Chapter 14:

Hydrocarbons

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Short Questions (Exercise)

1. Give three examples of saturated hydrocarbons.

- Methane (CH_4)
- Ethane (C_2H_6)
- Propane (C_3H_8)

Explanation: Saturated hydrocarbons, also called alkanes, contain only single bonds between carbon atoms.

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2. Draw the structure for ethane.

Structure of Ethane (C_2H_6):

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

Ethane consists of two carbon atoms connected by a single bond, with each carbon atom bonded to three hydrogen atoms.

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3. Draw structural formulas of an alkane containing five carbon atoms.

Pentane (C_5H_{12}):

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H H H H H
| | | | |
H-C-C-C-C-C-H
| | | | |
H H H H H
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Explanation: Pentane is a straight-chain alkane with five carbon atoms and twelve hydrogen atoms.

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4. What do you mean by hydrogenation reaction? Give one example.

Definition:
Hydrogenation is a chemical reaction where hydrogen (H_2) is added to an unsaturated hydrocarbon (alkene or alkyne) to convert it into a saturated hydrocarbon (alkane).

Example:
$C_2H_4 + H_2 \rightarrow C_2H_6$
(Ethene reacts with hydrogen to form ethane in the presence of a catalyst like nickel or palladium.)

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5. What is meant by cracking?

Definition:
Cracking is the process of breaking down long-chain hydrocarbons into smaller, more useful hydrocarbons such as alkanes and alkenes.

Types of Cracking:

1. Thermal Cracking: Uses high temperature and pressure.
2. Catalytic Cracking: Uses a catalyst to lower the required temperature.

Example:
$C_{12}H_{26} \rightarrow C_6H_{12} + C_6H_{14}$
(Long-chain hydrocarbons are broken into smaller ones like hexene and hexane.)

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6. Discuss methods for the preparation of ethane.

Preparation of Ethane (C_2H_6):

1. **From Sodium Ethanoate (Decarboxylation Reaction):**
   $CH_3COONa + NaOH \rightarrow CH_4 + Na_2CO_3$
   (Heating sodium ethanoate with soda lime produces methane. Ethane can also be formed similarly.)
2. **From Ethene (Hydrogenation):**
   $C_2H_4 + H_2 \rightarrow C_2H_6$
   (Ethene reacts with hydrogen in the presence of a nickel catalyst to produce ethane.)

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7. Describe properties of alkanes.

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Physical Properties

- Alkanes are nonpolar and insoluble in water.
- Boiling and melting points increase with molecular size.
- Lower alkanes (C_1-C_4) are gases, while higher alkanes are liquids or solids.

Chemical Properties

- Alkanes are relatively inert due to strong C-C and C-H bonds.
- They undergo combustion:
  $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

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8. Write a chemical equation to show the preparation of an alkane from an alkene and an alkyne.

From Alkene to Alkane (Hydrogenation):
$C_2H_4 + H_2 \rightarrow C_2H_6$
(Ethene reacts with hydrogen to form ethane.)

From Alkyne to Alkane:
$C_2H_2 + 2H_2 \rightarrow C_2H_6$
(Ethyne reacts with hydrogen to form ethane.)

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Think Tank

Chemical Equations for the Preparation of Propane

1. **Preparation of Propane by Hydrogenation of Propene**
   Propene reacts with hydrogen in the presence of a nickel catalyst to produce propane.
   Equation:
   $CH_3\text{-}CH{=}CH_2 + H_2 \rightarrow CH_3\text{-}CH_2\text{-}CH_3$
   (Propene + Hydrogen → Propane)

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2. **Preparation of Propane by Wurtz Reaction**
   Ethyl bromide reacts with sodium in the presence of dry ether to form propane.
   Equation:
   $CH_3CH_2Br + 2Na + CH_3Br \rightarrow CH_3\text{-}CH_2\text{-}CH_3 + 2NaBr$
   (Ethyl bromide + Methyl bromide + Sodium → Propane + Sodium bromide)

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3. **Preparation of Propane by Decarboxylation of Butanoic Acid**
   Sodium butanoate is heated with soda lime to produce propane.
   Equation:
   $CH_3CH_2CH_2COONa + NaOH \rightarrow CH_3\text{-}CH_2\text{-}CH_3 + Na_2CO_3$
   (Sodium butanoate + Soda lime → Propane + Sodium carbonate)

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Extera Short Questions (Topic Wise)

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14.1: Alkanes

Questions and Answers:

1. **What are alkanes?**
   Alkanes are saturated hydrocarbons containing only single bonds between carbon atoms. They follow the general formula **CnH2n+2**.
   Example: Methane (CH_4), Ethane (C_2H_6).

2. **What are the physical properties of alkanes?**
   - Alkanes are generally nonpolar, insoluble in water, and have low boiling points.
   - Boiling points increase with molecular size due to stronger van der Waals forces.
     Example: Methane (CH_4) is a gas, while hexane (C_6H_{14}) is a liquid at room temperature.

3. **How do alkanes react chemically?**
   Alkanes undergo substitution reactions, such as halogenation, where hydrogen atoms are replaced by halogen atoms.
   Example: $CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$ (chloromethane).

4. **Why are alkanes called saturated hydrocarbons?**
   Alkanes are "saturated" because all carbon atoms are bonded to the maximum number of hydrogen atoms via single bonds.

14.2: Alkenes

Questions and Answers:

1. **What are alkenes?**
   Alkenes are unsaturated hydrocarbons containing at least one double bond between carbon atoms. They follow the general formula **CnH2n**.
   Example: Ethene (C_2H_4), Propene (C_3H_6).

2. **What are the properties of alkenes?**
   - Alkenes are more reactive than alkanes due to the presence of a double bond.
   - They are nonpolar and insoluble in water.
     Example: Ethene is a colorless gas used to ripen fruits.

3. **What type of reactions do alkenes undergo?**
   Alkenes primarily undergo **addition reactions**, such as hydrogenation and halogenation.
   Example: $C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$ (dibromoethane).

4. **Why are alkenes considered unsaturated hydrocarbons?**
   Alkenes are unsaturated because the presence of double bonds allows more atoms to add to the molecule.

14.3: Alkynes

Questions and Answers:

1. **What are alkynes?**
   Alkynes are unsaturated hydrocarbons containing at least one triple bond between carbon atoms. They follow the general formula **CnH2n-2**.
   Example: Ethyne (C_2H_2), Propyne (C_3H_4).

2. **What are the physical properties of alkynes?**
   - Alkynes are nonpolar and insoluble in water.
   - They are more reactive than alkenes due to the triple bond.
     Example: Ethyne (acetylene) is used in welding torches.

3. **What type of reactions do alkynes undergo?**
   Alkynes undergo addition reactions similar to alkenes, where the triple bond is broken to form single bonds.
   Example: $C_2H_2 + H_2 \rightarrow C_2H_4$ (ethene).

4. **What makes alkynes more reactive than alkanes and alkenes?**
   The triple bond in alkynes has high electron density, making them highly reactive in chemical reactions.

14.4: Aromatic Compounds

Questions and Answers:

1. **What are aromatic compounds?**
   Aromatic compounds are hydrocarbons with one or more benzene rings in their structure. They are characterized by delocalized π-electrons.
   Example: Benzene (C_6H_6), Toluene ($C_6H_5CH_3$).

2. **What are the physical properties of aromatic compounds?**
   - Aromatic compounds are generally nonpolar and insoluble in water.
   - They have a characteristic smell and are liquids or solids at room temperature.
     Example: Benzene is a liquid with a sweet odor.

3. **What type of reactions do aromatic compounds undergo?**
   Aromatic compounds undergo **substitution reactions**, such as nitration and halogenation, instead of addition reactions to preserve the aromatic ring.
   Example: $C_6H_6 + HNO_3 \rightarrow C_6H_5NO_2 + H_2O$ (nitrobenzene).

4. **Why is benzene stable despite its unsaturation?**
   Benzene's stability is due to delocalized π-electrons, which create a resonance structure, reducing its reactivity.

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Extera Long Questions (Topic Wise)

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1. What are the differences between Alkanes, Alkenes, and Alkynes?

Definition

- **Alkanes:** Saturated hydrocarbons containing only single bonds between carbon atoms. General formula: **CnH2n+2**.
- **Alkenes**: Unsaturated hydrocarbons with at least one double bond. General formula: **CnH2n**.
- **Alkynes**: Unsaturated hydrocarbons with at least one triple bond. General formula: **CnH2n-2**.

Properties

1. **Bonding**:
    - Alkanes have single bonds, making them less reactive.
    - Alkenes have one or more double bonds, increasing their reactivity.
    - Alkynes have one or more triple bonds, making them highly reactive.
2. **Reactivity**:
    - Alkanes undergo substitution reactions, like halogenation.
    - Alkenes undergo addition reactions, like hydrogenation.
    - Alkynes also undergo addition reactions, but they can form double bonds in the process.
3. **Physical State**:
    - Lower alkanes (C_1-C_4) are gases, while higher alkanes are liquids or solids.
    - Lower alkenes and alkynes are gases, with higher members being liquids.

Examples

- **Alkane**: Methane (CH_4), a fuel source.
- **Alkene**: Ethene (C_2H_4), used in polymer production.
- **Alkyne**: Ethyne (C_2H_2), used in welding torches.

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2. What are Aromatic Compounds and Their Unique Characteristics?

Definition

Aromatic compounds are hydrocarbons that contain one or more benzene rings. These compounds are characterized by delocalized π-electrons within a conjugated ring system.

Structure of Benzene

- Benzene (C_6H_6) is the simplest aromatic compound.

- It consists of six carbon atoms arranged in a hexagonal ring with alternating single and double bonds (resonance structure).

Unique Characteristics

1. **Delocalized Electrons**:
   The π-electrons in the benzene ring are delocalized, which contributes to its stability.
   Example: Benzene resists addition reactions that would disrupt the aromatic system.

2. **Physical Properties**:
   Aromatic compounds are nonpolar, insoluble in water, and have a distinct odor.
   Example: Toluene is a liquid aromatic compound used as an industrial solvent.

3. **Chemical Reactions**:
   Aromatic compounds undergo substitution reactions like nitration and halogenation to maintain the stability of the aromatic ring.
   Example: Benzene reacts with HNO_3 to form nitrobenzene:
   $C_6H_6 + HNO_3 \rightarrow C_6H_5NO_2 + H_2O$.

Uses

- Aromatic compounds are widely used in the production of dyes, plastics, and pharmaceuticals.
- **Example**: Aspirin, an aromatic compound derived from salicylic acid, is used as a pain reliever.

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3. Why Are Hydrocarbons Important in Everyday Life?

Energy Source

Hydrocarbons, especially alkanes, are a major source of energy. Fossil fuels like natural gas (methane) and petroleum are composed of hydrocarbons.

- **Example**: Propane (C_3H_8) is used in cooking and heating.

Industrial Applications

1. **Polymers**: Hydrocarbons such as ethene and propene are used in producing plastics and synthetic fibers like polyethylene and polypropylene.
   Example: Polyethylene is made from ethene.

2. **Chemical Synthesis**: Hydrocarbons serve as raw materials for creating alcohols, acids, and other organic compounds.
   Example: Ethyne is used to produce vinyl chloride for making PVC.

Pharmaceuticals

Aromatic hydrocarbons are precursors for many medicines.

- **Example**: Benzene derivatives are used in creating aspirin, a widely used painkiller.

Environmental Concerns

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While hydrocarbons are essential, their combustion releases CO_2, a greenhouse gas, contributing to global warming. Efforts are ongoing to develop cleaner fuels and renewable energy alternatives.

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14.1: Alkanes

1. **What are alkanes?**
   a) Saturated hydrocarbons ✔
   b) Unsaturated hydrocarbons
   c) Aromatic hydrocarbons
   d) None of the above

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

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

4. **Which reaction is characteristic of alkanes?**
   a) Addition reaction
   b) Substitution reaction ✔
   c) Polymerization
   d) Nitration

5. **What type of bonds are present in alkanes?**
   a) Single bonds ✔
   b) Double bonds
   c) Triple bonds
   d) Aromatic bonds

6. **Which of the following is a gaseous alkane?**
   a) Hexane
   b) Butane
   c) **Methane** ✔
   d) Octane

14.2: Alkenes

7. **What are alkenes?**
   a) Saturated hydrocarbons
   b) **Unsaturated hydrocarbons with at least one double bond** ✔

c) Hydrocarbons with triple bonds
d) Aromatic hydrocarbons

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

9. **Which is the simplest alkene?**
   a) Methane
   b) **Ethene** ✔
   c) Propane
   d) Butane

10. **What type of reactions do alkenes undergo?**
    a) Substitution
    b) Polymerization
    c) **Addition reactions** ✔
    d) Combustion

11. **What happens when ethene reacts with bromine?**
    a) Ethyne is formed
    b) **Dibromoethane is formed** ✔
    c) Propene is formed
    d) Methanol is formed

12. **Why are alkenes considered unsaturated hydrocarbons?**
    a) They contain fewer carbon atoms
    b) **They contain double bonds** ✔
    c) They contain more hydrogen atoms
    d) They have no functional group

14.3: Alkynes

13. **What are alkynes?**
    a) Saturated hydrocarbons
    b) Aromatic hydrocarbons
    c) **Unsaturated hydrocarbons with at least one triple bond** ✔
    d) Cyclic hydrocarbons

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

15. **Which is the simplest alkyne?**
    a) Ethene

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b) Propene
c) **Ethyne** ✔
d) Methane

16. **What is another name for ethyne?**
a) Propane
b) **Acetylene** ✔
c) Methanol
d) Butane

17. **What type of reaction is characteristic of alkynes?**
a) Substitution
b) Neutralization
c) **Addition reactions** ✔
d) Hydrolysis

18. **Which of the following is used in welding torches?**
a) Methane
b) **Ethyne** ✔
c) Propene
d) Benzene

14.4: Aromatic Compounds

19. **What are aromatic compounds?**
a) Saturated hydrocarbons
b) Unsaturated hydrocarbons
c) **Hydrocarbons with delocalized π-electrons in a ring structure** ✔
d) Aliphatic hydrocarbons

20. **What is the simplest aromatic compound?**
a) Ethane
b) **Benzene** ✔
c) Toluene
d) Phenol

21. **What is the molecular formula of benzene?**
a) C_2H_4
b) C_6H_{10}
c) **C_6H_6** ✔
d) C_7H_8

22. **What type of reactions do aromatic compounds undergo?**
a) Addition reactions
b) **Substitution reactions** ✔
c) Combustion reactions
d) Esterification

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23. **What is the functional group in toluene?**
    a) Carboxyl group
    b) Hydroxyl group
    c) **Methyl group ($-CH_3$)** ✔
    d) Carbonyl group

24. **What is the resonance structure of benzene?**
    a) A single structure
    b) A triple bond
    c) **Delocalized π-electrons over a ring** ✔
    d) A zigzag chain

25. **Which of the following is an aromatic hydrocarbon?**
    a) Methane
    b) **Toluene** ✔
    c) Ethyne
    d) Propene

General Hydrocarbons

26. **Which of the following is an unsaturated hydrocarbon?**
    a) Methane
    b) **Ethene** ✔
    c) Propane
    d) Butane

27. **What is the hybridization of carbon in alkanes?**
    a) sp
    b) **sp^3** ✔
    c) sp^2
    d) None

28. **What is the hybridization of carbon in benzene?**
    a) sp
    b) sp^3
    c) **sp^2** ✔
    d) None

29. **Which hydrocarbon undergoes combustion to release energy?**
    a) Ethyne
    b) Propane
    c) Benzene
    d) **All of the above** ✔

30. **What are hydrocarbons commonly used for?**
    a) Fuel
    b) Plastics
    c) Pharmaceuticals
    d) **All of the above** ✔

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