NOTES | CHEMISTRY – 10

CHAPTER 21

ORGANIC CHEMISTRY

i. Classifications of Organic Compounds ii. Structural Formula iii. Homologous Series iv. Isomerism v. Functional Group vi. Naming Organic Compounds

Descriptive Questions

Q.1 ***Define organic chemistry. What are organic compounds? Which compounds of carbon are not assigned organic in nature?***

Organic Chemistry

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

Organic Compound

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.

Carbon Containing Inorganic Compounds

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.

Interesting Info — How does organic chemistry contribute to develop new materials? Organic chemistry plays a vital role in developing new materials with specific properties, such as polymers and drugs.

Q.2 ***How organic compounds are classified based on the type of carbon chain present in them?***

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:

- (1) Open chain or acyclic compounds
- (2) Closed chain or cyclic (or ring) compounds

(1) 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 along with certain cyclic compounds are also called aliphatic compounds.

(a) Straight chain (non-branched) compounds: Carbon atoms are linked in a straight line without any branches.

$$CH_3–CH_2–CH_2–CH_3 \text{ (Butane)} \qquad H_2C=CH–CH_2–CH_3 \text{ (But-}_1\text{-ene)} \qquad CH_3–CH_2–CH_2–CH_2–OH \text{ (Butan-}_1\text{-ol)}$$

(b) Branched chain compounds: Carbon atoms form branches or side chains with each other.

$$_2\text{-Methylpropane (Isobutane):}\ CH_3–CH(CH_3)–CH_3 \qquad _{2,2}\text{-Dimethylpropane (Neopentane):}\ C(CH_3)_4$$

(2) 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.

(a) Carbocyclic / Homocyclic compounds: When the ring contains carbon atoms only. If the ring contains other atoms along with carbon, 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. The saturated alicyclic hydrocarbons have the general formula CnH2n.

$$\text{Cyclopropane } (C_3H_6) \quad \text{Cyclobutane } (C_4H_8) \quad \text{Cyclohexane } (C_6H_{12}) \quad \text{Cyclohexene } (C_6H_{10})$$

(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, usually shown as a circle inside a hexagon.

- Examples: Benzene, Naphthalene, Anthracene etc.

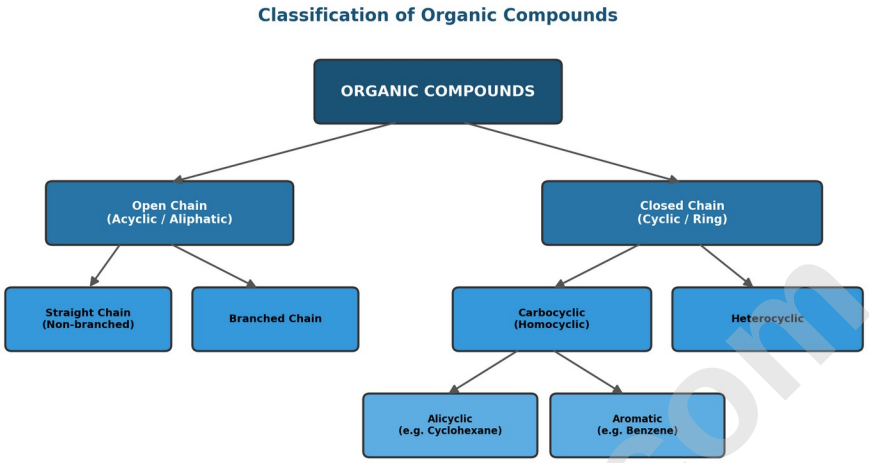

Fig. 1 — Classification of Organic Compounds

21.1 Quick Check 1. Difference between cyclohexane and benzene? Cyclohexane (C6H12) is a saturated hydrocarbon with a ring structure, while Benzene (C6H6) is an unsaturated aromatic hydrocarbon with alternate single and double bonds. 2. Two examples of branched chain compounds: 2-Methylpropane (Isobutane) and 2,2-Dimethylpropane (Neopentane).

Q.3 *Explain structural formula. How can we draw different structures of organic compounds?*

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.

Methods to Draw Structural Formula

1. Displayed formula (full structural 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. Example: Ethane, Ethene.

2. Condensed structural formula: Still uses lines between bonded atoms, but omits the carbon-to-hydrogen bonds. Example: CH3–CH3 (Ethane), CH2=CH2 (Ethene).

Table 21.1 — Condensed Structural Formulae

Compound	Condensed Structural Formula
Ethane	CH_3-CH_3
Ethene	CH_2=CH_2

Compound	Condensed Structural Formula
Ethyne	HC≡CH
Propane	CH_3-CH_2-CH_3
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_3-CH_2-CH_2-OH
Propan-$_2$-ol	CH_3-CH(OH)-CH_3
Butanol	CH_3-CH_2-CH_2-CH_2-OH
Butan-$_2$-ol	CH_3-CH(OH)-CH_2-CH_3
Ethanoic acid	CH_3-COOH
Propanoic acid	CH_3-CH_2-COOH
Methyl ethanoate	CH_3-COO-CH_3

21.2 Quick Check — Displayed & condensed formulae of butan-2-ol, ethyl ethanoate, 2-methylpropane, but-2-ene, pentane: butan-$_2$-ol: CH_3-CH(OH)-CH_2-CH_3 | ethyl ethanoate: CH_3-C(=O)-O-CH_2-CH_3 $_2$-methylpropane: CH_3-CH(CH_3)-CH_3 | but-$_2$-ene: CH_3-CH=CH-CH_3 | pentane: CH_3-CH_2-CH_2-CH_2-CH_3

Q.4 ***Define homologous series. Explain characteristics of homologous series.***

Homologous Series

A homologous series is a group of organic compounds with the same functional groups and general formula, where successive members differ by a −CH2− unit and have same chemical properties.

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

- (i) General formula: All the members of the series can be represented by a general formula, e.g. alkanes: CnH2n+2.
- (ii) Difference of −CH2 (Methylene) group: Successive members differ by a CH2 group and 14 units in relative molecular mass.
- (iii) Same functional group: Different members in a family share a common functional group.
- (iv) Identical chemical properties: Members in a family have almost identical chemical properties due to the same functional group.
- (v) Regular change in physical properties: Melting point, boiling point, density and solubility show a regular change with increasing molecular mass.
- (vi) Same method of preparation: All members of a series can be prepared by similar methods.

General Formulae of Homologous Series

Series	General Formula
Alkanes	C_nH_{2n+2}
Alkenes	C_nH_{2n}
Alkynes	C_nH_{2n-2}
Alcohols	$C_nH_{2n+1}OH$
Carboxylic Acids	$C_nH_{2n+1}COOH$

21.3 Quick Check 1. Molecular formula of a carboxylic acid with 3 carbon atoms: C3H6O2 — CH3CH2COOH (Propanoic acid). 2. Molecular formula of an alcohol with 4 carbon atoms: C4H10O — CH3CH2CH2CH2OH (Butan-1-ol).

Q.5 ***Define structural isomerism. Explain it by giving different examples.***

Isomerism

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.

Example of Butane

- The simplest hydrocarbon to have structural isomers is butane (C4H10).
- Methane, ethane and propane do not show 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, it is possible to arrange the atoms in more than one way to satisfy all valencies — i.e. two or more different arrangements for the same molecular formula.

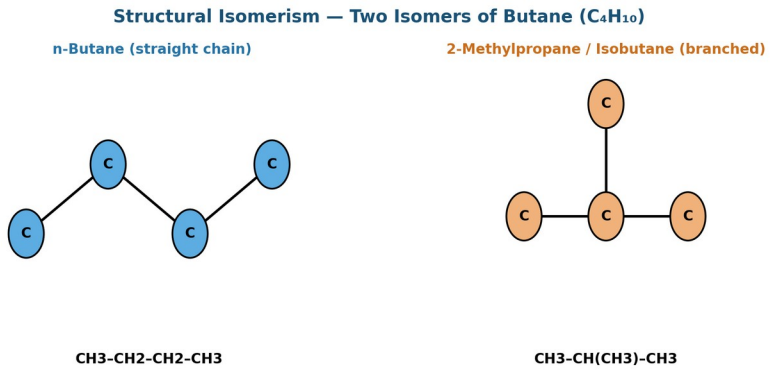

Fig. 2 — Structural isomers of butane: n-Butane vs. 2-Methylpropane (Isobutane)

Experimental evidence: There are two compounds with different physical properties but the same molecular formula C4H10.

Examples of higher hydrocarbons: As carbon atoms increase, the number of possible isomers increases rapidly. Pentane has three isomers. With thirty carbon atoms, the number of isomers exceeds four billion.

Example of unsaturated hydrocarbon: Structural isomerism is not confined to saturated hydrocarbons — all classes of organic compounds and their derivatives show this phenomenon. Butene (C4H8) has two structural isomers:

$$CH_3\text{-}CH_2\text{-}CH{=}CH_2 \ (But\text{-}_1\text{-}ene) \qquad CH_3\text{-}CH{=}CH\text{-}CH_3 \ (But\text{-}_2\text{-}ene)$$

Q.6 ***Define functional group. Explain the types of functional groups and their related classes of organic compounds.***

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 has its characteristic properties due to the presence of the −OH (hydroxyl) group, the functional group of alcohols.

Types of Functional Groups

(a) Hydroxy group (−OH):

- Hydroxyl group alcohols (−OH): organic compounds with −OH attached to an alkyl (−R) group are called alcohols. E.g. CH3-OH (Methanol), CH3-CH2-OH (Ethanol).
- Phenols: if the −OH group is attached to a benzene ring, the compound is a phenol. E.g. C6H5-OH (Phenol).

(b) Aldehyde group (−CHO): present in the family called aldehydes. E.g. H-CHO (Methanal/Formaldehyde), CH3-CHO (Ethanal/Acetaldehyde).

(c) Ketone group (>C=O, both sides R): present in ketones. E.g. CH3-CO-CH3 (Propanone/Acetone), CH3-CH2-CO-CH3 (Butanone).

(d) Carboxyl group (−COOH): present in carboxylic acids. E.g. H-COOH (Methanoic/Formic acid), CH3-COOH (Ethanoic/Acetic acid).

(e) Amino group (−NH2): present in amines. E.g. CH3-NH2 (Methylamine), CH3-CH2-NH2 (Ethylamine), C6H5-NH2 (Aniline).

(f) Amide group (−CONH2): present in acid amides. E.g. H-CONH2 (Formamide), CH3-CONH2 (Acetamide).

(g) Ester group (−COOR): present in carboxylic esters. E.g. CH3-COOCH3 (Methyl ethanoate/acetate), CH3-COOC2H5 (Ethyl ethanoate/acetate).

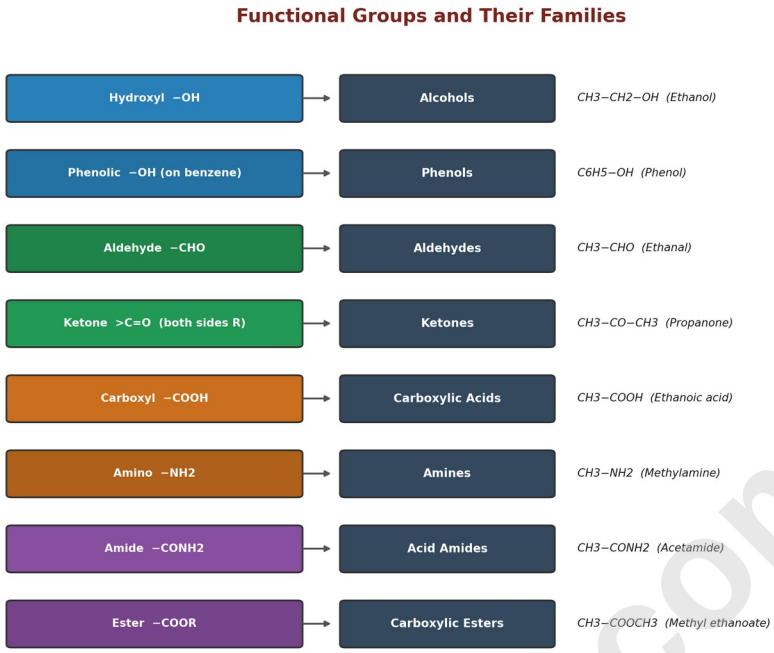

Fig. 3 — Functional Groups and Their Families

21.4 Quick Check 1. Phenols vs alcohols: alcohols have −OH attached to alkyl (−R) group (e.g. CH3-CH2-OH); phenols have −OH attached to phenyl (−C6H5) group (e.g. C6H5-OH). 2. Common formula element of aldehydic & ketonic groups: both share the carbonyl group (C=O). In aldehydes only one −R or −H is attached to the carbonyl carbon (R-CHO); in ketones two −R groups (same or different) are attached (R-CO-R').

Naming Organic Compounds

Q.7 ***Which two systems are used to name organic compounds generally?***

(a) Common or Trivial Names

Organic compounds are usually named by two systems: the common/trivial name system, given by early organic chemists — quite often used because they are simple and easy to use.

(b) IUPAC System of Nomenclature

Due to the existence of a large number of organic compounds and their complexity, it is not possible to give a common name to every compound individually. To deal with this, the International Union of Pure and Applied Chemistry (IUPAC) introduced a systematic way of naming organic compounds called IUPAC nomenclature.

Q.8 ***What are saturated and unsaturated hydrocarbons?***

Alkanes (Saturated Hydrocarbons)

Hydrocarbons: organic compounds containing carbon and hydrogen only. Saturated hydrocarbons (alkanes) are those in which all four valencies of carbon are utilized using single bonds only. They may have a straight or branched chain. Example: Methane (CH4), ethane, propane.

Unsaturated Hydrocarbons (Alkenes or Alkynes)

Hydrocarbons containing at least one double or triple bond. Compounds having a double bond are called alkenes; those with a triple bond are called alkynes.

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

Q.9 ***Write the names and details of different parts of an organic compound according to the IUPAC system. Discuss molecular, condensed and displayed formula of alkanes.***

IUPAC System of Nomenclature

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

- 1. Root: tells us the number of carbon atoms in the longest continuous chain present in the molecule.
- 2. Suffix: added after the root; tells us about the class of organic compound.
- 3. Prefix: indicated before the root; tells us about the group(s) attached to the longest chain.

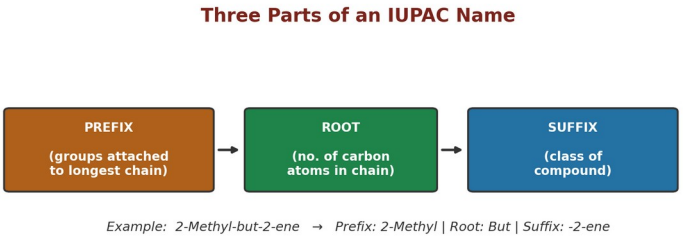

Fig. 4 — The Three Parts of an IUPAC Name

Table 21.3 — Formulae of Alkanes

Alkane	Molecular Formula	Condensed Structural Formula
Methane	CH_4	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-$(CH_2)_5$-CH_3
Octane	C_8H_{18}	CH_3-$(CH_2)_6$-CH_3
Nonane	C_9H_{20}	CH_3-$(CH_2)_7$-CH_3
Decane	$C_{10}H_{22}$	CH_3-$(CH_2)_8$-CH_3

Q.10 *What is an alkyl group? Write general rules to name alkanes by IUPAC system.*

Alkyl Group

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

$$CH_4\ (\text{Methane}) \rightarrow -H \rightarrow CH_3-\ (\text{Methyl}) \qquad C_2H_6\ (\text{Ethane}) \rightarrow -H \rightarrow C_2H_5-\ (\text{Ethyl})$$

Rules to Name Alkanes by IUPAC System

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

- a) Identify the longest continuous chain present in the compound.
- b) Identify the class of organic compound.

Example: CH3-CH2-CH2-CH3 has four carbon atoms in the longest continuous chain, belonging to alkanes. Root = But–, suffix = –ane → Butane.

21.5 Quick Check — Name by IUPAC system: i. CH_3-CH_2-CH_2-CH_2-CH_3 → Pentane ii. CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3 → Heptane

Q.11 *Write IUPAC rules for naming alkenes.*

Alkenes

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

IUPAC Rules of Naming Alkenes

Alkenes are named the same way as alkanes except the suffix used is –ene.

- 1. Count the number of carbon atoms in the longest continuous chain containing both 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 the position of the double bond, then the suffix –ene.

$CH_2=CH_2$ (Ethene) $CH_3\text{-}CH=CH_2$ (Propene) $CH_2=CH\text{-}CH_2\text{-}CH_3$ (But-$_1$-ene) $CH_3\text{-}CH=CH\text{-}CH_3$ (But-$_2$-ene) $CH_2=CH\text{-}CH_2\text{-}CH_2\text{-}CH_3$ (Pent-$_1$-ene) $CH_3\text{-}CH=CH\text{-}CH_2\text{-}CH_3$ (Pent-$_2$-ene)

Q.12 ***Explain IUPAC rules for naming alcohols. Give examples of alcohols showing their names and formulae.***

Alcohols

Monohydroxy derivatives of alkanes are also called alcohols. General formula for alcohols is R-OH.

IUPAC Rules for Naming Alcohols

- (i) The longest chain of carbon atoms containing the hydroxyl group is taken as the parent hydrocarbon; the ending 'e' of the alkane is replaced by 'ol'.
- (ii) The longest carbon chain is numbered starting from the end where the carbon atom attached with the hydroxyl group gets the lowest possible number.
- (iii) The position of the hydroxyl group is indicated by a number placed before the -ol.

Table 21.4 — Names and Formulas of Alcohols

Formula	Common Name	IUPAC Name
CH_3OH	Methyl Alcohol	Methanol
CH_3CH_2OH	Ethyl Alcohol	Ethanol
$CH_3\text{-}CH_2\text{-}CH_2\text{-}OH$	Propyl Alcohol	Propan-$_1$-ol
$CH_3\text{-}CH(OH)\text{-}CH_3$	Iso-Propyl Alcohol	Propan-$_2$-ol
$CH_2(OH)\text{-}CH_2\text{-}CH_2\text{-}CH_3$	n-Butyl Alcohol	Butan-$_1$-ol
$CH_3\text{-}CH(OH)\text{-}CH_2\text{-}CH_3$	Sec-Butyl Alcohol	Butan-$_2$-ol

Q.13 ***What are carboxylic acids? How would you name them according to the IUPAC system?***

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 R-COOH.

IUPAC Names of Carboxylic Acids

The IUPAC names 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.

Interesting Info — Common names of carboxylic acids are derived from the source from which they were first isolated. Formic acid was first isolated from red ants (Latin: Formica = ant). Acetic acid was isolated from vinegar (Latin: acetum = vinegar).

Table 21.5 — Names of Carboxylic Acids

Formula	Common Name	IUPAC Name
HCOOH	Formic acid	Methanoic acid
CH_3COOH	Acetic acid	Ethanoic acid

Formula	Common Name	IUPAC Name
CH_3CH_2COOH	Propionic acid	Propanoic acid
$CH_3CH_2CH_2COOH$	Butyric acid	Butanoic acid

Q.14 ***What are esters? How are they prepared? Give common and IUPAC names of esters.***

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'.

Preparation of Esters

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

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

Table 21.6 — Common and IUPAC Names of Esters

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

21.6 Quick Check — Family names of condensed formulae: i. CH_3-CH(OH)-CH_3 → Propan-$_2$-ol (Alcohols) ii. CH_3-CH_2-CO-CH_3 → $_2$-Butanone (Ketones) iii. CH_3-C(CH_3)=CH-CH_3 → $_2$-Methyl-$_2$-butene (Alkenes) iv. CH_2(COOH)-CH_2-CH_3 → Butanoic acid (Carboxylic acids) v. C_3H_6 → Propene (Alkenes) vi. C_5H_{12} → Pentane (Alkanes) vii. HCHO → Methanal (Aldehydes) viii. CH_3-CH_2-CO-O-CH_2-CH_3 → Ethyl Propanoate (Esters)

Multiple Choice Questions

A. Choose and Tick the Correct Answer

1. Choose the correct IUPAC name for the compound $HC{\equiv}CH_2\text{-}CH_3$ with $=CH_2$ branch:
(a) But-$_3$-ene (b) But-$_1$-ene (c) But-$_2$-ene (d) Butene

2. Select a branched chain compound.
(a) $CH_2{=}CH\text{-}CH_2\text{-}CH_3$ (b) $CH_2{=}C(CH_3)\text{-}CH\text{-}CH_3$ (c) $CH_2\text{-}CH{=}CH\text{-}CH_3$ (d) $CH_3\text{-}CH{=}CH\text{-}CH_2\text{-}CH_3$

3. Which is the displayed formula of ethanol?
(a) C_2H_5OH (b) $CH_3\text{-}CH_2\text{-}OH$ (c) Full displayed formula with H-C-C-OH (d) H-C-C-O-H (displayed)

4. Identify the aldehydic functional group among the following:
(a) -C(=O)-OH (b) -OH (c) -C(=O)- (d) -C(=O)-H

5. Select the general formula of alkyne family:
(a) CnH_2n+_1 (b) CnH_2n (c) CnH_2n-_2 (d) CnH_2n-_1

6. How many structural isomers will there be 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) $CH_3\text{-}CO\text{-}OCH_3$ (b) $CH_3\text{-}CH_2\text{-}CO\text{-}OCH_3$ (c) $CH_3\text{-}CO\text{-}OC_2H_5$ (d) $CH_3\text{-}CH_2\text{-}CO\text{-}OC_2H_5$

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

SLO Based Multiple Choice Questions

Organic Chemistry and Classification

9. In organic compounds, the bonds between carbon atoms are:
(a) Ionic (b) Covalent (c) Polar (d) Coordinate covalent

10. Which element is often found in organic compounds along with carbon?
(a) Chlorine (b) Oxygen (c) Hydrogen (d) Nitrogen

11. Which other elements are present in organic compounds containing carbon and hydrogen?
(a) Oxygen (b) Nitrogen (c) Sulphur (d) All of these

12. Which of the following is not typically considered an organic compound?
(a) Carbohydrates (b) Hydrocarbons (c) Carbonates (d) Alkane

13. Organic chemistry is the branch of chemistry which deals with study of:
(a) Minerals (b) Acid & Base (c) Hydrocarbons and their derivatives (d) Salts

14. Organic compounds are broadly classified into:
(a) Open and closed chain (b) Ionic and covalent (c) Acidic and basic (d) Hydrides and oxides

15. Acyclic compounds are also called:
(a) Cyclic compounds (b) Open chain compounds (c) Closed chain compounds (d) Aromatic compounds

16. Which is an example of straight-chain compound?
(a) $_2$-Methylpropane (b) Neopentane (c) Isobutane (d) n-Butane

17. Which branch of chemistry is responsible for the development of polymers and drugs?
(a) Organic chemistry (b) Analytical chemistry (c) Physical chemistry (d) Inorganic chemistry

18. Closed chain organic compounds are called:
(a) Acyclic compounds (b) Open chain compounds (c) Cyclic compounds (d) Isomers

19. Alicyclic compounds resemble with which type of compounds?
(a) Aromatic compounds (b) Aliphatic compounds (c) Heterocyclic compounds (d) Inorganic compounds

20. CnH_2n is the general formula of?
(a) Alkane (b) Alkyne (c) Aromatic compounds (d) Saturated alicyclic compounds

21. Which of the following is an example of alicyclic compound?
(a) Benzene (b) Cyclopropane (c) Naphthalene (d) Anthracene

22. Aromatic compounds are those which contain:
(a) Single bond (b) Double bond (c) At least one benzene ring (d) None of these

23. Carbon atoms in aromatic compounds are bonded by:
(a) Six single bonds (b) Three double bonds (c) Three triple bonds (d) Three alternate double and single bonds

Structural Formula

24. What does structural formula of a compound show?
(a) Only the molecular weight (b) The arrangement of atoms and bonds (c) The color of the compound (d) The melting point

25. Which formula shows every atom and every bond with lines?
(a) Condensed structural formula (b) Molecular formula (c) Displayed formula (d) Empirical formula

Homologous Series

26. A homologous series is a group of organic compounds having the same:
(a) Molecular formula (b) Functional group (c) Percentage composition (d) Number of carbon atoms

27. Successive members of a homologous series differ by:
(a) $-CH_3$ (b) $-CH_2-$ (c) -OH (d) -COOH

28. What is the general formula of alkenes?
(a) CnH_2n+_2 (b) CnH_2n-_1 (c) CnH_2n (d) CnH_2n-_2

29. The functional group of alcohols is:
(a) -COOH (b) -CHO (c) -OH (d) -O-

30. Which of the following belong to the alkane series?
(a) C_3H_6 (b) C_4H_8 (c) C_5H_{12} (d) C_2H_2

31. In a homologous series two successive members differ by the mass of:
(a) $_{12}$ (b) $_{14}$ (c) $_{16}$ (d) $_{18}$

32. The molecular formula of an alcohol containing $_4$ carbon atoms is:
(a) C_4H_8OH (b) C_4H_9OH (c) C_4H_{10} (d) C_4H_8

Isomerism

33. Isomerism is the phenomenon in which compounds have:
(a) Same structural formula but different molecular formula (b) Same molar mass (c) Same molecular formula but different structural formula (d) Same physical properties

34. The simplest hydrocarbon that shows structural isomerism is:
(a) Methane (b) Ethane (c) Propane (d) Butane

35. Pentane (C_5H_{12}) has how many structural isomers?
(a) $_2$ (b) $_3$ (c) $_4$ (d) $_5$

36. The other isomer of n-Butane is:
(a) $_1$-Methylbutane (b) $_1$-Methylpropane (c) $_2$-Methylbutane (d) $_2$-Methylpropane

Functional Group

37. Functional group of alcohols (-OH) is called:
(a) Carbonyl group (b) Aldehyde (c) Hydroxyl (d) Ketone

38. Which of the following is an alcohol?
(a) CH_3OH (b) CH_3CHO (c) CH_3COCH_3 (d) CH_4

39. When (-OH) is attached to benzene ring the compound is called:
(a) Alcohols (b) Phenols (c) Ketene (d) Aldehyde

40. General formula of ketone functional group is:
(a) R-OH (b) R-COOH (c) R-CO-R (d) R-CHO

41. The -COOH group is called:
(a) Aldehyde group (b) Ketene group (c) Carboxyl group (d) Ester group

42. Methanoic acid is also known as:
(a) Acetic acid (b) Formic acid (c) Acetone (d) Formaldehyde

43. Ethyl ethanoate belongs to which class of compounds?
(a) Ketones (b) Esters (c) Amines (d) Aldehydes

Naming Organic Compounds

44. In IUPAC nomenclature, the 'root' indicates:
(a) Functional group (b) Number of carbon atoms in longest chain (c) Type of bonding (d) Position of substituent

45. The suffix in an organic compound name indicates:
(a) Number of carbons (b) Side chain (c) Class of compounds (d) Position of substituent

46. The prefix in IUPAC name indicates:
(a) Number of carbon atoms (b) Functional groups (c) Groups attached to longest chain (d) Type of bond

47. The root word for $_8$ carbon atoms is:
(a) Oct (b) Hept (c) Non (d) Dec

48. An Alkyl is formed when an alkane molecule loses how many hydrogen atoms:
(a) $_1$ (b) $_2$ (c) $_3$ (d) $_4$

49. Generally, an alkyl group is represented by:
(a) RH (b) -R (c) Alk (d) Meth

50. Esters can be prepared by reacting an alcohol with a carboxylic acid in the presence of catalyst which is:
(a) An acid (b) A base (c) A metal (d) Zn / HCl

51. The Latin word for vinegar is:
(a) Formica (b) Acidus (c) Acetum (d) Formica

52. Formic acid was first isolated from:
(a) Vinegar (b) Minerals (c) Acid (d) Red ants

Answer Key

1	2	3	4	5	6	7
b	b	d	d	c	b	d
8	9	10	11	12	13	14
c	b	c	d	c	c	a
15	16	17	18	19	20	21
b	d	a	c	b	d	b
22	23	24	25	26	27	28
c	d	b	c	b	c	b
29	30	31	32	33	34	35
c	c	b	b	c	d	b
36	37	38	39	40	41	42
d	c	a	b	c	c	b
43	44	45	46	47	48	49
b	b	c	c	a	a	b
50	51	52				
a	c	d				

Short Answer Questions

1. *What is the difference between saturated and unsaturated hydrocarbons?*

Saturated Hydrocarbons (Alkanes)	Unsaturated Hydrocarbons
Contain carbon and hydrogen only; all four valencies of carbon utilized by single bonds only.	Contain at least one double or triple bond. Compounds with a double bond are alkenes; with a triple bond are alkynes.

2. *Write down the structural formula of Butan-$_2$-ol.*

$$CH_3\text{-}CH(OH)\text{-}CH_2\text{-}CH_3 \quad (\text{Butan-}_2\text{-ol})$$

3. *Why is ethylamine CH_3-CH_2-NH_2 called an organic compound?*

Ans. Amines are an important family of organic compounds in which an alkyl group (-R) is attached to an amino (-NH_2) group. It is categorized as organic because it contains carbon-to-carbon as well as carbon-to-hydrogen bonds.

4. *Write down the formula of an ester called ethyl methanoate.*

$$HCOOCH_2CH_3 \quad (\text{Ethyl methanoate})$$

5. *Define structural isomerism.*

Ans. Two or more compounds having the same molecular formula but different structural formulae and properties are said to be isomers of each other, and the phenomenon is called structural isomerism. Example: Butane has two isomers — n-Butane and $_2$-Methylpropane.

6. *Give IUPAC name to CH_3-CH_2-CH_2-CH_3.*

Ans. The IUPAC name of the compound is n-Butane.

7. *What is common in carboxyl group, amide functional group and ester functional group?*

Ans. The carbonyl group (C=O) is common to carboxylic acid (R-COOH), amide (R-$CONH_2$) and ester (R-COOR) functional groups.

SLO Based Short Answer Questions

Organic Chemistry

8. *Define organic chemistry.*

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

9. *What are organic compounds?*

Ans. Organic compounds are chemical compounds that contain carbon atoms covalently bonded to hydrogen and other elements like oxygen, nitrogen, sulphur and halogens.

10. *List which compounds of carbon are not regarded as organic compounds.*

- Oxides of carbon
- Carbonates and hydrogen carbonates
- Carbides
- Cyanides

Classification of Organic Compounds

11. *Why are organic compounds classified into various branches?*

Ans. There are millions of organic compounds; it is practically not possible to study each individually. To facilitate their study, organic compounds are classified into various groups and sub-groups.

12. *In which groups are organic compounds broadly classified?*

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

13. *What are aliphatic compounds? Give examples.*

Ans. Open chain compounds along with certain cyclic compounds are also called aliphatic compounds. Straight chain: carbon atoms linked in a straight line without branches.

$$CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_3 \text{ (Butane)} \qquad H_2C{=}CH\text{-}CH_2\text{-}CH_3 \text{ (But-}_1\text{-ene)}$$

14. *Differentiate between homocyclic and heterocyclic compounds.*

Homocyclic / Carbocyclic Compounds	Heterocyclic Compounds
When the ring of cyclic compounds contains carbon atoms only, they are called homocyclic or carbocyclic compounds.	When the ring contains other atoms along with carbon atoms, the compounds are called heterocyclic compounds.

15. *Differentiate between alicyclic and aromatic compounds.*

Alicyclic Compounds	Aromatic Compounds
Carbocyclic compounds which contain a ring of three or more carbon atoms and resemble aliphatic compounds. Example: Cyclopropane, Cyclohexane.	Carbocyclic compounds which contain at least one benzene ring having six carbons bonded by three alternate single and three double bonds. Example: Benzene, Naphthalene.

Structural Formula

16. *What is the difference between displayed and condensed structural formula?*

Displayed Formula	Condensed Structural Formula
Shows the detailed structure of a molecule showing the relative position of atoms, number and type of bonds between them. Example: full H-C-C-H structure of ethane.	Simplifies the representation of a molecule by grouping atoms, especially hydrogen atoms, with carbon atoms — saving time and space, especially for large molecules. Example: $H_3C\text{-}CH_3$.

17. *Give the molecular, condensed and structural formula of butane.*

Ans. Molecular formula: C_4H_{10}. Condensed formula: $CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_3$.

Homologous Series

18. *Define homologous series.*

Ans. A homologous series is a group of organic compounds with the same functional group, same chemical properties, and same general formula. In each series, successive members differ by a ($\text{-}CH_2\text{-}$) group.

19. *Write general formulae of the following series: Alkenes, alkynes, alcohols and carboxylic acids.*

Series	General Formula
Alkenes	CnH_2n
Alkynes	$CnH_2n\text{-}_2$
Alcohols	CnH_2n+_1OH
Carboxylic acids	CnH_2n+_1COOH

20. *What is the trend of change in physical properties of compounds within a homologous series?*

Ans. Physical properties such as melting point, boiling point, density and solubility show a regular change with the increase in molecular masses in successive members of a homologous series.

21. *Draw the structural isomers of butane.*

$CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_3$ (n-Butane) $\qquad$ $CH_3\text{-}CH(CH_3)\text{-}CH_3$ ($_2$-Methylpropane / Isobutane)

Functional Group

22. *Define functional group. Give example.*

Ans. 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 has its characteristic properties due to the -OH (hydroxyl) group.

23. *What is the difference between carboxylic group and ester group?*

Carboxylic Acid	Ester Group
Present in the family of compounds called carboxylic acids. General formula: -COOH. Example: Formic acid, H-COOH.	Present in a family called carboxylic esters. General formula: -COOR. Example: Methyl ethanoate, $CH_3\text{-}COOCH_3$.

24. *Differentiate between Amino group and amide group.*

Amino Group / Amines	Amide Group / Acid Amides
Present in a series of compounds called "amines". General formula: $R\text{-}NH_2$. Example: Methyl amine, $CH_3\text{-}NH_2$.	Present in a family called "acid amides". General formula: $R\text{-}CONH_2$. Example: Formamide, $H\text{-}CONH_2$.

25. *Write structural formula of formic acid, acetic acid, aniline and acetamide.*

Formic acid: H-COOH Acetic acid: CH_3-COOH Aniline: C_6H_5-NH_2 Acetamide: CH_3-$CONH_2$

Isomerism

26. *What are isomers? How do they differ from each other?*

Ans. Isomers are compounds having the same molecular formula and different structural formula. They differ from each other on the basis of physical properties like melting and boiling points.

Naming Organic Compounds

27. *What is the purpose of naming the organic compounds by the IUPAC system?*

Ans. Due to the existence of a large number of organic compounds and their complexity, it is not possible to give a common name to every compound individually — hence the systematic IUPAC nomenclature is used.

28. *What are the main parts of an IUPAC name for organic compounds?*

Ans. According to the IUPAC system, the entire name of an organic compound has three parts — Root (number of carbon atoms in the longest chain), Suffix (class of organic compound) and Prefix (group(s) attached to the longest chain).

29. *Draw the alkyl radical from methane and ethane.*

$CH_4 \rightarrow$ -H $\rightarrow CH_3$- (Methyl) $C_2H_6 \rightarrow$ -H $\rightarrow C_2H_5$- (Ethyl)

30. *What does the suffix "ane" signify in organic compounds?*

Ans. The suffix -ane is used to name alkanes. Alkanes are saturated hydrocarbons with only single covalent bonds between carbon atoms. Example: combining 'meth' with 'ane' gives methane (CH_4), the simplest alkane.

31. *How do you name alkanes based on their carbon chain length?*

Ans. Alkanes are named by combining the appropriate stem (based on the number of carbon atoms) with the suffix -ane. Example: a four-carbon alkane is called butane, while a six-carbon alkane is hexane.

32. *Why do we use numbering in naming alkenes and alkynes?*

Ans. Numbering is used to indicate the position of the double or triple bond in the carbon chain. It ensures that the bond gets the lowest possible number, which is essential for accuracy.

33. *What suffix "-yne" is used in the IUPAC names of alkynes?*

Ans. The suffix "-yne" denotes the presence of a carbon-carbon triple bond in alkynes; the position of the triple bond is also indicated by numbering the carbon chain accordingly. Example: ethyne, H-C≡C-H.

34. *What are alcohols? Give their general formula.*

Ans. Monohydroxy derivatives of alkanes are called alcohols. General formula for alcohols is R-OH. Examples: CH_3OH (Methanol), CH_3CH_2OH (Ethanol).

35. *Define carboxylic acid. Why are they called fatty acids?*

Ans. 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.

36. *Give the formulae of the first four members of the carboxylic acid series.*

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

37. *Why are esters commonly used as flavouring agents?*

Ans. Esters are sweet smelling compounds with a fruity smell. They are commonly used as flavouring agents in certain food items.

38. *How can esters be prepared from carboxylic acids and alcohols?*

Ans. Esters can be prepared by reacting an alcohol with a carboxylic acid in the presence of an acid catalyst. This process is called esterification.

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

Constructed Response Questions

1. *Why do the members of a homologous series have similar chemical properties?*

Ans. Members of a homologous series have similar chemical properties because they all contain the same functional group. Chemical properties mainly depend on the functional group, not on the length of the carbon chain. Example: in alcohols (-OH group), all members react similarly because of the hydroxyl group; in carboxylic acids (-COOH group), acidic character is due to the carboxyl group. The functional group is the reactive part of the molecule, so all members of a homologous series undergo similar types of reactions.

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

$$\text{n-Butane: } CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_3 \qquad \text{₂-Methylpropane: } CH_3\text{-}CH(CH_3)\text{-}CH_3$$

Ans. Both compounds contain the same number of carbon atoms and the same molecular formula (C_4H_{10}). They differ in properties because they have different structures (chain isomers) — n-butane has a straight chain while ₂-methylpropane (isobutane) has a branched structure. This affects shape, intermolecular forces and physical properties, especially boiling point.

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

Ans. Pentane has three structural isomers:

$$\text{i. } CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3 \text{ (n-Pentane) ii. } CH_3\text{-}CH(CH_3)\text{-}CH_2\text{-}CH_3 \text{ (₂-Methylbutane / Isopentane) iii. } C(CH_3)_4 \text{ i.e. } CH_3\text{-}C(CH_3)_2\text{-}CH_3 \text{ (₂,₂-Dimethylpropane)}$$

4. *Write down the structural formulae of the isomers shown by butene.*

Ans. Butene (C_4H_8) has three structural isomers:

$$\text{i. } CH_3\text{-}CH_2\text{-}CH{=}CH_2 \text{ (But-₁-ene) ii. } CH_3\text{-}CH{=}CH\text{-}CH_3 \text{ (But-₂-ene) iii. } CH_2{=}C(CH_3)\text{-}CH_3 \text{ (₂-Methylpropene)}$$

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

Aldehyde	Ketone	Carboxylic Acid
Functional group: -CHO. The carbonyl group (C=O) is attached to hydrogen on one side while the	Functional group: -CO- (ketonic). In a ketone, both sides of the carbonyl group are occupied by	Functional group: -COOH. The carbonyl group is necessarily attached to an -OH group, while

Aldehyde	Ketone	Carboxylic Acid
other side may be another H or an R group. General formula: H-CO-H/R. Examples: HCHO (Methanal), CH_3-CHO (Ethanal).	alkyl groups, which may be same or different. General formula: R-CO-R'. Examples: CH_3-CO-CH_3 (Propanone), CH_3-CO-CH_2-CH_3 (Butanone).	the other side may be an H or R group. General formula: H/R-COOH. Examples: H-COOH (Formic acid), CH_3-COOH (Acetic/Ethanoic acid).

Descriptive Questions (Exercise)

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

Ans. See Q.$_2$ from theory section — Classification of Organic Compounds.

2. *Explain structural formula, giving examples.*

Ans. See Q.$_3$ from theory section — Structural Formula.

3. *Write down five characteristics of a homologous series.*

Ans. See Q.$_4$ from theory section — Homologous Series.

4. *Give IUPAC rules for naming alcohols.*

Ans. See Q.$_{12}$ from theory section — IUPAC Rules for Naming Alcohols.

5. *Name the following compounds.*

Compound	IUPAC Name	Common Name
CH_3-CH_2-CH_2OH	Propan-$_1$-ol	Propyl alcohol
CH_3-CH_2-CHO	Propanal	Propionaldehyde
CH_3-CH_2-CH_2-COOH	Butanoic acid	Butyric acid
CH_3-CH_2-CO-O-CH_3	Methyl propanoate	Methyl propionate