1. Explain the chemical differences in reactions between alkanes, alkenes, and alkynes using suitable examples.

Answer:
Alkanes are saturated hydrocarbons and undergo substitution reactions. For example, methane reacts with chlorine under UV light to form chloromethane. Alkenes and alkynes are unsaturated and undergo addition reactions. Ethene reacts with bromine to form 1,2-dibromoethane, while ethyne undergoes hydrogenation to form ethane. The double or triple bonds in alkenes and alkynes make them more reactive than alkanes. Alkenes undergo electrophilic addition, and alkynes show even greater reactivity due to electron-rich triple bonds. This difference in reactivity is crucial in organic synthesis and polymer formation.

2. Discuss how functional groups influence the chemical reactivity and physical properties of organic compounds with examples.

Answer:
Functional groups such as –OH, –COOH, –CHO, and –NH_2 determine an organic compound's reactivity and physical properties. For example, alcohols (–OH) engage in hydrogen bonding, making them more soluble and raising their boiling points. Carboxylic acids (–COOH) exhibit acidity and form esters in reactions with alcohols. Aldehydes (–CHO) and ketones (–CO–) undergo nucleophilic addition. Functional groups dictate chemical reactions and dictate naming, classification, and applications. Ethanol, with a –OH group, is a solvent and fuel, while ethanoic acid with –COOH is acidic and used in food and industry.

3. Describe isomerism in hydrocarbons and compare chain, position, and functional group isomerism.

Answer:
Isomerism is the existence of compounds with the same molecular formula but different structures. Chain isomerism arises from different carbon skeletons (e.g., butane and isobutane). Position isomerism occurs when a functional group changes position, like 1-butene and 2-butene. Functional group isomerism involves different functional groups, such as ethanol (–OH) and dimethyl ether (–O–). These structural changes impact physical and chemical properties like boiling points, acidity, and reactivity. Isomerism is significant in pharmaceuticals, where structural differences may lead to different biological activity.

4. Explain the preparation and chemical properties of ethanoic acid and its role in esterification reactions.

Answer:

Ethanoic acid (CH_3COOH) is prepared by oxidizing ethanol using acidified potassium dichromate. It is a weak acid and reacts with bases to form salts and water. It reacts with metals to release hydrogen and with carbonates to produce CO_2. In esterification, ethanoic acid reacts with alcohols in the presence of sulfuric acid to form esters. For example, $CH_3COOH + CH_3OH \rightarrow CH_3COOCH_3$ (methyl ethanoate) + H_2O. Esters are used in perfumes and flavorings. This reaction is reversible and demonstrates the importance of organic acids in synthesis.

5. How are soaps and detergents different in chemical composition, and why are detergents preferred in hard water?

Answer:

Soaps are sodium or potassium salts of fatty acids, while detergents are synthetic compounds derived from petroleum, containing sulfonate or sulfate groups. In hard water, soaps form insoluble scum with calcium and magnesium ions, reducing cleaning efficiency. Detergents remain soluble and effective in both soft and hard water. For example, sodium dodecyl sulfate is a common detergent. Detergents are more chemically stable in acidic or hard water and are widely used in household and industrial cleaning. However, detergents may be less biodegradable compared to soaps.

6. Discuss the allotropes of carbon and compare their structure and physical properties.

Answer:

Carbon exists in crystalline (diamond, graphite) and amorphous (charcoal, lampblack) allotropes. Diamond has a tetrahedral structure where each carbon atom is bonded to four others, making it the hardest known substance and an excellent insulator. Graphite has a planar hexagonal structure with delocalized electrons, making it soft and a good conductor. Amorphous carbon lacks a regular structure and includes coal and soot. These differences are due to the bonding and atomic arrangement, influencing hardness, conductivity, and uses in jewelry, lubricants, and electrodes.

7. Explain how homologous series help in systematic study of organic compounds with examples.

Answer:

A homologous series consists of compounds with the same functional group and general formula, differing by a CH_2 unit. For instance, alkanes follow the formula C_nH_{2n+2}: methane, ethane, propane, etc. They exhibit similar chemical properties but differ in physical properties like boiling point, which increases with molecular mass. Studying such series helps predict properties and reactions. For example, knowing ethane's combustion allows predicting similar behavior in propane. This systematic approach simplifies understanding the behavior of vast numbers of organic compounds.

8. Describe the structure, preparation, and uses of ethanol and explain its chemical reactivity.

Answer:
Ethanol (CH_3CH_2OH) has a hydroxyl group attached to an ethyl group. It can be prepared by fermenting glucose using yeast or by hydration of ethene. Ethanol is a polar solvent, miscible with water, and used in beverages, sanitizers, and fuels. It reacts with sodium to release hydrogen and with carboxylic acids to form esters (esterification). On oxidation, it gives ethanoic acid. Ethanol burns with a blue flame and is renewable. Its versatile chemical reactivity makes it valuable in organic synthesis and industrial applications.

9. How is IUPAC naming applied to compounds with multiple functional groups and side chains?

Answer:
IUPAC naming involves identifying the longest carbon chain with the highest-priority functional group. The parent chain is numbered to give the functional group the lowest number. Prefixes denote substituents, and suffixes indicate the main functional group. For example, $CH_3CH(OH)CH_2COOH$ is named 3-hydroxybutanoic acid. Carboxylic acid has the highest priority and is named with the suffix –oic acid. Functional groups like halides, alkyl groups, and hydroxyl are arranged alphabetically as prefixes. This systematic approach ensures that each compound has a unique, standardized name.

10. Compare the physical and chemical properties of alkane, alkene, and alkyne series in terms of bond type and reactivity.

Answer:
Alkanes contain only single bonds (σ bonds) and are relatively inert, showing mainly substitution and combustion reactions. Alkenes have one double bond (one σ and one π bond), making them more reactive due to the π bond, which undergoes electrophilic addition. Alkynes have a triple bond (one σ and two π bonds), and are even more reactive, undergoing addition and polymerization. Physically, boiling points rise with molecular mass. Chemically, the reactivity increases from alkane < alkene < alkyne. These differences guide their use in fuels, synthesis, and polymer industries.