UNIQUE STUDY POINT

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Class: X	**Subject:** Science	**Session:** 2025-26
Chapter: 04 - Carbon and its Compounds	**Time:** 1½ Hours	**Max. Marks:** 40

General Instructions:

1. All questions are compulsory.
2. This question paper contains 20 questions divided into five sections A, B, C, D and E.
3. Section A contains 10 MCQs of 1 mark each.
4. Section B contains 4 questions of 2 marks each.
5. Section C contains 3 questions of 3 marks each.
6. Section D contains 1 question of 5 marks.
7. Section E contains 2 Case Study Based questions of 4 marks each.

SECTION A - Multiple Choice Questions (1 mark each)

Q1. Alkanes have the general formula:

(a) C_nH_{2n}

(b) C_nH_{2n+2}

(c) C_nH_{2n-2}

(d) C_nH_n

Q2. Buckminsterfullerene C_{60} has carbon atoms arranged in the shape of:

(a) Linear chain

(b) Hexagonal layers

(c) Tetrahedron

(d) Football

Q3. Which is NOT a property of diamond?

(a) Hardest natural substance

(b) Good conductor of electricity

(c) High refractive index

(d) Rigid 3D structure

Q4. The IUPAC name of CH_3-CO-CH_3 is:

(a) Propanol

(b) Propanone

(c) Propanal

(d) Propanoic acid

Q5. In substitution reaction of CH_4 with Cl_2, what condition is required?

(a) Heat

(b) Sunlight

(c) Nickel catalyst

(d) High pressure

Q6. Which functional group is present in ketones?

(a) -OH

(b) -CHO

(c) -CO-

(d) -COOH

Q7. Vinegar contains:

(a) 5-8% methanoic acid

(b) 5-8% ethanoic acid

(c) 5-8% propanoic acid

(d) Pure ethanoic acid

Q8. Scum is formed when soap reacts with:

(a) Soft water

(b) Distilled water

(c) Hard water

(d) Rain water

Q9. Which element shows maximum catenation?

(a) Carbon

(b) Silicon

(c) Germanium

(d) Tin

Q10. Isomers have:

(a) Same molecular formula but different structures

(b) Different molecular formula but same structure

(c) Same molecular formula and same structure

(d) Different molecular formula and different structure

SECTION B - Short Answer Questions (2 marks each)

Q11. What are structural isomers? Draw two isomers of butane (C_4H_{10}).

Q12. Explain why diamond is hard while graphite is soft, even though both are made of carbon.

Q13. Write the IUPAC names of:

(i) CH_3-CH_2-CH_2-OH

(ii) CH_3-CH(Br)-CH_3

Q14. What is the difference between addition and substitution reactions? Give one example of each.

SECTION C - Short Answer Questions (3 marks each)

Q15. Explain saponification with chemical equation. What are soaps chemically?

Q16. (a) Define functional group with two examples.

(b) How does the functional group determine the properties of carbon compounds?

Q17. Compare the structures of diamond and graphite. Why is graphite used as a lubricant while diamond is used for cutting?

SECTION D - Long Answer Question (5 marks)

Q18. (a) Write three structural isomers of pentane (C_5H_{12}) with their structural formulae.
(b) Define isomerism.
(c) Why do isomers have different physical properties but similar chemical properties?

SECTION E - Case Study Based Questions (4 marks each)

Q19. **Case Study 1:** Carbon exists in different forms called allotropes. The three important allotropes are diamond, graphite, and fullerenes. Diamond has a rigid three-dimensional structure where each carbon is bonded to four others forming a tetrahedral network. Graphite has a layered structure where each carbon bonds to three others in hexagonal arrays, with weak forces between layers. Fullerenes like C_{60} have carbon atoms arranged in hollow spherical structures.

Based on the above information, answer the following:
(i) Why is diamond the hardest substance while graphite is soft and slippery? (1 mark)
(ii) Explain why graphite conducts electricity but diamond does not. (1 mark)
(iii) What is the shape of Buckminsterfullerene (C_{60})? Why was it given this name? (2 marks)

Q20. **Case Study 2:** IUPAC (International Union of Pure and Applied Chemistry) has developed a systematic method for naming organic compounds. The name is based on the longest carbon chain, the functional group present, and the position of substituents. Prefixes like meth-, eth-, prop-, but- indicate the number of carbon atoms. Suffixes like -ane, -ene, -yne indicate saturation, while -ol, -al, -one, -oic acid indicate functional groups.

Based on the above information, answer the following:
(i) Write the IUPAC name of CH_3-CH_2-CH_2-CHO. (1 mark)
(ii) What does the suffix '-oic acid' indicate in a name? Give one example. (1 mark)
(iii) Draw the structure of 2-bromopropane and explain how the name indicates its structure. (2 marks)

DETAILED ANSWER KEY - PAPER 02

SECTION A - Answers to MCQs

Ans 1. (b) C_nH_{2n+2}

Alkanes are saturated hydrocarbons with only single bonds. Examples: CH_4 (n=1), C_2H_6 (n=2), C_3H_8 (n=3).

Ans 2. (d) Football

C_{60} has 60 carbon atoms arranged like a soccer ball with hexagons and pentagons. Named after architect Buckminster Fuller who designed geodesic domes.

Ans 3. (b) Good conductor of electricity

Diamond is an insulator as all 4 valence electrons of carbon are involved in bonding, leaving no free electrons for conduction.

Ans 4. (b) Propanone

3 carbons (prop-) + ketone group (-one). The functional group -CO- is in the middle.

Ans 5. (b) Sunlight

$CH_4 + Cl_2$ --sunlight--> $CH_3Cl + HCl$. Sunlight provides energy for the substitution reaction.

Ans 6. (c) -CO-

Ketones have carbonyl group (-CO-) bonded to two carbon atoms. Example: CH_3-CO-CH_3 (propanone).

Ans 7. (b) 5-8% ethanoic acid

Vinegar is dilute acetic acid (ethanoic acid) used as preservative in pickles.

Ans 8. (c) Hard water

Hard water contains Ca^{2+} and Mg^{2+} ions which react with soap to form insoluble precipitate called scum.

Ans 9. (a) Carbon

Carbon shows maximum catenation due to strong C-C bonds (356 kJ/mol) and small atomic size allowing effective orbital overlap.

Ans 10. (a) Same molecular formula but different structures

Isomers have identical molecular formulas but different arrangements of atoms, resulting in different physical properties.

SECTION B - Answers to Short Answer Questions

Ans 11. Structural isomers and butane isomers

Structural isomers: Compounds with the same molecular formula but different structural arrangements of atoms.

Two isomers of butane (C_4H_{10}):

1. n-Butane (straight chain):

```
  H H H H
  | | | |
H-C-C-C-C-H
  | | | |
```

H H H H

2. Isobutane (branched):
H
|
H-C-H
| H H
H-C-C-C-H
| | |
H H H

Ans 12. Diamond vs Graphite hardness

Diamond: Hard because each carbon atom is covalently bonded to 4 other carbons in a rigid 3D tetrahedral network. Breaking diamond requires breaking strong covalent bonds.

Graphite: Soft because carbon atoms are arranged in layers with weak van der Waals forces between layers. Layers can slide over each other easily, making graphite soft and slippery.

Ans 13. IUPAC names

(i) CH_3-CH_2-CH_2-OH = **Propan-1-ol** or **1-Propanol**
(3 carbon atoms + alcohol group at position 1)

(ii) CH_3-CH(Br)-CH_3 = **2-Bromopropane**
(3 carbon atoms with bromine attached to middle carbon)

Ans 14. Addition vs Substitution reactions

Addition Reaction: Unsaturated compounds add atoms/groups without removing anything. Double/triple bonds break to form single bonds.
Example: CH_2=CH_2 + H_2 --Ni--> CH_3-CH_3

Substitution Reaction: One atom/group replaces another atom/group in a molecule.
Example: CH_4 + Cl_2 --sunlight--> CH_3Cl + HCl

SECTION C - Answers to Short Answer Questions

Ans 15. Saponification and soaps

Saponification: The reaction of ester with alkali (NaOH/KOH) to produce alcohol and salt of carboxylic acid (soap).

Chemical Equation:
Ester + NaOH → Alcohol + Soap (Sodium salt of fatty acid)
$CH_3COOC_2H_5$ + NaOH → C_2H_5OH + CH_3COONa

For soap preparation:
Oil/Fat + NaOH → Glycerol + Sodium salt of fatty acid (Soap)

Chemical nature of soaps: Soaps are sodium or potassium salts of long-chain fatty acids (carboxylic acids). General formula: R-COO^-Na^+ where R is a long hydrocarbon chain (C_{15}-C_{17}).

Ans 16. Functional groups

(a) **Functional group:** An atom or group of atoms that determines the characteristic properties of an organic compound.

Examples:
• Alcohols: -OH (hydroxyl group)
• Aldehydes: -CHO (aldehyde group)
• Ketones: -CO- (carbonyl group)
• Carboxylic acids: -COOH (carboxyl group)

(b) **How functional group determines properties:**
• The functional group determines the chemical reactions of the compound
• Compounds with same functional group show similar chemical behavior
• Length of carbon chain has minimal effect on chemical properties
• Example: All alcohols (-OH group) react with Na to release H_2, regardless of chain length

Ans 17. Diamond vs Graphite structures and uses

Diamond Structure:
• Each carbon bonded to 4 others in tetrahedral arrangement
• Forms rigid 3D network structure
• All valence electrons used in bonding - no free electrons
• Very strong covalent bonds throughout

Graphite Structure:
• Each carbon bonded to 3 others in hexagonal layers
• Layers held by weak van der Waals forces
• One free electron per carbon - can move between layers
• Strong bonds within layers, weak forces between layers

Uses based on structure:
• **Diamond for cutting:** Extreme hardness due to rigid 3D structure makes it ideal for cutting tools, glass cutters, and drill bits
• **Graphite as lubricant:** Layers slide easily over each other due to weak inter-layer forces, providing smooth lubrication in machinery

SECTION D - Answer to Long Answer Question

Ans 18. Structural isomers of pentane

(a) **Three structural isomers of pentane (C_5H_{12}):**

1. **n-Pentane** (straight chain):

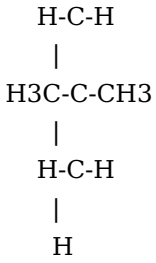
```
  H H H H H
  | | | | |
H-C-C-C-C-C-H
  | | | | |
  H H H H H
```

2. **Isopentane / 2-Methylbutane** (branched):

```
    H
    |
  H-C-H
    |  H H H
H-C-C-C-C-H
    |  | | |
    H H H H
```

3. **Neopentane / 2,2-Dimethylpropane** (highly branched):

```
      H
      |
```



(b) **Isomerism:** The phenomenon in which two or more compounds have the same molecular formula but different structural arrangements is called isomerism. Such compounds are called isomers.

(c) **Properties of isomers:**
Different physical properties:
• Different arrangements lead to different shapes and structures
• This affects intermolecular forces and packing
• Results in different melting points, boiling points, and densities
• Example: n-pentane (BP: 309K), isopentane (BP: 301K), neopentane (BP: 283K)

Similar chemical properties:
• Same molecular formula means same functional groups
• Same types and numbers of bonds
• Therefore undergo same types of chemical reactions
• Example: All three pentane isomers undergo combustion to give CO_2 and H_2O

SECTION E - Answers to Case Study Based Questions

Ans 19. Case Study 1 - Allotropes of Carbon

(i) **Diamond hard vs Graphite soft:** (1 mark)
Diamond is hard because each carbon is covalently bonded to 4 others in a rigid 3D network requiring breaking of strong covalent bonds. Graphite is soft because it has layered structure with weak van der Waals forces between layers that allow easy sliding.

(ii) **Electrical conductivity:** (1 mark)
Graphite conducts electricity because each carbon uses only 3 electrons for bonding, leaving one free electron per atom that can move between layers to conduct current. Diamond doesn't conduct because all 4 valence electrons are used in bonding with no free electrons available.

(iii) **Buckminsterfullerene structure and name:** (2 marks)
Shape: C_{60} has 60 carbon atoms arranged in a hollow spherical cage structure resembling a football/soccer ball, with 12 pentagons and 20 hexagons.

Why this name: It was named after American architect Richard Buckminster Fuller who designed geodesic domes with similar hexagonal and pentagonal patterns. The molecule's structure resembles his architectural designs, hence "Buckminsterfullerene" or "Buckyball".

Ans 20. Case Study 2 - IUPAC Nomenclature

(i) **IUPAC name of CH_3-CH_2-CH_2-CHO:** (1 mark)
Butanal
(4 carbon atoms = but- + aldehyde group = -al)

(ii) **Suffix '-oic acid':** (1 mark)
The suffix '-oic acid' indicates the presence of carboxylic acid functional group (-COOH).
Example: CH_3COOH = Ethanoic acid
(2 carbons = ethan- + carboxylic acid = -oic acid)

(iii) **2-Bromopropane structure and explanation:** (2 marks)

Structure:

```
  H H H
  | | |
H-C-C-C-H
  | | |
  H Br H
```

Name explanation:

- **Propane:** 3 carbon atoms in the main chain
- **Bromo:** Bromine (Br) is attached as substituent
- **2-:** Bromine is attached to carbon number 2 (the middle carbon)
- Numbering starts from the end closest to the substituent
