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ICSE
Living Science
Chemistry

Class 10

Chapter-12 Organic Chemistry - I

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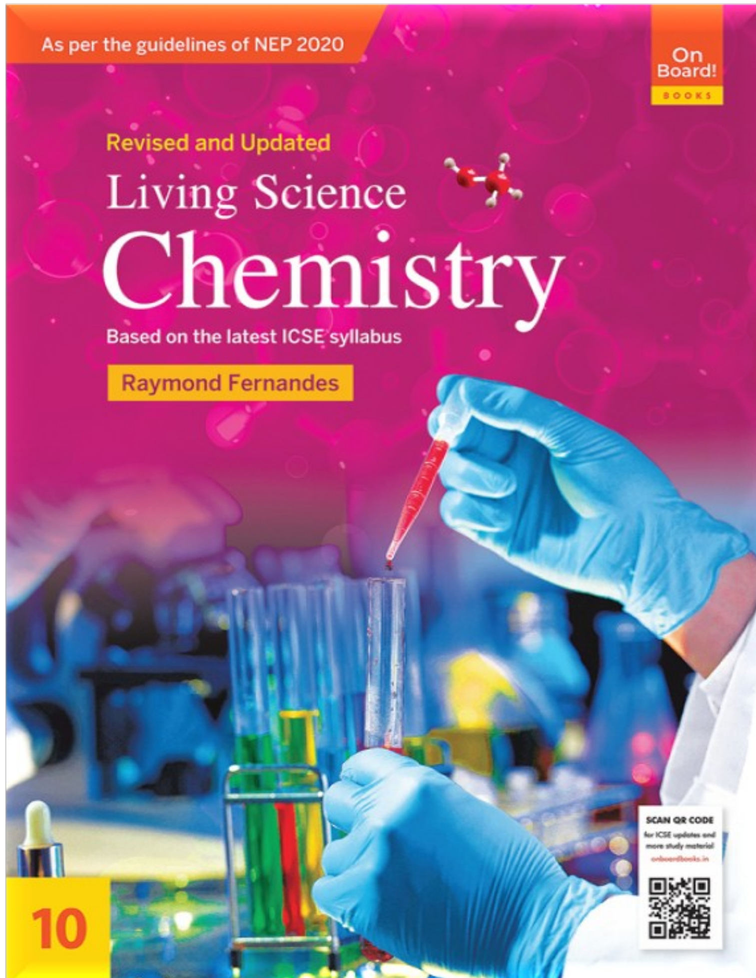


LEARNING OBJECTIVES

Characteristics of Organic Compounds

- Comparison between organic and inorganic compounds

Unique Nature of Carbon Atom

- Classification of organic compounds
- Functional groups

Nomenclature of Organic Compounds

- Nomenclature of different classes of organic compounds

IUPAC Rules for Naming an Organic Compound

- Writing the structural formula of organic compounds

Homologous Series

- Characteristics of homologous series
- Isomerism in Organic Compounds

Modern definition of organic compounds

Organic compounds, whether natural or synthetic, contain carbon and hydrogen as the main elements along with other elements like nitrogen, oxygen, sulphur, halogens and phosphorus. Therefore, organic chemistry is defined as the chemistry of carbon compounds containing usually hydrogen and one or more additional elements like oxygen, nitrogen, sulphur, halogens and phosphorus.

Characteristics of Organic Compounds

1. They are compounds of carbon.
2. They can exist in all three states, i.e. solid, liquid and gas.
3. They are covalent compounds.
4. They are insoluble in water but dissolve in organic solvents like benzene and toluene.
5. They have low melting points and boiling points.
6. They are poor conductors of electricity.
7. They are volatile and flammable.
8. The reaction rate of organic compounds is slow.
9. They exhibit isomerism.

Comparison between organic and inorganic compounds

This comparison is made on the fact that the bonding in organic compounds is entirely covalent while most inorganic compounds have ionic bonds.

Table 12.1 A comparison of properties of organic and inorganic compounds

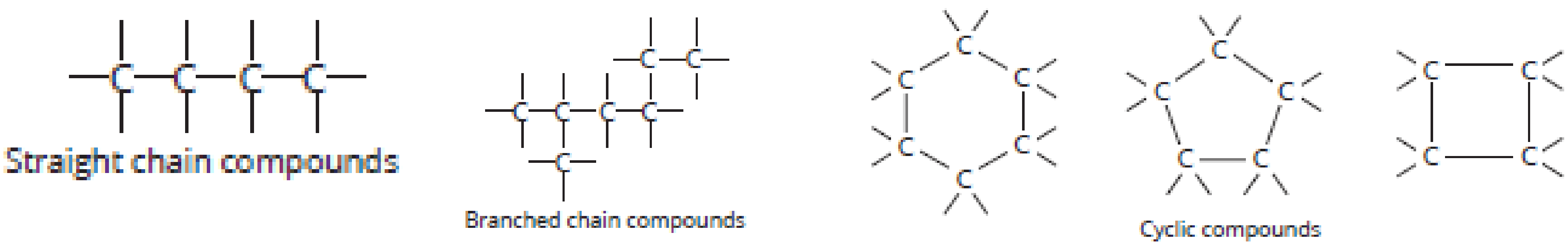
Organic compounds	Inorganic compounds
Bonding is entirely covalent.	Most have ionic bonds.
Many are gases, liquids or solids with low melting points.	Most are solids with high melting points.
Most are insoluble in water but soluble in organic solvents like ether and benzene.	Many are soluble in water and insoluble in organic solvents.
Their aqueous solutions do not conduct electricity.	Their aqueous solutions contain ions, and hence, conduct electricity.
Almost all burn and decompose.	Very few burn.
Reactions of such compounds are slow.	Reactions are very fast.

Unique Nature of Carbon Atom

A carbon atom has unique nature which enables the existence of a large number of organic compounds.

1. Tetravalency of carbon atom: Carbon has four valence electrons and it forms four covalent bonds by sharing its four electrons with atoms of carbon or some other element. This characteristic property is called **tetravalency**.

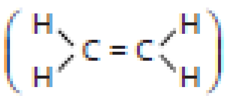
2. Catenation: Carbon has the unique ability to form bonds with other atoms of carbon, thereby, forming a large number of molecules. This property is called **catenation**. These compounds may have long chains of carbon, branched chain of carbon or carbon atoms arranged in a ring. Carbon atoms may be linked by single, double or triple bonds.



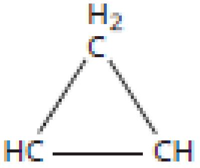
3. **Isomerism:** Organic compounds having the same molecular formula but different structural formulae are called isomers and the phenomenon is called **isomerism**. The isomers have different properties as the arrangement of atoms are different.

Classifications of Organic Compounds

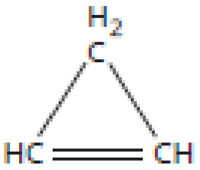
- **Hydrocarbons** (Compounds of carbon and hydrogen)
  - **Open chain** (Acyclic compounds/ Aliphatic compounds)
    - **Saturated** (Single bonds between all carbon atoms)
      - **Alkanes** (Paraffins) ($CH_3 - CH_2 - CH_2 - CH_3$) butane
    - **Unsaturated** (At least one double or triple bond)
      - **Alkenes** (Olefins) Double bond



      - **Alkynes** (Acetylenes) Triple bond ($H - C \equiv C - H$)
  - **Closed chain** (Cyclic compounds)
    - **Alicyclic compounds**

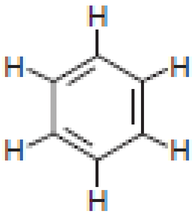


Cyclopropane



Cyclopropene

    - **Aromatic compounds** (Special types of compounds, include benzene ring compounds)



Benzene

[ring containing six carbon atoms having carbon-carbon single and carbon-carbon double bonds in alternate position]

Organic compounds can be classified as:
1. Open chain compounds
2. Closed chain compounds

Open chain compounds are also called **aliphatic compounds** (or acyclic compounds) and closed chain compounds are called **cyclic compounds**.

Cyclic compounds can be classified further into **heterocyclic compounds** and **homocyclic** or **carbocyclic** compounds.

Homocyclic or **carbocyclic compound** is a compound in which the ring comprises only carbon atoms.

A **heterocyclic compound** contains other elements besides carbon in the ring. Homocyclic compounds then can be subdivided into alicyclic compounds and aromatic compounds.

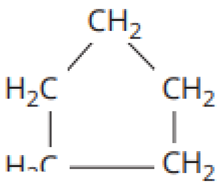
Hydrocarbons: Hydrocarbons are organic compounds containing only carbon and hydrogen. They are divided into aliphatic (open chain) and cyclic (closed chain) compounds.

Hydrocarbons can either be **saturated** or **unsaturated**. Saturated hydrocarbons contain only single covalent bonds between carbon atoms. Saturated hydrocarbons are called **alkanes** or **paraffins**.

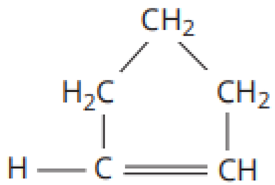
Unsaturated hydrocarbons contain atleast one carboncarbon double bond or carbon-carbon triple bond. Unsaturated hydrocarbons are of two types, **alkenes** or **olefins** and **alkynes** or **acetylenes**.

Cyclic compounds can also be saturated or unsaturated.

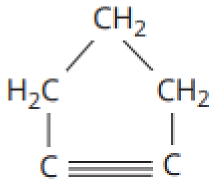
1. Saturated cyclic compounds containing single covalent bonds are called cycloalkanes. For example, cyclopentane.



2. Unsaturated cyclic compounds containing double covalent bonds are called cycloalkenes. For example, cyclopentene.



3. Unsaturated cyclic compounds containing triple covalent bonds are called cycloalkynes. For example, cyclopentyne



Functional groups

A functional group is a chemically reactive atom or group of atoms present within the molecule of an organic compound which is responsible for its characteristic chemical properties.All the compounds with the same functional group show similar chemical properties.

TABLE 12.2 Some functional groups in carbon compounds

Functional group	Formula of functional group	Types of organic compounds
Halo–(chloro, bromo)	– Cl, –Br	Haloalkanes
Hydroxyl	– OH	Alcohols
Aldehyde	$-\mathrm{C}\begin{smallmatrix}\diagup \mathrm{H}\\ \diagdown\!\!\diagdown \mathrm{O}\end{smallmatrix}$	Aldehydes
Ketone	$-\underset{\underset{\displaystyle \mathrm{O}}{\|}}{\mathrm{C}}-$	Ketones
Carboxyl	$-\overset{\overset{\displaystyle \mathrm{O}}{\|}}{\mathrm{C}}-\mathrm{OH}$	Carboxylic acids

Nomenclature of Organic Compounds

There are two systems for naming the organic compounds:

1. Trivial system

2. IUPAC system

1. Trivial system: The organic compounds are named on the basis of their source, properties and their Latin or Greek origin. For example

CH_3COOH - Acetic acid HCHO - Formaldehyde

CH_3COCH_3 -Acetone $CHCl_3$ -Chloroform

2. IUPAC system: The IUPAC system assigns only one name to the compound. A systematic name of an organic compound may consists of:

Root Word: This depends upon the number of carbon atoms selected present in the longest carbon chain.

Suffix: The suffix is added to the appropriate root word. The suffix represents the nature of the functional group.

Prefix: This denotes the substituent (alkyl group or functional group) if present in the carbon chain.

Nomenclature of different classes of organic compounds

1. Alkanes

General formula: C_nH_{2n+2}

UPAC name: Alkane

Examples:	**Formula**	**IUPAC name**
	CH_4	Methane
	C_2H_6	Ethane

2. Alkenes

General formula: C_nH_{2n}

IUPAC name: Alkene

Examples:

Formula	IUPAC name
C_2H_4	Ethene
C_3H_6	Propene

3. Alkynes

General formula: C_nH_{2n-2}

UPAC name: Alkyne

Examples:

Formula	IUPAC name
C_2H_2	Ethyne
C_3H_4	Propyne

4. Halogen derivatives

General formula: $C_nH_{2n+1}X$ (where X = F, Cl,Br, I)

Formula	IUPAC name	Common name
CH3Cl	Chloromethane	Methyl chloride
C2H5Br	Bromoethane	Ethyl bromide

5. Alcohols

General formula: C_nH_{2n+1} OH

Formula	IUPAC name	Common name
CH_3OH	Methanol	Methyl alcohol
C_2H_5OH	Ethanol	Ethyl alcohol

6. Aldehydes

General formula: $C_nH_{2n+1}CHO$

Formula	IUPAC name	Common name
HCHO	Methanal	Formaldehyde
CH_3CHO	Ethanal	Acetaldehyde

7. Ketones

General formula: $C_nH_{2n+2}CO$

Formula	IUPAC name	Common name
CH_3COCH_3	2-Propanone	Acetone
$CH_3COC_2H_5$	2-Butanone	Ethyl methyl ketone

8. Carboxylic acid

General formula: $C_nH_{2n+1}COOH$

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

9. Ethers

General formula: $C_nH_{2n+2}O$

Formula	IUPAC name	Common name
CH3OCH3	Methoxymethane	Dimethyl ether
CH3OC2H5	Methoxyethane	Ethyl methyl ether

IUPAC rules for naming an organic compound

Note: For naming the organic compound, pl. refer to the rules described in detail in the book p 219 to 221.

Writing the structural formula of organic compounds

1. Write the number of carbon atoms in the chain according to the word root and number them.
2. Now according to suffix, –ane, –ene or –yne, the position of the bond is specified in the parent chain.
3. Next add the functional group or substituent to the mentioned carbon atom.
4. Add –H to complete the bonding of carbon atoms.

Homologous Series

A homologous series is a series of organic compounds each containing a characteristic functional group. The successive members of the series are called homologues.

Characteristics of homologous series

1. Different members of a homologous series can be assigned the same general formula. For example, the alkanes are represented by C_nH_{2n+2}.

2. Every member of a homologous series differs from its successive member by a CH_2 group.

3. All homologues have the same chemical properties.

4. Different homologues can be prepared by the same general method of preparation.

5. The root names of all homologues depend on the number of carbon atoms.

6. An increase in molecular mass of members within a homologous series shows a regular gradation of the physical properties, such as physical state, melting point and boiling point. Melting and boiling points of compounds in a homologous series increase with increase in molecular mass.

Note: Refer to Table 12.7 for Homologous Series

Structure Of Some Common Organic Compounds

Organic compounds are covalently bonded compounds in which carbon bonds with other elements and also with other carbon atoms. Carbon is tetravalent, which means its valency can be satisfied when it bonds with four other elements.

Carbon can also form double and triple bonds either with other carbon atoms or atoms of other elements capable of forming such bonds.

Organic compounds can therefore be represented by molecular and structural formulae. **Refer to (Table 12.8).**

Isomerism in Organic Compounds

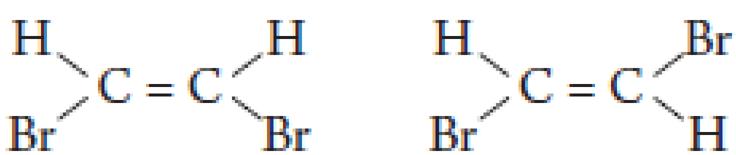
Compounds that have the same molecular formula but different molecular structures (structural formulae) are called **isomers** and the phenomenon is called **isomerism**.

Isomerism arises due to the:

a. difference in the mode of linking of atoms.

For example: C_3H_8O can be written as $CH_3CH_2CH_2OH$ as well as $CH_3CH_2OCH_3$

b. difference in the arrangement of atoms or groups in space. For example, 1, 2 – dibromoethene can be drawn as:



Classification of isomerism

Isomerism can be classified into two broad types:

1. Structural isomerism **2.** Stereoisomerism

Structural isomerism is further of four types:

1. Chain isomerism **2.** Positional isomerism

3. Functional isomerism **4.** Tautomerism

Stereoisomerism is again of two types:

1. Optical isomerism **2.** Geometrical isomerism

Chain isomers are compounds that have the same molecular formula but different carbon skeleton. This phenomenon is called chain isomerism.

For example,

Butane $CH_3-CH_2-CH_2-CH_3$

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

Positional isomers are compounds that have the same molecular formula but differ in the position of particular atoms or groups. The phenomenon is termed positional isomerism.

For example,

Propan-1-ol $CH_3-CH_2-CH_2-OH$

Propan-2-ol $CH_3-\underset{\displaystyle OH}{\underset{|}{CH}}-CH_3$

Functional isomers are compounds that have the same molecular formula but different functional groups and therefore belong to different homologous series.

The phenomenon is called functional isomerism.

For example,

Ethyl alcohol C_2H_5OH

Dimethyl ether $CH_3 – O – CH_3$

Tautomers are compounds that have the same molecular formula but contain different functional groups that are in equilibrium.

SUMMARY

1. Compounds can be classified as organic and inorganic.

2. Organic compounds are the compounds of carbon. They exist in all three states, i.e. solids, liquids and gases.

3. Organic compounds have low melting points and boiling points and are poor conductors of electricity.

4. The reaction rate of organic compounds is low.

5. Organic compounds exhibit isomerism.

6. Organic compounds can also be classified as acyclic and cyclic; homocyclic and heterocyclic; saturated and unsaturated.

7. A series of organic compounds containing a particular characteristic group is called the homologous series.

8. Different members of a homologous series can be assigned the same general formula.

9. Every member of a homologous series is called a homologue and differs from its successive member by a CH_2 group.

10. All homologues have the same chemical properties.

11. The steps to be followed during nomenclature of organic compounds:

- Identify the longest chain.

- Number the chain suitably and therefore select the root word from the numbering.
- Depending on the nature of the chain attached, suffixes like –ane, –ene and –yne are used.
- Add prefixes and suffixes with appropriate numerals to indicate the number and position of each side chain, functional group or the substituent.

Nomenclature of homologous series

Add

Name	Nomenclature	General formula
Alkanes	–ane	C_nH_{2n+2}
Alkenes	–ene	C_nH_{2n}
Alkynes	–yne	C_nH_{2n-2}
Halogen derivatives	Haloalkane	$C_nH_{2n+1}X$ (where X = F, Cl, Br, I)
Alcohol	–ol	$C_nH_{2n+1}OH$
Aldehyde	–al	$C_nH_{2n+1}CHO$
Ketone	–one	$C_nH_{2n+2}CO$
Carboxylic acid	– oic acid	$C_nH_{2n+1}COOH$

13. The steps to be followed when writing the structural formulae of organic compounds:

- Locate the parent alkane from the name.

Write the number of carbon atoms in the chain and number them.

- Now locate suffixes.
- Locate the functional groups.
- Then add the substituents as the side chains.
- Add –H to complete the bonding.

14. Organic compounds that have the same molecular formula but different structural formulae are called **isomers** and the phenomenon is called **isomerism**.

15. Isomerism can be classified into two broad types:

- Structural isomerism • Stereoisomerism

16. Structural isomerism is of four types:

- Chain isomerism • Positional isomerism
- Functional isomerism • Tautomerism

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THANK YOU