

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 $\text{CH}_2=\text{CH}_2$, $\text{CH}_3\text{CH}_2\text{OH}$, $\text{CH}_3\text{COOCH}_3$
- 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 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$ and $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_3$ and C_2H_4 as $\text{CH}_2\text{CH}=\text{CH}_2$ and $\text{CH}_3\text{CH}=\text{CHCH}_3$.
- 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 -oic 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.

Subjective Type Questions

Long Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

21.1 + 21.2 Classifications of Organic Compounds + Structural Formula

Q.1: What is an organic compound? How organic compound are classified based on the type of carbon chain present in them?

Ans. Organic Compound:

An organic compound is chemical compound primarily compound of carbon atoms that are covalently bonded to each other or the 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.

Classifications of Organic Compounds:

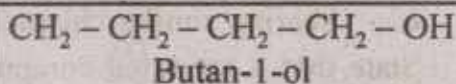
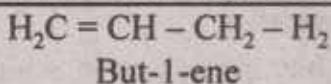
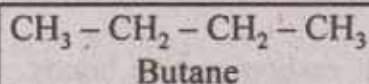
There are millions of organic compounds. It is practically not possible to study each individual compound. To facilitate their study, organic compounds are classified into various groups and sub-groups. They may be broadly classified into the following classes:

- (i) Open chain or Acyclic compounds.
- (ii) Closed chain or Cyclic (or ring) compounds

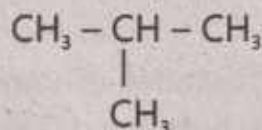
(i) Open Chain or Acyclic Compounds:

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.

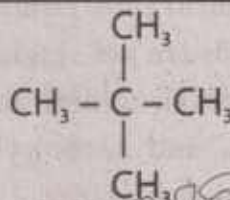
Straight chain (or non-branched) compounds:



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.

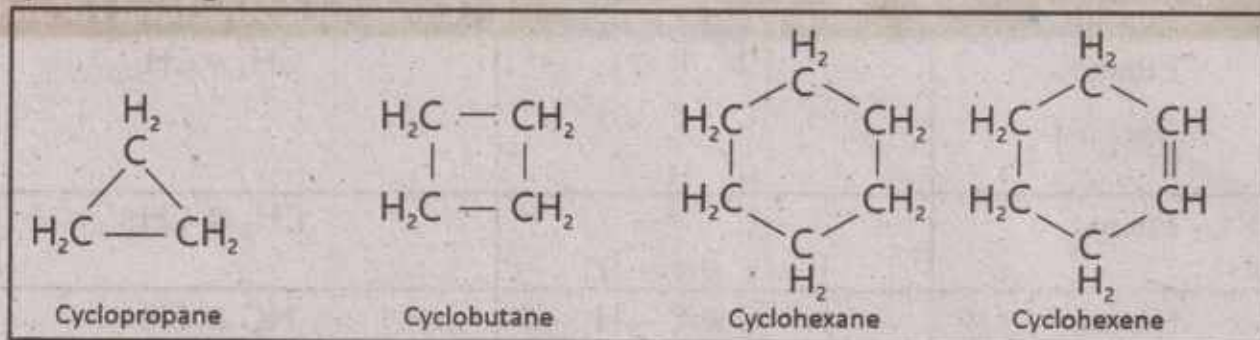
When the ring contains carbon atoms only, the compounds are called carbocyclic compounds. However, if the ring contains other atoms alongwith carbon atoms, the

compounds are called heterocyclic compounds. Carbocyclic compounds are further classified as;

- (i) Alicyclic compounds (ii) Aromatic compounds

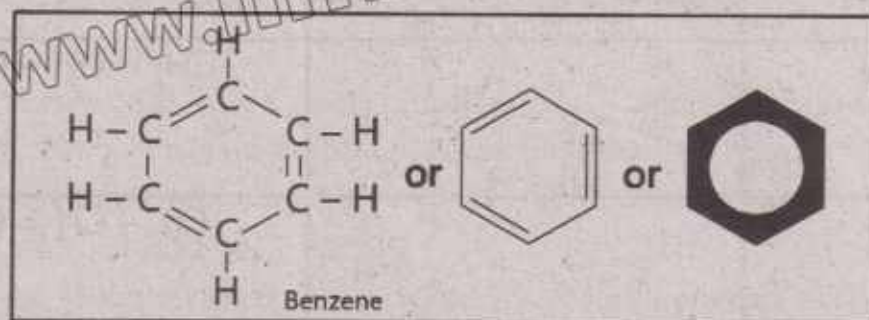
(i) Alicyclic compounds:

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.



(ii) 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.



Q.2: Explain structural formula giving examples.

Ans. Structural Formula:

The structural formula of a compound shows the arrangement of atoms and bonds present in that compound.

Explanation:

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.

Condensed Structural Formulae

Compound	Displayed Formula	Condensed Structural Formula
Ethane	$\begin{array}{c} \text{H} & \text{H} \\ & \\ \text{H}-\text{C}- & \text{C}-\text{H} \\ & \\ \text{H} & \text{H} \end{array}$	$\text{CH}_3 - \text{CH}_3$
Ethene	$\begin{array}{c} \text{H} & \text{H} \\ & \\ \text{H}-\text{C} = & \text{C}-\text{H} \\ & \\ \text{H} & \text{H} \end{array}$	$\text{CH}_2 = \text{CH}_2$
Ethyne	$\text{H}-\text{C} \equiv \text{C}-\text{H}$	$\text{HC} \equiv \text{CH}$
Propane	$\begin{array}{c} \text{H} & \text{H} & \text{H} \\ & & \\ \text{H}-\text{C}- & \text{C}- & \text{C}-\text{H} \\ & & \\ \text{H} & \text{H} & \text{H} \end{array}$	$\text{CH}_3 - \text{CH}_2 - \text{CH}_3$
Butane	$\begin{array}{c} \text{H} & \text{H} & \text{H} & \text{H} \\ & & & \\ \text{H}-\text{C}- & \text{C}- & \text{C}- & \text{C}-\text{H} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array}$	$\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3$
But-1-ene	$\begin{array}{c} & & \text{H} & \text{H} \\ & & & \\ \text{H} & \text{C} = & \text{C}- & \text{C}- & \text{C}-\text{H} \\ & & & \\ \text{H} & & \text{H} & \text{H} \end{array}$	$\text{CH}_2 = \text{CH} - \text{CH}_2 - \text{CH}_3$
But-2-ene	$\begin{array}{c} & & & \text{H} \\ & & & \\ \text{H} & \text{C}- & \text{C} = & \text{C}- & \text{C}-\text{H} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array}$	$\text{CH}_3 - \text{CH} = \text{CH} - \text{CH}_3$
Ethanol	$\begin{array}{c} \text{H} & \text{H} \\ & \\ \text{H}-\text{C}- & \text{C}-\text{O}-\text{H} \\ & \\ \text{H} & \text{H} \end{array}$	$\text{CH}_3 - \text{CH}_2 - \text{OH}$
Propanol	$\begin{array}{c} \text{H} & \text{H} & \text{H} \\ & & \\ \text{H}-\text{C}- & \text{C}- & \text{C}-\text{H} \\ & & \\ \text{O} & \text{H} & \text{H} \\ \\ \text{H} \end{array}$	$\begin{array}{c} \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \\ \\ \text{OH} \end{array}$
Propan-2-ol	$\begin{array}{c} \text{H} & \text{H} & \text{H} \\ & & \\ \text{H}-\text{C}- & \text{C}- & \text{C}-\text{H} \\ & & \\ \text{H} & \text{O} & \text{H} \\ & \\ & \text{H} \end{array}$	$\begin{array}{c} \text{CH}_2 - \text{CH} - \text{CH}_3 \\ \\ \text{OH} \end{array}$

Butanol	$ \begin{array}{ccccccc} & \text{H} & \text{H} & \text{H} & \text{H} & & \\ & & & & & & \\ \text{H} & - \text{C} & - \text{C} & - \text{C} & - \text{C} & - \text{H} \\ & & & & & & \\ & \text{O} & \text{H} & \text{H} & \text{H} & & \\ & & & & & & \\ & \text{H} & & & & & \end{array} $	$ \begin{array}{c} \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \\ \\ \text{OH} \end{array} $
Butan-2-ol	$ \begin{array}{ccccccc} & \text{H} & \text{H} & \text{H} & \text{H} & & \\ & & & & & & \\ \text{H} & - \text{C} & - \text{C} & - \text{C} & - \text{C} & - \text{H} \\ & & & & & & \\ & \text{H} & \text{O} & \text{H} & \text{H} & & \\ & & & & & & \\ & & \text{H} & & & & \end{array} $	$ \begin{array}{c} \text{CH}_3 - \text{CH} - \text{CH}_2 - \text{CH}_3 \\ \\ \text{OH} \end{array} $
Ethanoic acid	$ \begin{array}{ccccccc} & \text{H} & & \text{O} & & & \\ & & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - \text{O} & - \text{H} \\ & & & & & & \\ & \text{H} & & & & & \end{array} $	$ \begin{array}{c} \text{O} \\ \\ \text{CH}_3 - \text{C} - \text{OH} \end{array} $
Propanoic acid	$ \begin{array}{ccccccc} & \text{H} & \text{H} & & \text{O} & & \\ & & & & & & \\ \text{H} & - \text{C} & - \text{C} & - & \text{C} & - \text{O} & - \text{H} \\ & & & & & & \\ & \text{H} & \text{H} & & & & \end{array} $	$ \begin{array}{c} \text{O} \\ \\ \text{CH}_3 - \text{CH}_2 - \text{C} - \text{OH} \end{array} $
Methyl ethanoate	$ \begin{array}{ccccccc} & \text{H} & & \text{O} & & \text{H} & \\ & & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - \text{O} & - \text{C} & - \text{H} \\ & & & & & & \\ & \text{H} & & & & \text{H} & \end{array} $	$ \begin{array}{c} \text{O} \\ \\ \text{CH}_3 - \text{C} - \text{O} - \text{CH}_3 \end{array} $

21.3 + 21.4 + 21.5

Homologous Series + Isomerism + Functional Group

Q.3: Write down five characteristics of a homologous series.

Ans. Homologous Series:

Organic compounds have 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:

- 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 $\text{C}_n\text{H}_{2n+2}$ 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	$\text{C}_n\text{H}_{2n-2}$
Alcohols	$\text{C}_n\text{H}_{2n+1}\text{OH}$
Carboxyl acids	$\text{C}_n\text{H}_{2n+1}\text{COOH}$

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

Q.4: Write a detailed note on isomerism.

Ans. 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.

Simplest Hydrocarbon:

The simplest hydrocarbon to have structural isomers is butane (C_4H_{10}).

Hydrocarbons not showing Isomerism:

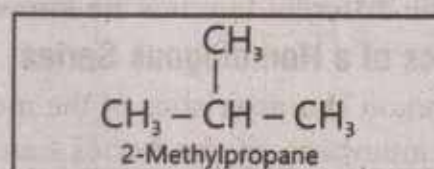
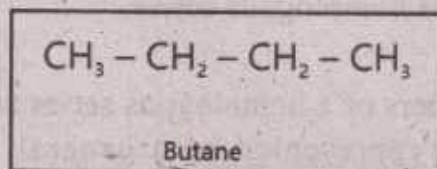
Methane, ethane and propane do not show the phenomenon of isomerism because each exists in one structural form only.

Same Molecular Formula:

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.

Example:

Butane molecule can have two different arrangements as represented by the following structural formulae:



Support by on Experimental Evidence:

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} .

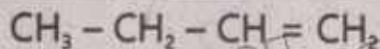
Relationship between Carbon Atoms and Isomers:

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 in Unsaturated Hydrocarbons:

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.



But-1-ene



But-2-ene

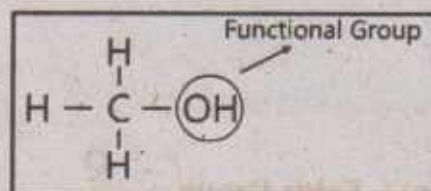
Q.5: Discuss some important functional groups.

Ans. Functional Group:

A functional group may be defined as an atom or group of atoms that determines the characteristic properties of an organic compound.

Example:

The family of alcohols have its characteristic properties due to the presence of -OH (hydroxyl) group, called the functional group of alcohols.



Important Functional Groups:

Some important functional groups are described below.

(a) Hydroxyl group (-OH):

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

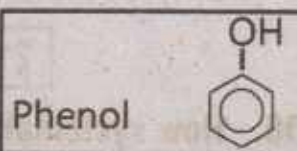


Methanol



Ethanol

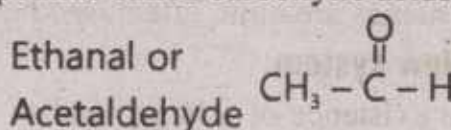
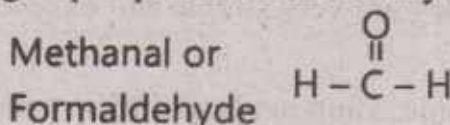
If hydroxyl (-OH) group is attached to benzene ring the compound is a member of a series which is named as phenols.



Phenol

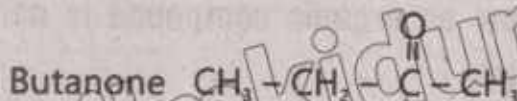
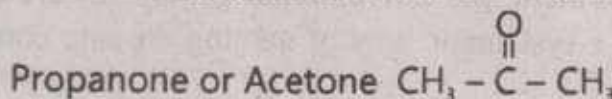
(b) Aldehyde Group ($\text{-}\overset{\text{O}}{\parallel}{\text{C}}\text{-H}$):

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



(c) Ketone Group ($\text{R} > \text{C} = \text{O}$ where R is an alkyl group):

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



(d) Carboxyl Group ($\text{-}\overset{\text{O}}{\parallel}{\text{C}}\text{-OH}$):

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

Methanoic acid or Formic acid $\text{H}-\overset{\text{O}}{\parallel}{\text{C}}-\text{OH}$

Ethanoic acid or Acetic acid $\text{CH}_3-\overset{\text{O}}{\parallel}{\text{C}}-\text{OH}$

(e) **Amino Group ($-\text{NH}_2$):**

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

Formamide $\text{H}-\overset{\text{O}}{\parallel}{\text{C}}-\text{NH}_2$

Acetamide $\text{CH}_3-\overset{\text{O}}{\parallel}{\text{C}}-\text{NH}_2$

(g) **Ester Group ($-\overset{\text{O}}{\parallel}{\text{C}}-\text{OR}$):**

Ester group is present in a family called carboxylic esters.

Methyl ethanoate or
Methyl acetate $\text{CH}_3-\overset{\text{O}}{\parallel}{\text{C}}-\text{OCH}_3$

Ethyl ethanoate or
Ethyl acetate $\text{CH}_3-\overset{\text{O}}{\parallel}{\text{C}}-\text{OC}_2\text{H}_5$

21.6

Naming Organic Compounds

Q6. How systematic way of naming organic compounds was introduced?

Ans. Historical Naming of 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.

Need of a New system:

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.

Introduction of the IUPAC System of Nomenclature:

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.

Q7. What are Alkanes. How an organic compound is named according to IUPAC system of Nomenclature.

Ans. Hydrocarbons:

The organic compounds containing carbon and hydrogen only are called hydrocarbons.

Saturated Hydrocarbons:

The hydrocarbons in which all the four valencies of carbon are utilized using single bonds only are called saturated hydrocarbons or alkanes.

Unsaturated hydrocarbons:

The hydrocarbons containing at least one double or triple bond are called unsaturated hydrocarbons.

Carbon Atoms in Saturated 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 (CH₄):

Methane (CH₄) is the simplest member of saturated hydrocarbons.

Naming of an Organic Compound According IUPAC system:

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.

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

Molecular Formulae, Displayed Formulae or Condensed Structural Formulae"

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

Formulae of Alkanes

Methane	CH ₄	$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H} \end{array}$
Ethane	C ₂ H ₆ CH ₃ - CH ₃	$\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array}$
Propane	C ₃ H ₈ CH ₃ - CH ₂ - CH ₃	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array}$
Butane	C ₄ H ₁₀ CH ₃ - (CH ₂) ₂ - CH ₃	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array}$
Pentane	C ₅ H ₁₂	CH ₃ - CH ₂ - CH ₂ - CH ₂ - CH ₃

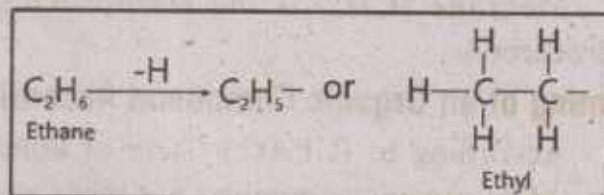
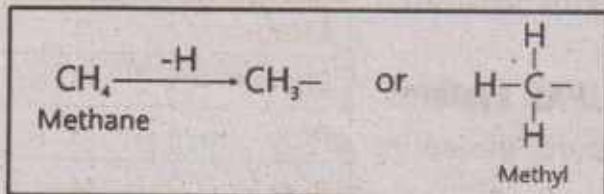
Hexane	C_6H_{14}	$CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3$
Heptane	C_7H_{16}	$CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3$
Octane	C_8H_{18}	$CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3$
Nonane	C_9H_{20}	$CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3$
Decane	$C_{10}H_{22}$	$CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3$

Q.8: How is Alkyl Group formed?

Ans. Alkyl Group:

An alkyl group is functional group which is formed when an alkane molecule loses one of its many hydrogen atoms.

Example:



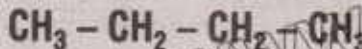
Representation of an Alkane:

An Alkane is represented by $R-H$.

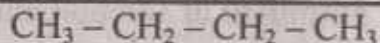
Representation of an Alkyl Group:

An Alkyl group is represented by $R-$.

Q9. Name the following compound to explain the IUPAC System.

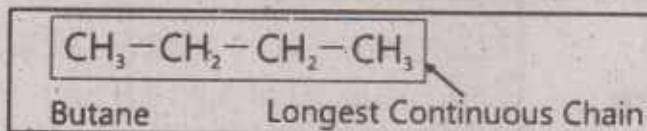


Ans. To explain the IUPAC system, let us name the following compound.



- Identify the longest continuous chain present in the compound.
- 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.



Q.10: What are Alkenes. How are Alkenes named using IUPAC System?

Ans. 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.

- 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:

$\text{CH}_2 = \text{CH}_2$ Ethere	$\text{CH}_3 - \text{CH} = \text{CH}_2$ Propene
$\overset{1}{\text{CH}_2} = \overset{2}{\text{CH}} - \overset{3}{\text{CH}_2} - \overset{4}{\text{CH}_3}$ But-1-ene	$\overset{1}{\text{CH}_3} - \overset{2}{\text{CH}} = \overset{3}{\text{CH}} - \overset{4}{\text{CH}_3}$ But-2-ene
$\text{CH}_2 = \text{CH} - \text{CH}_2 - \text{CH}_2 - \text{CH}_3$ Pent-1-ene	$\text{CH}_3 - \text{CH} = \text{CH} - \text{CH}_2 - \text{CH}_3$ Pent-2-ene

Q.11: Give IUPAC rules for naming alcohols.

Ans. Alcohols:

Monohydroxy derivatives of alkanes are also called alcohols.

General Formula:

General formula for alcohol is ROH.

Naming Alcohols:

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:

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

Names and formulas of Alcohols

Alcohol	CH_3OH	$\text{CH}_3\text{CH}_2\text{OH}$	$\overset{3}{\text{CH}_3} - \overset{2}{\text{CH}_2} - \overset{1}{\text{CH}_2} \text{OH}$
Common Name	Methyl Alcohol	Ethyl Alcohol	Propyl alcohol
IUPAC Name	Methanol	Ethanol	Propan-1-ol
Alcohol	$\overset{1}{\text{CH}_3} - \overset{2}{\underset{\text{OH}}{\text{CH}}} - \overset{3}{\text{CH}_3}$	$\text{CH}_3 - \text{CH}_2 - \underset{\text{OH}}{\text{CH}_2} - \text{CH}_3$	$\text{CH}_3 - \underset{\text{OH}}{\text{CH}} - \text{CH}_2 - \text{CH}_3$
Common Name	Iso-Propyl Alcohol	n-Butyl Alcohol	Sec-Butyl Alcohol
IUPAC Name	Propan-2-ol	Butan-1-ol	Butan-2-ol

Q.12: What are Carboxylic acids. How are they named by IUPAC system?

Ans. 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 .

General Formula:

They are represented by the general formula RCOOH .

IUPAC Names of Carboxylic Acids:

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 given below:

Names of Carboxylic Acids

Carboxylic Acids	HCOOH	CH_3COOH	$\text{CH}_3\text{CH}_2\text{COOH}$	$\text{CH}_3\text{CH}_2\text{COOH}$
Common Name	Formic acid	Acetic acid	Propionic acid	Butyric acid
IUPAC Name	Methanoic acid	Ethanoic acid	Propanoic acid	Butanoic acid

Q.13: What are Esters? Give some common and IUPAC names of Esters.

Ans. Esters:

Esters are sweet smelling compounds.

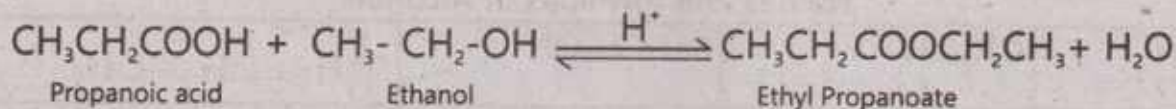
Uses of Esters:

They are commonly used as flavouring agents in certain food items.

General Formula:

They are represented by a general formula RCOOR .

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



Common and IUPAC Names of Esters:

Common and IUPAC names of esters are shown in Table given below:

Common Names of some Esters

Esters	$\text{CH}_3\text{COOCH}_3$	$\text{CH}_3\text{COOCH}_2\text{CH}_3$	$\text{HCOOCH}_2\text{CH}_3$
Common Name	Methyl acetate	Ethyl acetate	Ethyl formate
IUPAC Name	Methyl ethanoate	Ethyl ethanoate	Ethyl methanoate
Esters	$\text{CH}_3\text{CH}_2\text{COOC}_2\text{H}_5$	$\text{CH}_3\text{CH}_2\text{COOCH}_3$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{COOCH}_3$
Common Name	Ethyl Propionate	Methyl Propionate	Methyl butyrate
IUPAC Name	Ethyl propanoate	Methyl propanoate	Methyl butanoate

21.1 Quick Check!

1. What is the difference between cyclohexane and benzene?

Ans. Cyclohexane

It is an alicyclic compound with single bonds between carbon atoms (C_6H_{12}).

Benzene

It is an aromatic compound with alternate double and single bonds in a six carbon ring (C_6H_6).

2. Give the examples of branched chain compounds.

Ans. (i) 2-Methyl propane (ii) 2,2-Dimethylpropane

21.2 Quick Check!

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

Ans.

Compound	Displayed Formula	Condensed Structural
Butan-2-ol	$ \begin{array}{ccccccc} & H & & H & & H & & H \\ & & & & & & & \\ H & - C & - & C & - & C & - & C - H \\ & & & & & & & \\ & H & & O & & H & & H \\ & & & & & & & \\ & & & H & & & & \end{array} $	$ \begin{array}{c} CH_3 - CH - CH_2 - CH_3 \\ \\ OH \end{array} $
Ethyl ethanoate	$ \begin{array}{ccccccc} & H & & O & & H & & H \\ & & & & & & & \\ H & - C & - & C & - O & - C & - C - H \\ & & & & & & & \\ & H & & & & H & & H \end{array} $	$ \begin{array}{c} CH_3 - C(=O) - O - CH_2 - CH_3 \end{array} $
2-Methyl propane	$ \begin{array}{ccccccc} & H & & H & & H \\ & & & & & \\ H & - C & - & C & - & C - H \\ & & & & & \\ & H & & C & & H \\ & & & & & \\ & & & H & & \end{array} $	$ \begin{array}{c} CH_3 - CH - CH_3 \\ \\ CH_3 \end{array} $
But-2-ene	$ \begin{array}{ccccccc} & & & & & H & & \\ & H & & & & & & \\ & & & & & & & \\ H & - C & - & C = & C & - C - H \\ & & & & & & & \\ & H & & H & & H & & H \end{array} $	$CH_3 - CH = CH - CH_3$
Pentane	$ \begin{array}{ccccccc} & H & & H & & H & & H & & H \\ & & & & & & & & & \\ H & - C & - & C & - & C & - & C & - & C - H \\ & & & & & & & & & \\ & H & & H & & H & & H & & H \end{array} $	$CH_3 - CH_2 - CH_2 - CH_2 - CH_3$

21.3 Quick Check!

1. Write down the molecular formula of a carboxylic acid having three carbon atoms.

Ans. The general formula for a carboxylic acid is $C_nH_{2n+1}COOH$. For a molecule with a total of three carbon atoms, one carbon is already part of the functional group ($-COOH$), so we let $n = 2$ for the alkyl group.

Name = Propanoic acid

Molecular Formula = $C_3H_6O_2$

Condensed Formula = $CH_3 - CH_2 - \overset{\overset{O}{||}}{C} - OH$

2. Write down the molecular formula of an alcohol containing four carbon atoms.
Ans. The general formula of an alcohol is $C_nH_{2n+1}OH$. For a molecule with four carbon atoms, we let $n = 4$

Name = Butanol (Specifically 1-Butanol)
Molecular Formula = $C_4H_{10}O$
Condensed Formula = $CH_3 - CH_2 - CH_2 - CH_2 - OH$

21.4 Quick Check!

1. How phenols are different from alcohols?

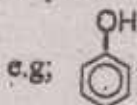
Ans. Both phenols and alcohols contain the hydroxyl group ($-OH$) but they differ based on the structure they are attached to:

Attachment of ($-OH$) in Alcohols

In alcohols the group ($-OH$) is attached to an aliphatic carbon atom (a chain-like structure, e.g., $CH_3 - CH_2 - OH$).

Attachment of ($-OH$) in phenols

In phenols, the group ($-OH$) is directly attached to a carbon atom of an aromatic benzene ring.



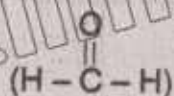
2. What is common between the formula of aldehydic and ketonic functional groups.

Ans. Aldehyde and ketone functional groups both contain the carbonyl group ($C=O$)

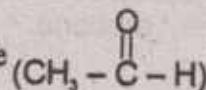
Aldehyde: In aldehyde, it is at the end of the chain ($\sim C-H$)

Examples

• Methanal or Formaldehyde



• Ethanal or Acetaldehyde

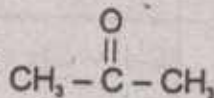


Ketone:

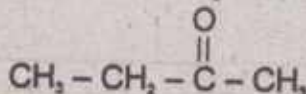
In ketone, it is between two carbon atoms ($\begin{matrix} R \\ \diagdown \\ C=O \\ \diagup \\ R \end{matrix}$)

Examples

• Propanone or Acetone



• Butanone



21.5 Quick Check!

1. Name the following compounds according to IUPAC system of nomenclature.

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

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

Ans. Number of carbons: 5

Root Name: Pent-

Suffix: -ane (Since it is a saturated hydrocarbon)

IUPAC Name: Pentane

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

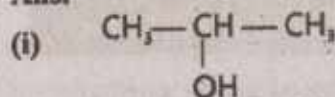
Ans. Number of carbons: 7

Root Name: Hept -
 Suffix: -ane (since it is a saturated hydrocarbon)
 IUPAC Name: Heptane

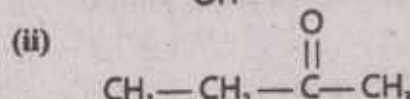
21.6 Quick Check!

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

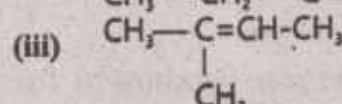
Ans.



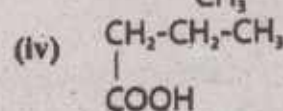
Ans: Family Name = Alcohol



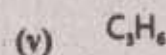
Ans: Family Name = Ketone



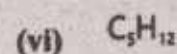
Ans: Family Name = Alkene



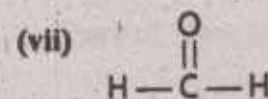
Ans: Family Name = Carboxylic Acid



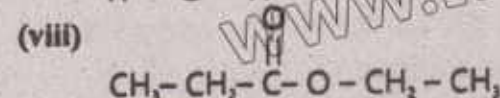
Ans: Family Name = Alkene (Propene)



Ans: Family Name = Alkane (Pentane)



Ans: Family Name = Aldehyde



Ans: Family Name = Ester

INTERESTING INFORMATION

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

INTERESTING INFORMATION

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

INTERESTING INFORMATION

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



Objective Type Questions

Additional MCQ's

Multiple Choice Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

21.1 + 21.2

Classifications of Organic Compounds + Structural Formula

- Organic chemistry is primarily defined as the study of compounds containing which two elements?
(a) Hydrogen and Oxygen (b) Carbon and Nitrogen
(c) Carbon and Oxygen (d) Carbon and Hydrogen
- Which of the following is considered as an inorganic carbon compound for historical reasons?
(a) Benzene (b) Ethane
(c) Calcium Carbonate (d) Methane
- What is another name for open chain organic compounds?
(a) Aromatic compounds (b) Alicyclic compounds
(c) Heterocyclic compounds (d) Acyclic compounds
- A compound with a continuous series of carbon atoms without any branch is called a:
(a) Branched chain compound (b) Aromatic compound
(c) straight chain compound (d) Cyclic compound
- Cyclic compounds containing only carbon atoms in the ring are called:
(a) Acyclic compounds (b) Homocyclic compounds
(c) Aliphatic compounds (d) Heterocyclic compounds
- What is the general formula for saturated alicyclic hydrocarbons?
(a) C_nH_{2n} (b) C_nH_{2n-2} (c) C_nH_{2n+2} (d) C_nH_n
- Which molecule is a common example of an aromatic compound containing six carbons and alternate double bonds?
(a) Cyclo butane (b) Benzene (c) Propane (d) Cyclohexane
- A formula that shows the relative position of every atom and all bonds represented by lines is called a/an:
(a) Empirical formula (b) Condensed structural formula
(c) displayed structural formula (d) Molecular formula
- Condensed structural formula of Ethane is:
(a) CH_3-CH_3 (b) $CH_2=CH_2$ (c) $HC\equiv CH$ (d) $CH_3-CH_2-CH_3$
- Condensed structural formula of But-2-ene is:
(a) $CH_3-C(OH)-CH_2-CH_3$ (b) $CH_3-CH_2-CH_2-CH_3$
(c) $CH_3-CH=CH-CH_3$ (d) $CH_2=CH-CH_2-CH_3$

11. What is the general formula for the Alkynes series?
 (a) C_nH_{2n+2} (b) C_nH_{2n-2} (c) C_nH_{2n+1} (d) C_nH_{2n}
12. Which of these hydrocarbons does Not show structural isomerism?
 (a) Pentane (b) Butane (c) Hexane (d) Propane
13. The functional group ($-OH$) attached to an alkyl group identifies which family?
 (a) Aldehydes (b) Alcohols (c) Ethers (d) Phenols
14. Which functional group is present in both Aldehydes and ketones?
 (a) Amino group (b) Carbonyl group (c) Carboxyl group (d) Hydroxyl group
15. Which is the name of the simplest aldehyde also known as formaldehyde?
 (a) Propanone (b) Ethanal (c) Methanol (d) Methanal
16. It is a compound containing a Nitrogen atom in its functional group.
 (a) Methyl ethanoate (b) Methyl amine
 (c) Acetone (d) Phenol
17. What is the specific functional group for Ester?
 (a) $-CHO$ (b) $-COOR$ (c) $CO-NH_2$ (d) $-NH_2$
18. Which of the following is the formula for Acetone (Propanone)?
 (a) $CH_3-CO-CH_3$ (b) CH_3-CHO
 (c) CH_3-COOH (d) CH_3-NH_2
19. If a hydroxyl ($-OH$) group is attached to a benzene ring, the compound is a member of:
 (a) Phenols (b) Alcohols (c) Ketones (d) Esters
20. Successive members of a homologous series differ in molecular mass by how many units?
 (a) 12 units (b) 16 units (c) 2 units (d) 14 units

21.6

Naming Organic Compounds

21. Which part of the IUPAC name indicates the number of carbon atoms in the longest continuous chain?
 (a) Infix (b) Root (c) Prefix (d) Suffix
22. What is the IUPAC root for a compound containing seven carbon atoms?
 (a) Non- (b) Hept- (c) Hex- (d) Oct-
23. An alkyl group is formed when an alkane loses how many hydrogen atoms?
 (a) Four (b) Two (c) Three (d) One
24. What is the correct IUPAC name for $CH_3-CH_2-CH_2-CH_3$?
 (a) Ethane (b) Pentane (c) Butane (d) Propane
25. What is the IUPAC name for "Isopropyl Alcohol"?
 (a) Propan-2-ol (b) Ethanol
 (c) Butan-2-ol (d) Propan-1-ol

26. Esters are prepared by the reaction between:
 (a) A ketone and an Aldehyde (b) An Alcohol and a carboxylic acid
 (c) An Alkane and an Alkene (d) An Amine and an Alcohol
27. What is the common name for Ethanoic acid?
 (a) Butyric acid (b) Acetic acid (c) Propionic acid (d) Formic acid
28. The root 'Prop' corresponds to how many carbon atoms?
 (a) 2 (b) 3 (c) 4 (d) 5

Answers

- | | | | | | | |
|---------|---------|---------|---------|---------|---------|---------|
| 1. (d) | 2. (c) | 3. (d) | 4. (c) | 5. (b) | 6. (a) | 7. (b) |
| 8. (c) | 9. (a) | 10. (c) | 11. (b) | 12. (d) | 13. (b) | 14. (b) |
| 15. (d) | 16. (b) | 17. (b) | 18. (a) | 19. (a) | 20. (d) | 21. (b) |
| 22. (b) | 23. (d) | 24. (c) | 25. (a) | 26. (b) | 27. (b) | 28. (b) |

Additional Short Questions

Short Answer Questions prepared in the light of new Examination Techniques
 (Knowledge, Understanding, Application, Analytical & Conceptual)

21.1 + 21.2

Classifications of Organic Compounds + Structural Formula

1. Define Organic Chemistry.

Ans. Organic Chemistry: Organic Chemistry is defined as that branch of chemistry in which we study compounds of carbon and hydrogen (hydrocarbons) and their derivatives.

2. What are organic compounds?

Ans. Organic Compound: An organic compound is a chemical compound primarily composed of carbon atoms that are covalently bonded to each other to other elements. Apart from carbon, majority of organic compounds also contain hydrogen.

3. Why are carbon oxides and carbonates studied in inorganic chemistry despite containing carbon?

Ans. Carbon oxides and carbonates are studied as inorganic compounds for historical and conventional reasons, as their properties align more closely with inorganic substances.

4. How are organic compounds broadly classified?

Ans. Organic compounds are classified into two main groups:

- Open chain or Acyclic compounds
- Closed chain or Cyclic (or ring) compounds

5. Distinguish between straight chain and branched chain compounds.

Ans. Straight chain: Carbon atoms are linked in a continuous series (e.g; n-Butane).

Branched chain: There is at least one "branch" or side chain of carbon atoms

attached to the main chain (e.g; 2-Methylpropane)

6. What are Aliphatic compounds?

Ans. Aliphatic Compounds: Open chain compounds along with certain cyclic compounds are called aliphatic compounds.

7. Define Homocyclic (carbocyclic) compounds.

Ans. Carbocyclic Compounds: These are cyclic compounds where the ring contains carbon atoms only.

(i) Alicyclic compounds (ii) Aromatic compounds

8. What are Carbocyclic compounds further classified?

Ans. Carbocyclic compounds are further classified as:

(i) Alicyclic compounds (ii) Aromatic compounds

9. What are alicyclic compounds? Give their general formula and examples.

Ans. Alicyclic compounds: The carbocyclic compounds which contain a ring of three or more carbon atoms and resemble aliphatic compounds are called alicyclic compounds.

General Formula: C_nH_{2n}

Examples: Cyclopropene, Cyclobutane, Cyclohexane, Cyclohexene

10. What are aromatic compounds?

Ans. Aromatic compounds: These are cyclic compounds which contain one benzene ring. A benzene ring has six carbon atoms with three alternate double and single bonds.

11. Define Heterocyclic compounds.

Ans. Heterocyclic compounds: Cyclic compounds in which the ring contains other atoms along with carbon atoms (such as nitrogen, oxygen or sulphur) are called heterocyclic compounds.

12. What is a structural formula?

Ans. Structural Formula: The structural formula of a compound shows the arrangement of atoms and bonds present in that compound.

13. Define Displayed (Full) structural formula.

Ans. Displayed (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.

14. What is condensed structural formula?

Ans. Condensed Structural Formula: This formula still uses lines between bonded atoms, but it omits the carbon to hydrogen bonds.

21.3 + 21.4 + 21.5 Homologous Series + Isomerism + Functional Group

15. Define the term homologous series.

Ans. Homologous series: Organic compounds have 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.

16. What is isomerism?

Ans. 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.

17. Which is the simplest hydrocarbon to have structural isomers?

Ans. The simplest hydrocarbon to have structural isomers is butane (C_4H_{10}).

18. Why do Methane, Ethane and Propane not show isomerism?

Ans. Methane, Ethane and Propane do not show the phenomenon of isomerism because each exists in one structural form only.

19. Name the two structural isomers of Butane (C_4H_{10}).

Ans. Two structural isomers of Butane (C_4H_{10}) are:

- n-Butane (straight chain) • 2-Methyl propane (Branched chain)

20. Name the two structural isomers of Butene (C_4H_8).

Ans. Two structural isomers of Butene (C_4H_8) are:

- But-1-ene • But-2-ene

21. How many isomers do pentane has?

Ans. Pentane has three isomers.

22. Define functional group.

Ans. 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.

23. Distinguish between Alcohols and phenols.

Ans. Alcohols and phenols both contain the Hydroxyl group ($-OH$).

Alcohols: In alcohols, the hydroxyl group is attached to an alkyl group (e.g., Methanol).

Phenols: In phenols, the hydroxyl group is directly attached to a benzene ring.

24. Give one example of an Amide group Compound.

Ans. Formamide $H-\overset{\overset{O}{||}}{C}-NH_2$ (or) Acetamide $CH_3-\overset{\overset{O}{||}}{C}-NH_2$

21.6

Naming Organic Compounds

25. How are IUPAC names of alcohols derived?

Ans. The ending '-e' of the parent alkane is replaced by '-ol'.

Example: Methane becomes Methanol

26. From what formic acid was first isolated?

Ans. Formic acid was first isolated from red ants.

27. What does formica mean?

Ans. The latin word Formica means ant.

28. From what acetic acid was isolated?

Ans. Acetic acid was isolated from vinegar.

29. What is the Latin word for vinegar?

Ans. The Latin word for vinegar is acetum.

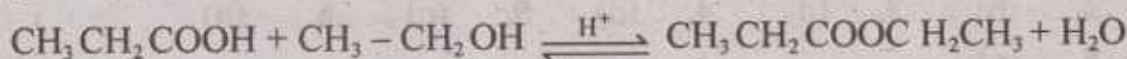
30. What are Esters and what are they used for?

Ans. Esters: Esters are sweet smelling compounds.

Use: They are commonly used as flavouring agents in certain food items.

31. How is an Ester prepared?

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



32. How do you name a Carboxylic acid in the IUPAC system?

Ans. Replace the ending '-e' of the alkane with '-oic acid'.

Example: Ethane becomes Ethanoic acid.

Exercise Questions (Solved)

A. Multiple Choice Questions

☆ Choose and tick the correct answer from the given choices.

1. Choose the correct IUPAC name for the compound $\begin{array}{c} \text{HC} - \text{CH} - \text{CH}_3 \\ || \\ \text{CH}_3 \end{array}$
- (a) But-3-ene (b) But-1-ene (c) But-2-ene (d) Butene
2. Select a branched chain compound.

- (a) $\text{CH}_2 = \text{CH} - \text{CH}_2 - \text{CH}_3$ (b) $\begin{array}{c} \text{CH}_2 = \text{C} - \text{CH} - \text{CH}_3 \\ | \\ \text{CH}_3 \end{array}$
- (c) $\text{CH}_2 = \text{C} - \text{CH} - \text{CH}_3$ (d) $\text{CH}_3 = \text{CH} = \text{CH}_2 - \text{CH}_3$

3. Which is the displayed formula of ethanol?

- (a) $\text{C}_2\text{H}_5\text{OH}$ (b) $\text{CH}_3 - \text{CH}_2 - \text{OH}$
- (c) $\begin{array}{c} \text{H} \quad \text{H} \\ | \quad | \\ \text{H} - \text{C} - \text{C} - \text{OH} \\ | \quad | \\ \text{H} \quad \text{H} \end{array}$ (d) $\begin{array}{c} \text{H} \quad \text{H} \\ | \quad | \\ \text{H} - \text{C} - \text{C} - \text{O} - \text{H} \\ | \quad | \\ \text{H} \quad \text{H} \end{array}$

4. Identify the aldehydic functional group among the following:

- (a) $\begin{array}{c} \text{O} \\ || \\ -\text{C}-\text{OH} \end{array}$ (b) $\begin{array}{c} \text{O} \\ || \\ -\text{C}- \end{array}$ (c) $-\text{OH}$ (d) $\begin{array}{c} \text{O} \\ || \\ -\text{C}-\text{H} \end{array}$

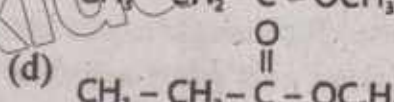
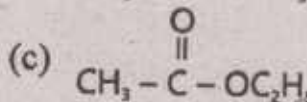
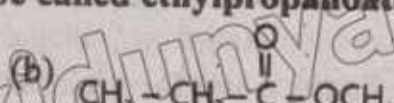
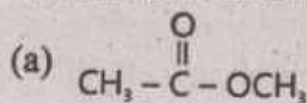
5. Select the general formula of alkyne family.

- (a) $\text{C}_n\text{H}_{2n+1}$ (b) C_nH_{2n} (c) $\text{C}_n\text{H}_{2n-2}$ (d) $\text{C}_n\text{H}_{2n-1}$

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 ethylpropanoate?



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

Answers

1. (b) 2. (b) 3. (d) 4. (d) 5. (c) 6. (b)
7. (d) 8. (c)

B. Short Answer Questions

21.1 What is the difference between saturated and unsaturated hydrocarbons?

Ans. Saturated Hydrocarbons: The hydrocarbons in which all the four valencies of carbon are utilized using single bonds only are called saturated hydrocarbons or alkanes.

Unsaturated Hydrocarbons: The hydrocarbons containing at least one double or triple bond are called unsaturated hydrocarbons.

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

Ans. The structural formula of Butan-2-ol is:

$$\begin{array}{c} \text{CH}_3 - \text{CH} - \text{CH}_2 - \text{CH}_3 \\ | \\ \text{OH} \end{array}$$

21.3 Why is ethylamine $\text{CH}_3 - \text{CH}_2 - \text{NH}_2$ called an organic compound?

Ans. Ethylamine ($\text{CH}_3 - \text{CH}_2 - \text{NH}_2$) is called an organic compound because it is a derivative of a hydrocarbon where a hydrogen atom is replaced by an amino group ($-\text{NH}_2$).

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

Ans. The formulae of an ester called ethyl methanoate is as follows: $\text{HCOCH}_2\text{CH}_3$.

21.5 Define structural isomerism.

Ans. Structural 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.

21.6 Give IUPAC name to $\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3$.

Ans. The IUPAC name for $\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3$ is Butane (4 carbons in a straight saturated chain).

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

Ans. The common feature in the carboxyl group, amide functional group and ester

functional group is the carbonyl group ($C=O$).

All three groups contain a carbon atom double-bonded to an oxygen atom.

C. Constructed Response Questions

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

Ans. The members of a homologous series have similar chemical properties due to the presence of the same functional group. Because the reactive part of the molecule is identical across the series, they undergo the same types of chemical reactions.

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

Ans. Even though both share the molecular formula C_4H_{10} , they are structural isomers, meaning their atoms are bonded in different arrangements.

- **n-butane** is a straight-chain alkane. It has a larger surface area, leading to stronger intermolecular forces. This results in a higher boiling point ($-0.5^\circ C$).
- **2-methylpropane (isobutane)** is a branched chain alkane. Branching makes the molecule more spherical, decreasing its surface area and weakening the intermolecular forces. This results in a lower boiling point ($-11.7^\circ C$).

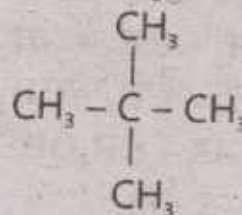
21.3 Write down the structural formulae of isomers shown by saturated hydrocarbon containing five carbon atoms.

Ans. A saturated hydrocarbon with five carbon is pentane (C_5H_{12}). It has three structural isomers:

i. **n-pentane:** $CH_3-CH_2-CH_2-CH_2-CH_3$

ii. **Isopentane (2-methyl butane):** $CH_3-CH(CH_3)-CH_2-CH_3$

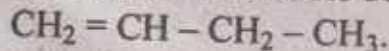
iii. **Neopentane (2,2-dimethyl propane):** $(CH_3)_4C$



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

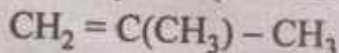
Ans. Butene (C_4H_8) exhibits isomerism based on the position of the double bond and the arrangement of the carbon skeleton:

i. **1-Butene:** The double bond is between the first and second carbon.



ii. **2-Butene:** the double bond in the centre. $CH_3-CH=CH-CH_3$

iii. **Isobutylene (2-methyl propene):** A branched structure with a double bond.



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

Ans. All three contain the carbonyl group ($C=O$), but they differ in what else is attached to that carbon:

- **Aldehyde:** The carbonyl carbon is bonded to at least one hydrogen atom. It is

always located at the end of a carbon chain.

General Formula: $R - CHO$

- **Ketone:** The carbonyl carbon is bonded to two other carbon atoms. It is always located inside the carbon chain.

General Formula: $R - CO - R'$

- **Carboxylic Acid:** The carbonyl carbon is bonded to hydroxyl group ($-OH$). This combination is called a carboxyl group.

General Formula: $R - COOH$

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?

Ans. For answer see Q1

21.2 Explain structural formula giving examples.

Ans. For answer see Q2

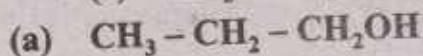
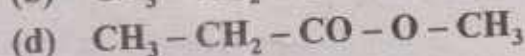
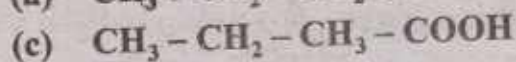
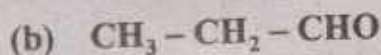
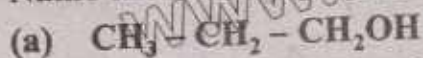
21.3 Write down five characteristics of a homologous series.

Ans. For answer see Q3

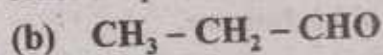
21.4 Give IUPAC rules for naming alcohols.

Ans. For answer see Q11

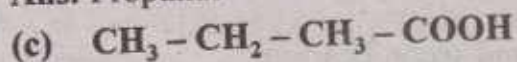
21.5 Name the following compounds.



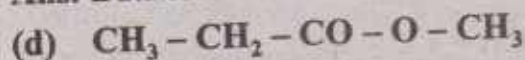
Ans. Propan - 1 - ol



Ans. Propanal



Ans. Butanoic acid



Ans. Methyl propanoate