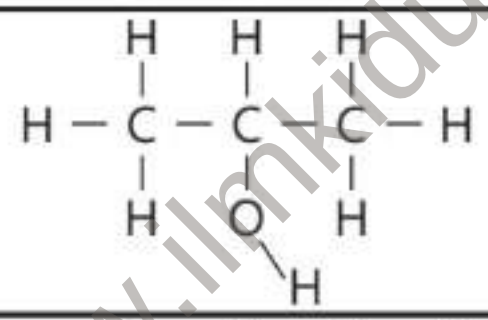
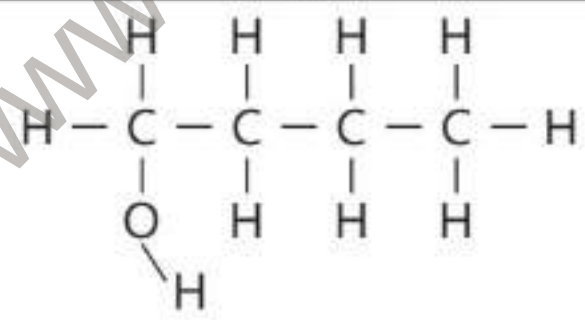
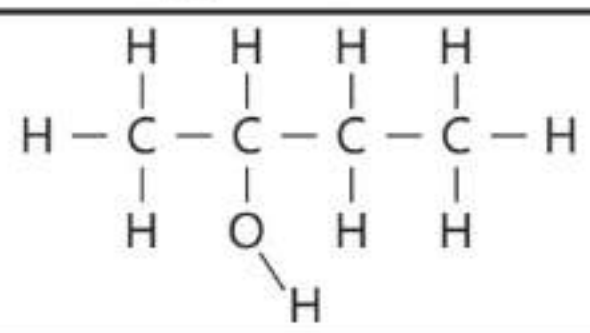
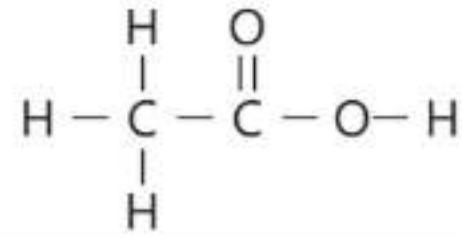
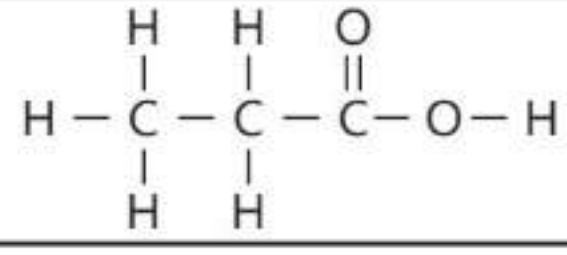
This formula shows the detailed structure of a molecule showing the relative position of atoms, the number and type of bonds between them. The bonds are represented by lines.

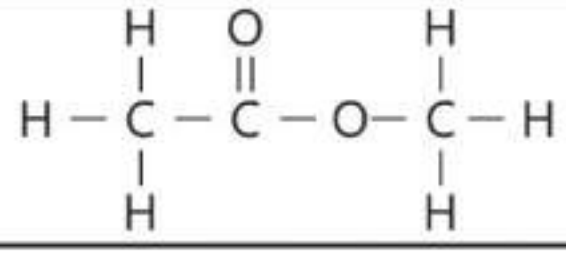
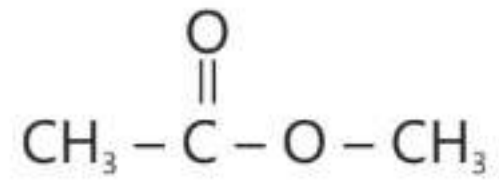
Condensed Structural Formula

This formula still uses lines between bonded atoms, but it omits the carbon to hydrogen bonds.

Table 21.1 Condensed Structural Formulae

Compound	Displayed Formula	Condensed Structural Formula
Ethane		$CH_3 - CH_3$
Ethene		$CH_2 = CH_2$
Ethyne	$H - C \equiv C - H$	$HC \equiv CH$
Propane		$CH_3 - CH_2 - CH_3$

Compound	Displayed Formula	Condensed Structural Formula
Butane		$CH_3 - CH_2 - CH_2 - CH_3$
But-1-ene		$CH_2 = CH - CH_2 - CH_3$
But-2-ene		$Ch_3 - CH = CH - CH_3$
Ethanol		$CH_3 - CH_2 - OH$
Propanol		$CH_2 - CH_2 - CH_3$ | OH
Propan-2-ol		$CH_2 - CH - CH_3$ | OH
Butanol		$CH_2 - CH_2 - CH_2 - CH_3$ | OH
Butan-2-ol		$CH_3 - CH - CH_2 - CH_3$ | OH
Ethanoic acid		$CH_3 - C(=O) - OH$
Propanoic acid		$CH_3 - CH_2 - C(=O) - OH$

Compound	Displayed Formula	Condensed Structural Formula
Methyl ethanoate		

21.2 Quick Check! Write down the displayed and condensed formulae of butan-2-ol, ethyl ethanoate, 2-methylpropane, but-2-ene and pentane.

21.3 Homologous Series

Organic compounds have also been classified into various families. Each family contains closely related organic compounds, as their structure and chemical properties are similar. The different families are known as homologous series.

Characteristics of a Homologous Series

The common characteristics of the members of a homologous series are:

(I) All the members of the series can be represented by a general formula. For example, the general formula for the series of saturated hydrocarbons called alkanes is C_nH_{2n+2} where n represents the number of carbon atoms present in a member. The general formula of some other families are given below.

Series	General formula
Alkenes	C_nH_{2n}
Alkynes	C_nH_{2n-2}
Alcohols	C_nH_{2n+1} OH
Carboxyl acids	C_nH_{2n+1} COOH

21.3 Quick Check!

1. Write down the molecular formula of a carboxylic acid having three carbon atoms.
2. Write down the molecular formula of an alcohol containing four carbon atoms.

(ii) Successive members of the series differ by CH_2 group and 14 units in their relative molecular masses.

(iii) Different members in a family have common functional group e.g. all the members of carboxylic acid family have –COOH group as the functional group.

(iv) The members in any particular family have almost identical chemical properties due to the presence of the same functional group.

(v) The physical properties such as melting point, boiling point, density and solubility show a regular change with the increase in the molecular masses.

(vi) All members of a series can be prepared by similar methods.

21.4 Isomerism

Two or more compounds having the same molecular formula but different structural formulae and properties are said to be isomers and the phenomenon is called structural isomerism.

The simplest hydrocarbon to have structural isomers is butane (C_4H_{10}). Methane, ethane and propane do not show the phenomenon of isomerism because each exists in one structural form only. If we study the structural formula of butane or other higher hydrocarbons of the alkane family, we will observe that it is possible to arrange the atoms present in the molecule in more than one way to satisfy all valencies. This means that it is possible to have two or more different arrangements for the same molecular formula. For example, butane molecule can have two different arrangements as represented by the following structural formulae:

$CH_3 - CH_2 - CH_2 - CH_3$

Butane

$$CH_3 - \underset{\displaystyle CH_3}{\underset{|}{CH}} - CH_3$$

2-Methylpropane

This fact has been supported by an experimental evidence that there are two compounds with different physical properties but with the same molecular formula of C_4H_{10}.

As the number of carbon atoms in a hydrocarbon increases, the number of possible isomers increase very rapidly. The five carbon compounds, pentane, has three isomers. When the number of carbon atoms increases to thirty, the number of isomers are over four billions.

Structural isomerism is not confined to saturated hydrocarbons only. In fact, all classes of organic compounds and their derivatives show the phenomenon of structural isomerism.

Butene (C_4H_8) has two structural isomers.

$CH_3 - CH_2 - CH = CH_2$

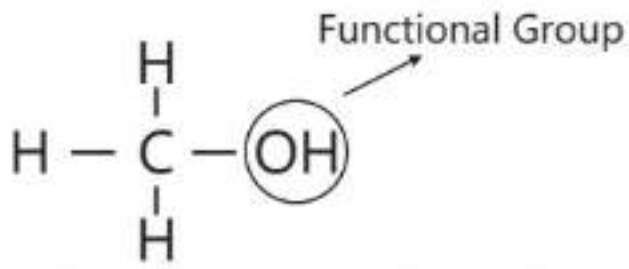
But-1-ene

$CH_3 - CH = CH - CH_3$

But-2-ene

21.5 Functional Group

A functional group may be defined as an atom or group of atoms that determines the characteristic properties of an organic compound. For example, the family of alcohols have its characteristic properties due to the presence of -OH (hydroxyl) group, called the functional group of alcohols.



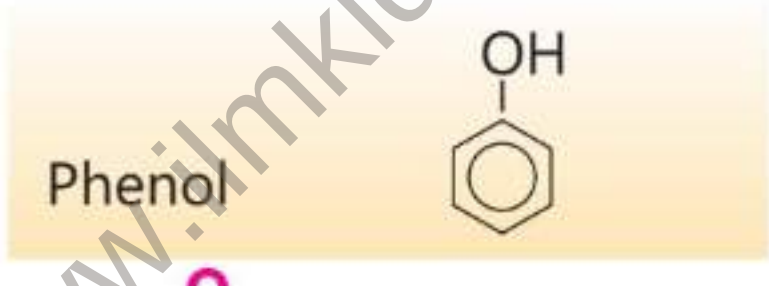
Some important functional groups are described below.

(a) Hydroxyl group (-OH)

This group is present in the family of compounds called alcohols.

$CH_3 - OH$	$CH_3 - CH_2 - OH$
Methanol	Ethanol

If hydroxyl (– OH) group is attached to benzene ring the compound is a member of a series which is named as phenols.



(b) Aldehyde Group ($-\overset{O}{\overset{\|}{C}}-H$)

This group is present in the family called aldehydes. For example,

Methanal or Formaldehyde	$H-\overset{O}{\overset{\|}{C}}-H$	Ethanal or Acetaldehyde	$CH_3-\overset{O}{\overset{\|}{C}}-H$

(c) Ketone Group ($\begin{matrix}R\\R\end{matrix}\!\!>\!C=O$ where R is an alkyl group)

The homologous series which contains a ketonic functional group is called ketones.

Propanone or Acetone $CH_3-\overset{O}{\overset{\|}{C}}-CH_3$

Butanone $CH_3-CH_2-\overset{O}{\overset{\|}{C}}-CH_3$

(d) Carboxyl Group (– C(=O) – OH)

This group is present in the family of compounds called carboxylic acids.

Methanoic acid or Formic acid $H-C(=O)-OH$

Ethanoic acid or Acetic acid $CH_3-C(=O)-OH$

(e) Amino Group (– NH_2)

This group is present in a series of compounds called amines.

Methyl amine CH_3-NH_2

Ethyl amine $CH_3-CH_2-NH_2$

Aniline

(f) Amide Group (– C(=O) – NH_2)

Amide functional group is present in a family called acid amides.

Formamide $H-C(=O)-NH_2$

Acetamide $CH_3-C(=O)-NH_2$

(g) Ester Group (– C(=O) – OR)

Ester group is present in a family called carboxylic esters.

Methyl ethanoate or Methyl acetate $CH_3-C(=O)-OCH_3$

Ethyl ethanoate or Ethyl acetate $CH_3-C(=O)-OC_2H_5$

21.4 Quick Check!

1. How phenols are different from alcohols?
2. What is common between the formula of aldehydic and ketonic functional groups.

21.6 Naming Organic Compounds

The early organic chemists prepared many organic compounds and gave them names which are called common or trivial names. These names are quite often used because they are very simple and easy to use. However, due to existence of a large number of organic compounds and their complexity, it is not possible to give common name to every compound individually. To deal with this problem, the International Union of Pure and Applied Chemistry (IUPAC) has introduced a systematic way of naming organic compounds called IUPAC nomenclature.

Table 21.2 Roots used for IUPAC Names

Root	No. of Carbon atoms
Meth-	1
Eth-	2
Prop-	3
But-	4
Pent-	5
Hex-	6
Hept-	7
Oct-	8
Non-	9
Dec-	10

1 Alkanes

The organic compounds containing carbon and hydrogen only are called hydrocarbons. The hydrocarbons in which all the four valencies of carbon are utilized using single bonds only are called saturated hydrocarbons or alkanes. While those containing at least one double or triple bond are called unsaturated hydrocarbons. The saturated hydrocarbons or alkanes may contain one or more carbon atoms and they may have a straight chain or a branched chain.

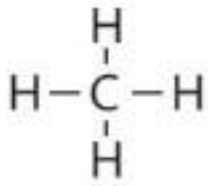
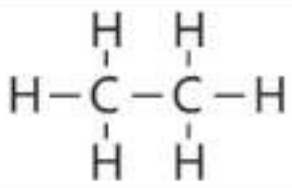
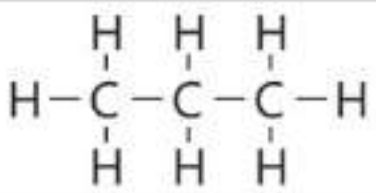
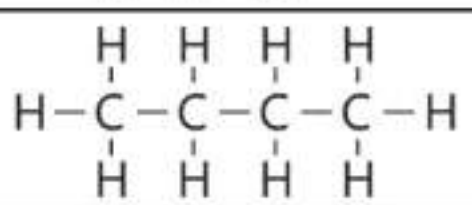
Methane (CH_4)is the simplest member of saturated hydrocarbons.

According to IUPAC system of nomenclature, the entire name of an organic compound has three parts.

1. **Root:** It tells us the number of carbon atoms in the longest continuous chain present in the molecule. The roots up to ten carbon atoms are shown in Table 21.2.
2. **Suffix:** It is added after the root and tells us about the class of organic compound.
3. **Prefix:** It is indicated before the root and tells us about the group or groups attached to the longest chain.

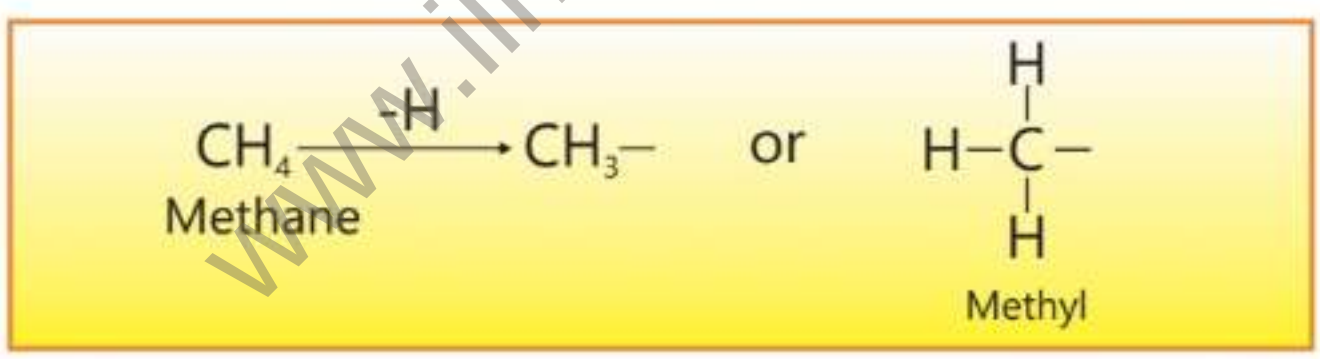
The molecular formulae, the displayed formulae or the condensed structural formulae of some alkanes are given in Table 21.3:

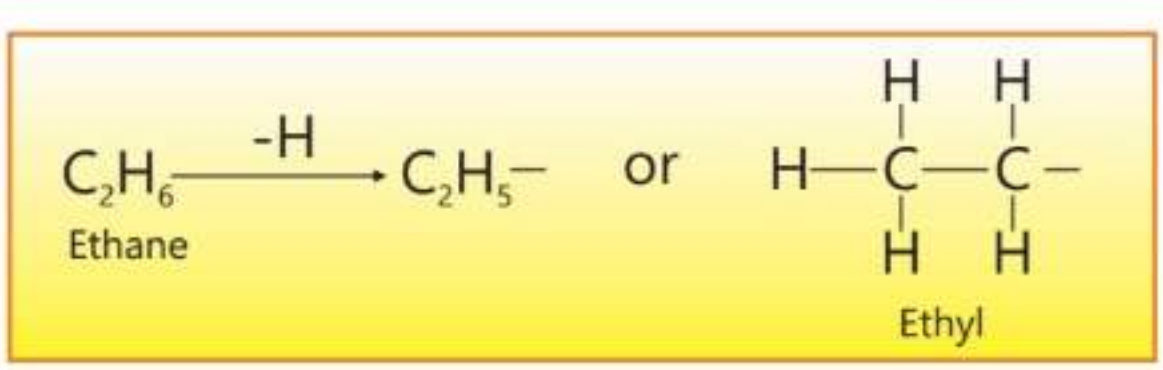
Table 21.3 Formulae of Alkanes

Methane	CH_4	
Ethane	C_2H_6 $CH_3–CH_3$	
Propane	C_3H_8 $CH_3–CH_2–CH_3$	
Butane	C_4H_{10} $CH_3–(CH_2)_2–CH_3$	
Pentane	C_5H_{12}	$CH_3–CH_2–CH_2–CH_2–CH_3$
Hexane	C_6H_{14}	$CH_3–CH_2–CH_2–CH_2–CH_2–CH_3$
Heptane	C_7H_{16}	$CH_3–CH_2–CH_2–CH_2–CH_2–CH_2–CH_3$
Octane	C_8H_{18}	$CH_3–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–CH_3$
Nonane	C_9H_{20}	$CH_3–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–CH_3$
Decane	$C_{10}H_{22}$	$CH_3–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–CH_3$

2 Alkyl Group

An alkyl is formed when an alkane molecule loses one of its many hydrogen atoms. For example,





Generally, an alkane is represented by RH and an alkyl group is represented by R–.

To explain the IUPAC system, let us name the following compound.

$$CH_3-CH_2-CH_2-CH_3$$

a) Identify the longest continuous chain present in the compound.

b) Identify the class of organic compound.

The organic compound contains four carbon atoms in the longest continuous carbon chain and it belongs to the family of hydrocarbons called Alkanes. The root is, therefore, But- and the suffix -ane is added to this. The organic compound will, thus, be given the name Butane.

$CH_3-CH_2-CH_2-CH_3$

Butane — Longest Continuous Chain

21.5 Quick Check!

Name the following compounds according to IUPAC system of nomenclature.

(i) $CH_3 - CH_2 - CH_2 - CH_2 - CH_3$

(ii) $CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2$

3. Alkenes

Hydrocarbons containing at least one carbon to carbon double bond are called Alkenes.

Alkenes are named in the same way as alkanes except the suffix used is –ene. The rules for naming alkenes are as follows.

1. Count the number of carbon atoms in the longest continuous chain that contains both the carbon atoms of the double bond.
2. Number the chain starting from the end nearest to the double bond carbon atom.
3. Write the root, then position of double bond and finally the suffix -ene.

Examples of alkenes are as follows:

$CH_2 = CH_2$
Ethene

$CH_3-CH=CH_2$
Propene

$\overset{1}{C}H_2=\overset{2}{C}H-\overset{3}{C}H_2-\overset{4}{C}H_3$
But-1-ene

$\overset{1}{C}H_3-\overset{2}{C}H=\overset{3}{C}H-\overset{4}{C}H_3$
But-2-ene

$CH_2=CH-CH_2-CH_2-CH_3$
Pent-1-ene

$CH_3-CH=CH-CH_2-CH_3$
Pent-2-ene

4. Alcohols

Monohydroxy derivatives of alkanes are also called alcohols. General formula for alcohol is ROH. According to IUPAC system, alcohols are named observing the following rules.

(i) The longest chain of carbon atoms containing the hydroxyl group is taken as a parent hydrocarbon. The ending **'e'** of alkane is replaced by **'ol'**.

(ii) The longest carbon chain is numbered, starting from the end where carbon atom attached with hydroxyl group gets the lowest possible number.

(iii) The position of hydroxyl group is indicated by a number placed before the **-ol**.

Names and condensed formulae of some simple alcohols are given in the Table 21.4:

Table 21.4 Names and formulas of Alcohols

Alcohol	CH_3OH	CH_3CH_2OH	$\overset{3}{C}H_3-\overset{2}{C}H_2-\overset{1}{C}H_2-OH$
Common Name	Methyl Alcohol	Ethyl Alcohol	Propyl alcohol
IUPAC Name	Methanol	Ethanol	Propan-1-ol
Alcohol	$\overset{1}{C}H_3-\overset{2}{C}H(OH)-\overset{3}{C}H_3$	$\overset{1}{C}H_2(OH)-CH_2-CH_2-CH_3$	$CH_3-CH(OH)-CH_2-CH_3$
Common Name	Iso-Propyl Alcohol	n-Butyl Alcohol	Sec-Butyl Alcohol
IUPAC Name	Propan-2-ol	Butan-1-ol	Butan-2-ol

5. Carboxylic Acids

Organic compounds containing a carboxyl group (–COOH) as a functional group are called carboxylic acids. They are also commonly called fatty acids because some carboxylic acids are obtained from fats. They are represented by the general formula RCOOH.

The IUPAC names of carboxylic acids are derived from the names of alkanes containing the same number of carbon atoms as the acid. The ending 'e' of the alkane name is replaced by '-oic' acid.

The common and IUPAC names of some common carboxylic acids are shown in Table 21.5.

Interesting Information

The common names of carboxylic acids are derived from the source from which they were first isolated. Formic acid was first isolated from red ants. The Latin word Formica means ant. Similarly acetic acid was isolated from vinegar. The Latin word for vinegar is acetum.

Table (21.5) Names of Carboxylic Acids

Carboxylic Acids	HCOOH	CH_3COOH	CH_3CH_2COOH	$CH_3CH_2CH_2COOH$
Common Name	Formic acid	Acetic acid	Propionic acid	Butyric acid
IUPAC Name	Methanoic acid	Ethanoic acid	Propanoic acid	Butanoic acid

6. Esters

Esters are sweet smelling compounds. They are commonly used as flavouring agents in certain food items. They are represented by a general formula RCOOR.

Esters can be prepared by reacting an alcohol with a carboxylic acid in the presence of an acid catalyst.

$$\underset{\text{Propanoic acid}}{CH_3CH_2COOH} + \underset{\text{Ethanol}}{CH_3\text{-}CH_2\text{-}OH} \rightleftharpoons^{H^+} \underset{\text{Ethyl Propanoate}}{CH_3CH_2COOCH_2CH_3} + H_2O$$

Common and IUPAC names of esters are shown in Table 21.6.

Table 21.6 Common Names of some Esters

Esters	CH_3COOCH_3	$CH_3COOCH_2CH_3$	$HCOOCH_2CH_3$
Common Name	Methyl acetate	Ethyl acetate	Ethyl formate
IUPAC Name	Methyl ethanoate	Ethyl ethanoate	Ethyl methanoate
Esters	$CH_3CH_2COOC_2H_5$	$CH_3CH_2COOCH_3$	$CH_3CH_2CH_2COOCH_3$
Common Name	Ethyl Propionate	Methyl Propionate	Methyl butyrate
IUPAC Name	Ethyl propanoate	Methyl propanoate	Methyl butanoate

21.6 Quick Check!

- Condensed structural formulae of some organic compounds are given below. Write down the names of their families.

(i) $CH_3-\underset{\displaystyle OH}{\underset{|}{CH}}-CH_3$

(ii) $CH_3-CH_2-\overset{\displaystyle O}{\overset{\|}{C}}-CH_3$

(iii) $CH_3-\underset{\displaystyle CH_3}{\underset{|}{C}}=CH-CH_3$

(iv) $\underset{\displaystyle COOH}{\underset{|}{CH_2}}-CH_2-CH_3$

(v) C_3H_6

(vi) C_5H_{12}

(vii) $H-\overset{\displaystyle O}{\overset{\|}{C}}-H$

(viii) $CH_3-CH_2-\overset{\displaystyle O}{\overset{\|}{C}}-O-CH_2-CH_3$

EXERCISE

A Multiple Choice Questions

Choose and tick the correct answer from the given choices.

1. Choose the correct IUPAC name for the compound $HC(=CH_2)-CH_2-CH_3$.

(a) But-3-ene (b) But-1-ene

(c) But-2-ene (d) Butene

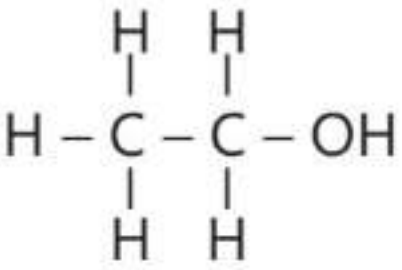
2. Select a branched chain compound.

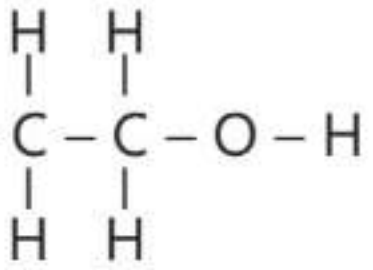
(a) $CH_2 = CH - CH_2 - CH_3$ (b) $CH_2 = \underset{\displaystyle CH_3}{\underset{|}{C}} - CH - CH_3$

(c) $CH_3 - CH = CH - CH_3$ (d) $CH_3 - CH = CH - CH_2 - CH_3$

3. Which is the displayed formula of ethanol?

(a) C_2H_5OH (b) $CH_3 - CH_2 - OH$

(c)


(d)


4. Identify the aldehydic functional group among the following:

(a) $-\overset{\overset{O}{\|}}{C}-OH$ (b) $-OH$

(c) $-\overset{\overset{O}{\|}}{C}-$ (d) $-\overset{\overset{O}{\|}}{C}-H$

5. Select the general formula of alkyne family.

(a) C_nH_{2n+1} (b) C_nH_{2n}

(c) C_nH_{2n-2} (d) C_nH_{2n-1}

6. How many structural isomers will be there for a saturated hydrocarbon having five carbon atoms?

(a) 2 (b) 3

(c) 4 (d) 5

7. Which ester among the following will be called ethyl propanoate?

(a) $CH_3-\overset{\overset{O}{\|}}{C}-OCH_3$ (b) $CH_3-CH_2-\overset{\overset{O}{\|}}{C}-OCH_3$

(c) $CH_3-\overset{\overset{O}{\|}}{C}-OC_2H_5$ (d) $CH_3-CH_2-\overset{\overset{O}{\|}}{C}-OC_2H_5$

8. Which functional group is present in alkenes?

(a) No functional group

(b) Carbon-carbon triple bond

(c) Carbon-carbon double bond

(d) Carbon-carbon single bond

B Short Answer Questions

21.1 What is the difference between saturated and unsaturated hydrocarbons?

21.2 Write down the structural formula of Butan-2-ol.

21.3 Why is ethylamine $CH_3 - CH_2 - NH_2$ called an organic compound?

21.4 Write down the formula of an ester called ethyl methanoate.

21.5 Define structural isomerism.

21.6 Give IUPAC name to $CH_3 - CH_2 - CH_2 - CH_3$

21.7 What is common in carboxyl group, amide functional group and ester functional group?

C Constructed Response Questions

21.1 Why the members of a homologous series have similar chemical properties?

21.2 How are the properties of 2-methylpropane different from n-butane, both containing the same number of carbon atoms?

21.3 Write down the structural formulae of isomers shown by saturated hydrocarbon containing five carbon atoms.

21.4 Write down the structural formulae of the isomers shown by butene.

21.5 Explain the difference among functional groups present in aldehyde, ketone and carboxylic acid.

D Descriptive Questions

21.1 What is an organic compound? How organic compounds are classified based on the type of carbon chain present in them?

21.2 Explain structural formula giving examples.

21.3 Write down five characteristics of a homologous series.

21.4 Give IUPAC rules for naming alcohols.

21.5 Name the following compounds.

(a) $CH_3 - CH_2 - CH_2OH$

(b) $CH_3 - CH_2 - CHO$

(c) $CH_3 - CH_2 - CH_2 - COOH$

(d) $CH_3 - CH_2 - CO - O - CH_3$