Chapter 13:

Organic Chemistry

Short Questions (Exercise)

1. What is catenation?

Catenation is the ability of an element, particularly carbon, to form long chains or rings by bonding with atoms of the same element. This property is due to carbon's tetravalency and strong covalent bonds.

Example: Carbon forms chains in compounds like ethane (C_2H_6), propane (C_3H_8), and butane (C_4H_{10}).

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2. Define isomerism.

Isomerism occurs when two or more compounds have the same molecular formula but different arrangements of atoms or structures, resulting in different properties.

Example:

- Structural Isomers: Butane (C_4H_{10}) exists as n-butane and isobutane.
- Geometric Isomers: Cis- and trans-but-2-ene.

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3. Give three examples of unsaturated compounds.

1. Ethene ($CH_2=CH_2$)
2. Propyne ($CH\equiv C-CH_3$)
3. Butene ($CH_2=CH-CH_2-CH_3$)

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4. Define a functional group.

A functional group is a specific group of atoms within a molecule that determines its chemical properties and reactions.

Example: The hydroxyl group (-OH) in alcohols like ethanol makes it polar and reactive.

5. What is the difference between an alkene and an alkyne?

- **Alkenes**: Contain at least one double bond between carbon atoms.
  Example: Ethene ($CH_2=CH_2$).
- **Alkynes**: Contain at least one triple bond between carbon atoms.
  Example: Ethyne (CH≡CH).

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6. Identify the following compounds and encircle the functional groups they contain.

1. CH_3-CH_2-OH → Ethanol (functional group: -OH, hydroxyl group)
2. CH_3-COOH → Acetic acid (functional group: -COOH, carboxyl group)
3. CH_3-CHO → Acetaldehyde (functional group: -CHO, aldehyde group)
4. CH_3-O-CH_3 → Dimethyl ether (functional group: -O-, ether group)

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7. What is the name of alkane having four carbon atoms in the chain?

The alkane with four carbon atoms is **butane (C_4H_{10})**.

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8. Give the structural formula of two simple alkenes and one alkyne.

- **Alkenes**:
  1. Ethene: $CH_2=CH_2$
  2. Propene: CH_3-CH=CH_2
- **Alkyne**:
  Ethyne: CH≡CH

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9. What is the term functional group?

A functional group is a specific cluster of atoms that imparts characteristic chemical reactivity to the compound.

Example:

- Hydroxyl group (-OH) in alcohols
- Carbonyl group (-C=O) in aldehydes and ketones.

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10. Identify the type of following compounds as alcohol, aldehyde, or ketone:

1. **$HOCH_2CHO$**: This is **glycolaldehyde**, which is an aldehyde.
2. **CH_3COCH_3**: This is **acetone**, which is a ketone.
3. **CH_3OH**: This is **methanol**, which is an alcohol.

Think Tank

8. Give the molecular formula of a compound containing C, H, and O and single bonds. List all the possible functional groups this compound can have.

Molecular Formula:

C_2H_6O

Possible Functional Groups:

1. **Alcohol (-OH):**
    - Example: Ethanol (CH_3-CH_2OH)
2. **Ether (-O-):**
    - Example: Dimethyl ether (CH_3-O-CH_3)

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9. Give the condensed structural formulas of the following compounds and classify each on the basis of functional group.

(a) CH_3-CH_2-COOH:

Condensed Formula: CH_3-CH_2-COOH
Functional Group: Carboxylic acid (-COOH).
Example: Propanoic acid.

(b) CH_3-CH_2-CH_2-OH:

Condensed Formula: CH_3-CH_2-CH_2-OH
Functional Group: Alcohol (-OH).
Example: Propanol.

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10. The diagram represents an organic compound that contains three different elements.

Answer:

This compound contains carbon (C), hydrogen (H), and chlorine (Cl).
It is likely **Vinyl Chloride (CH_2=CHCl)**, an important precursor for PVC (polyvinyl chloride).

Classify Vinyl Chloride as a saturated or unsaturated compound.

Answer: Vinyl chloride is an **unsaturated compound** because it contains a double bond (C=C) between two carbon atoms.

Sketch the structural formula of a two-carbon compound containing the following functional groups:

(a) Alcohol:

Structure: CH_3-CH_2-OH (Ethanol)

(b) Aldehyde:

Structure: CH_3-CHO (Ethanal)

(c) Carboxylic Acid:

Structure: CH_3-COOH (Ethanoic acid)

(d) Alkene:

Structure: CH_2=CH_2 (Ethene)

Aspirin is a mild painkiller and fever reducer. It is manufactured from salicylic acid.

Structure of Aspirin:

The functional groups in aspirin include:

1. Carboxylic acid (-COOH).
2. Ester (-COO-).

Identify the functional groups present in the compound and encircle them. Justify your selection.

Functional Groups:

1. **Carboxylic Acid (-COOH):** Present in aspirin.
2. **Ester (-COO-):** Contributes to aspirin's properties.

Construct the general formula for an alkane, an alkene, alkyne, and an alcohol containing two carbon atoms.

1. **Alkane:** C_2H_6 (Ethane)
2. **Alkene:** C_2H_4 (Ethene)
3. **Alkyne:** C_2H_2 (Ethyne)
4. **Alcohol:** C_2H_6O (Ethanol)

Water adds to ethene according to the following reaction:

CH_2=CH_2 + H_2O → CH_3CH_2OH

- **Functional Group in Reactants:**

- Double bond (C=C) in ethene.
- Hydroxyl group (-OH) in water.

- **Functional Group in Product:**
  - Hydroxyl group (-OH) in ethanol.

Extera Short Questions (Topic Wise)

13.1: Organic Compounds

1. What are organic compounds?

Organic compounds are chemical compounds that primarily contain carbon atoms bonded with hydrogen, oxygen, nitrogen, or other elements. They form the basis of life and include carbohydrates, proteins, and lipids.
Example: Methane (CH_4) is the simplest organic compound.

2. Why is carbon important in organic compounds?

Carbon's ability to form four covalent bonds allows it to create diverse structures such as chains, rings, and branches, making it the backbone of organic chemistry.
Example: Ethanol (C_2H_5OH) contains a carbon chain and is widely used as an alcohol.

3. What are hydrocarbons?

Hydrocarbons are organic compounds made only of carbon and hydrogen atoms. They are categorized into alkanes, alkenes, and alkynes based on their bonding.
Example: Propane (C_3H_8) is a hydrocarbon used in cooking fuel.

4. What are natural sources of organic compounds?

Natural sources include plants, animals, and fossil fuels such as petroleum and natural gas.
Example: Glucose ($C_6H_{12}O_6$) is an organic compound derived from plants through photosynthesis.

13.2: Functional Groups

1. What are functional groups in organic compounds?

Functional groups are specific groups of atoms within a molecule that determine its chemical properties and reactivity.
Example: The hydroxyl group (-OH) makes alcohols like ethanol soluble in water.

2. Why are functional groups important?

Functional groups influence the physical and chemical properties of organic molecules, enabling diverse chemical reactions.
Example: The carbonyl group (-C=O) is present in aldehydes and ketones.

3. Name common functional groups.

Some common functional groups are hydroxyl (-OH), carboxyl (-COOH), amino ($-NH_2$), and alkyl ($-CH_3$).
Example: The carboxyl group makes acetic acid (CH_3COOH) acidic.

4. What is the functional group in alcohols?

The functional group in alcohols is the hydroxyl group (-OH). It imparts solubility and polarity to the compound.
Example: Methanol (CH_3OH) is a simple alcohol with a hydroxyl group.

13.3: Homologous Series

1. What is a homologous series?

A homologous series is a group of organic compounds with the same functional group and similar chemical properties, differing by a CH_2 unit.
Example: Alkanes like methane (CH_4), ethane (C_2H_6), and propane (C_3H_8) form a homologous series.

2. What are the characteristics of a homologous series?

- Members differ by a CH_2 group.
- Have similar chemical properties but gradual changes in physical properties like boiling points.
  Example: Alkenes (C=C) show a homologous series, with ethene (C_2H_4) and propene (C_3H_6).

3. Why is a homologous series important?

It helps predict properties and reactions of compounds within the series.
Example: Knowledge of alkanes allows predictions about higher alkanes like butane (C_4H_{10}).

4. How do physical properties change in a homologous series?

As the molecular size increases, boiling and melting points also increase due to stronger intermolecular forces.
Example: Propane (C_3H_8) has a higher boiling point than methane (CH_4).

13.4: Nomenclature of Organic Compounds

1. What is IUPAC nomenclature?

The International Union of Pure and Applied Chemistry (IUPAC) system standardizes the naming of organic compounds based on structure.
Example: CH_4 is named methane.

2. What are the basic rules of IUPAC naming?

- Identify the longest carbon chain.
- Number the chain to give the lowest numbers to substituents.
- Use prefixes and suffixes for functional groups.
  Example: CH_3CH_2OH is named ethanol.

3. How are alkenes named?

Alkenes are named by replacing the "-ane" suffix in alkanes with "-ene" and indicating the position of the double bond.
Example: $CH_2=CH_2$ is named ethene.

4. What is the IUPAC name for CH_3COOH?

The compound CH_3COOH is named ethanoic acid, with "eth" indicating two carbons and "-oic acid" indicating the carboxyl group.
Example: Ethanoic acid is commonly known as vinegar.

13.5: Isomerism

1. What is isomerism in organic chemistry?

Isomerism occurs when compounds have the same molecular formula but different structures or arrangements of atoms.
Example: Butane (C_4H_{10}) has two isomers: n-butane and isobutane.

2. What are the types of isomerism?

- **Structural Isomerism**: Different connectivity of atoms.
- **Stereoisomerism**: Same connectivity but different spatial arrangements.
  Example: Glucose and fructose are structural isomers.

3. What are structural isomers?

Structural isomers have the same molecular formula but different arrangements of atoms, resulting in distinct properties.
Example: Pentane (C_5H_{12}) has straight-chain and branched isomers.

4. What are geometric isomers?

Geometric isomers (cis-trans isomers) differ in the spatial arrangement around a double bond or ring structure.
Example: In but-2-ene, cis-but-2-ene has both methyl groups on the same side, while trans-but-2-ene has them on opposite sides.

Extera Long Questions (Topic Wise)

1. Why are functional groups important in organic compounds?

Definition of Functional Groups

Functional groups are specific groups of atoms within molecules that determine the chemical properties and reactivity of organic compounds. They are the "active sites" where chemical reactions occur.

Importance of Functional Groups

1. **Chemical Reactivity**: Functional groups define how a molecule reacts in specific conditions.
2. **Classification**: Organic compounds are classified based on their functional groups, such as alcohols, aldehydes, and acids.
3. **Physical Properties**: They influence boiling point, solubility, and polarity.

Example:
The hydroxyl group (-OH) in alcohols like ethanol makes the compound soluble in water and reactive with acids.

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2. What is the difference between structural and geometric isomerism?

Structural Isomerism

Structural isomers have the same molecular formula but different arrangements of atoms within the molecule. This leads to differences in physical and chemical properties.
Example:
Butane (C_4H_{10}) exists as:

- **n-Butane**: A straight-chain structure.
- **Isobutane**: A branched-chain structure.

Geometric Isomerism

Geometric isomers have the same molecular formula and connectivity but differ in the spatial arrangement of atoms around a double bond or ring structure.
Example:

- **Cis-But-2-ene**: Both methyl groups are on the same side of the double bond.
- **Trans-But-2-ene**: Methyl groups are on opposite sides of the double bond.

Key Difference

- Structural isomers differ in connectivity.
- Geometric isomers differ in spatial arrangement.

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3. How do physical properties change in a homologous series?

Definition of a Homologous Series

A homologous series is a group of organic compounds with the same functional group and similar chemical properties, differing by a CH_2 unit.

Changes in Physical Properties

1. **Boiling and Melting Points**: As molecular size increases, boiling and melting points rise due to stronger van der Waals forces.
2. **Solubility**: Solubility in water decreases with an increase in molecular size because larger molecules become more nonpolar.
3. **Density**: The density of members also increases gradually.

Example:

- Methane (CH_4): Low boiling point (-161°C).
- Propane (C_3H_8): Higher boiling point (-42°C).

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4. What are the rules for naming alkanes in IUPAC nomenclature?

Steps for Naming Alkanes

1. **Find the Longest Chain**: Identify the longest continuous carbon chain in the molecule.
2. **Number the Chain**: Number the chain from the end nearest to a substituent to assign the lowest possible numbers to branches or functional groups.
3. **Name Substituents**: Use prefixes like methyl-, ethyl-, or propyl- for side chains, and arrange them alphabetically.
4. **Combine Names**: Add the names of the substituents to the base name of the alkane (based on the length of the longest chain). Use suffix "-ane" for alkanes.

Example:

CH_3-CH_2-CH_2-CH_3

- Longest chain: 4 carbons = "butane."
- No substituents, so the IUPAC name is **butane**.

For CH_3-$CH(CH_3)$-CH_2-CH_3:

- Longest chain: 4 carbons = "butane."
- Substituent: Methyl group (-CH_3) at position 2.
- IUPAC Name: **2-Methylbutane**.

MCQS

13.1: Organic Compounds

1. **What are organic compounds primarily made of?**
   a) Hydrogen and nitrogen
   b) Carbon and hydrogen ✔
   c) Oxygen and carbon
   d) Sodium and potassium

2. **Which of the following is the simplest organic compound?**
   a) Ethanol
   b) **Methane** ✔
   c) Acetone
   d) Benzene

3. **What are hydrocarbons?**
   a) Compounds with only oxygen and hydrogen
   b) Compounds with carbon, hydrogen, and oxygen
   c) **Compounds with only carbon and hydrogen** ✔
   d) Compounds with sulfur and nitrogen

4. **Which of the following is an example of a hydrocarbon?**
   a) H_2O
   b) **C_3H_8 (Propane)** ✔
   c) NaCl
   d) CO_2

5. **What is the primary source of organic compounds?**
   a) Plants
   b) Animals
   c) Fossil fuels
   d) **All of the above** ✔

13.2: Functional Groups

6. **Which of the following is a functional group?**
   a) -OH
   b) -COOH
   c) $-NH_2$
   d) **All of the above** ✔

7. **What is the functional group of alcohols?**
   a) $-NH_2$
   b) -COOH

c) **-OH** ✔
d) $-CH_3$

8. **What is the functional group in carboxylic acids?**
   a) -OH
   b) **-COOH** ✔
   c) $-NH_2$
   d) -C=O

9. **What is the functional group in aldehydes?**
   a) -OH
   b) -COOH
   c) **-CHO** ✔
   d) -C=C

10. **Which functional group is found in ketones?**
    a) -COOH
    b) $-NH_2$
    c) -CHO
    d) **-C=O** ✔

13.3: Homologous Series

11. **What is a homologous series?**
    a) A series of compounds with the same physical properties
    b) A series of compounds with different functional groups
    c) **A series of compounds with the same functional group and similar chemical properties** ✔
    d) A series of compounds with varying carbon content but no functional group

12. **Which group of compounds forms a homologous series?**
    a) Acids and bases
    b) Alkanes, alkenes, and alkynes
    c) Polymers
    d) **Hydrocarbons** ✔

13. **What is the general formula of alkanes?**
    a) CnH2n+2 ✔
    b) CnH2n
    c) CnH2n-2
    d) CnHn

14. **How do members of a homologous series differ from each other?**
    a) By a CH group
    b) By a -CO group
    c) **By a CH_2 group** ✔
    d) By a functional group

15. **Which is the first member of the alkane series?**
    a) Ethane
    b) **Methane** ✔
    c) Propane
    d) Butane

13.4: Nomenclature of Organic Compounds

16. **What does the prefix "meth-" indicate in IUPAC naming?**
    a) One carbon atom ✔
    b) Two carbon atoms
    c) Three carbon atoms
    d) Four carbon atoms

17. **What is the suffix used for alkanes?**
    a) -ene
    b) -yne
    c) **-ane** ✔
    d) -ol

18. **What is the IUPAC name of CH_4?**
    a) Methane ✔
    b) Ethane
    c) Propane
    d) Butane

19. **How are double bonds indicated in alkenes?**
    a) By adding the prefix "di-"
    b) By using the suffix "-yne"
    c) **By using the suffix "-ene"** ✔
    d) By adding a number

20. **What is the IUPAC name of CH_3-CH_2-OH?**
    a) Methanol
    b) **Ethanol** ✔
    c) Propanol
    d) Butanol

13.5: Isomerism

21. **What is isomerism?**
    a) Compounds with different molecular formulas but similar structures
    b) **Compounds with the same molecular formula but different structures** ✔
    c) Compounds with similar properties
    d) Compounds with the same structure but different atoms

22. **What are structural isomers?**
    a) Compounds with the same molecular formula but different spatial arrangements

b) **Compounds with the same molecular formula but different connectivity of atoms** ✔
c) Compounds with different molecular formulas
d) Compounds with identical structures

23. **What are geometric isomers?**
a) Isomers with the same molecular formula but different functional groups
b) **Isomers with the same molecular formula but different spatial arrangements around a double bond** ✔
c) Isomers with different molecular formulas
d) Isomers with the same structure

24. **What is the difference between cis- and trans-isomers?**
a) Cis-isomers are functional groups on the same side; trans-isomers are on opposite sides ✔
b) Cis-isomers have different molecular formulas; trans-isomers have the same
c) Cis-isomers are liquids; trans-isomers are solids
d) There is no difference

25. **What is the molecular formula of butane?**
a) C_2H_6
b) **C_4H_{10}** ✔
c) C_3H_8
d) C_5H_{12}

General Organic Chemistry

26. **Which type of bond is present in alkanes?**
a) Single bond ✔
b) Double bond
c) Triple bond
d) Aromatic bond

27. **What are alkenes?**
a) Compounds with single bonds only
b) **Compounds with at least one double bond** ✔
c) Compounds with triple bonds only
d) Compounds with aromatic rings

28. **What type of compound is ethyne (C_2H_2)?**
a) Alkane
b) Alkene
c) **Alkyne** ✔
d) Alcohol

29. **Which is the simplest ketone?**
a) Acetaldehyde
b) **Acetone** ✔
c) Ethanol
d) Methanol

30. **What is the name of CH_3-CH_2-COOH?**

a) Propane

b) **Propanoic acid** ✔

c) Ethanoic acid

d) Methanoic acid