4 CHAPTER

Carbon and Its Compounds

Level - 1

MULTIPLE CHOICE QUESTIONS (MCQs) (1 Mark)

1. Option (C) is correct.

Explanation: Carbon compounds are bad conductors of electricity as most carbon compounds do not have free electrons or ions. Carbon compounds, consist of covalent bonds resulting in weak inter molecular forces, e.g., Van der Waals forces.

2. Option (A) is correct.

Explanation:

(a) Each successive member in a homologous series differs by one —CH_2 group (14 u in molecular mass) in alkanes, alkenes, and alkynes.

(b) As molecular mass increases in a homologous series, intermolecular forces (e.g., Van der Waal's forces) increase, leading to higher melting and boiling points. Thus, melting point and boiling point increases with increasing molecular mass.

(c) The difference in molecular mass between successive members of a homologous series is 14 u (due to the —CH_2 group).

(d) C_2H_2 (ethyne) and C_3H_4 (propyne) are indeed successive members of the alkyne.

Hence, the correct options are option (a) and (b).

3. Option (B) is correct.

Explanation: Among the given options, the hydrocarbon C_7H_{14} is different because it does not follow the general formula for alkanes (C_nH_{2n+2}) and belongs to a different class of hydrocarbons, i.e., alkenes. Whereas, all the other options (C_4H_{10}, C_5H_{12} and C_2H_6) are alkanes.

4. Option (B) is correct.

Explanation:

- Benzene is a cyclic compound with six carbon atoms arranged in a hexagonal ring. Each of the 6 carbon atoms is bonded to 1 hydrogen atom through a C-H single bond (Total: 6 single bonds). In the ring, 3 carbon-to-carbon bonds are single bonds (Total: 3 single bonds). This means there are total 9 single bonds in the ring.
- In the benzene ring, there are 3 C=C double bonds (alternating in the ring structure). This means, in total there are 3 double bonds.

5. Option (C) is correct.

Explanation: Hydrocarbons are organic compounds composed solely of carbon and hydrogen atoms. The presence and arrangement of carbon-carbon bonds, including single, double, and triple bonds, determine the classification and properties of different hydrocarbon compounds.

- Ethyne (C_2H_2) contains only a triple bond no single C–C bonds.
- Propyne (C_3H_4) contains a triple bond but only one single C– C bond.
- Butyne (C_4H_6) contains two single C–C bonds and one triple bond.
- Benzene (C_6H_6) contains alternating single and double bonds, no triple bond.

6. Option (C) is correct.

Explanation: In the formation of an ethyne molecule, each carbon atom shares three electrons with the other carbon atom to form three covalent bonds. Additionally, each carbon atom shares one electron with a hydrogen atom to form a covalent bond. Thus, the total number of electrons shared in the formation of an ethyne molecule is:

3 (covalent bonds between the two carbon atoms) × 2 (number of carbon atoms) + 2 (covalent bond between each carbon atom and a hydrogen atom) × 2 (number of hydrogen atoms) = 6 + 4 = 10.

7. Option (D) is correct.

Explanation: When an organic compound undergoes complete combustion in the presence of an adequate supply of oxygen, it produces only carbon dioxide (CO_2) and water (H_2O).

- Alkanes (P) are hydrocarbons that combust completely to form CO_2 and H_2O.

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

- Alcohols (Q) also undergo complete combustion to form CO_2 and H_2O.

$$C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$$

- Aldehydes (R) combust completely, producing CO_2 and H_2O.

$$CH_3CHO + \frac{5}{2}O_2 \longrightarrow CO_2 + 2H_2O$$

Thus, the compound belong to any of the series.

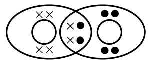
8. Option (C) is correct.

Explanation: Allotropy refers to the existence of an element in different physical forms, such as diamond, graphite, and fullerness in the case of carbon. While allotropy affects the physical properties of carbon, it does not contribute to the large number of carbon compounds formed due to bonding properties.

9. Option (B) is correct.

Explanation: When 1 mole of ethene undergoes an addition reaction to become a saturated compound, which in this case is ethane, it reacts with 1 mole of hydrogen (H_2). Therefore, the reaction would be $C_2H_4 + H_2 \longrightarrow C_2H_6$. On the other hand, ethyne (acetylene), which is C_2H_2, requires 2 moles of hydrogen to become saturated, so its reaction is $C_2H_2 + 2H_2 \longrightarrow C_2H_6$. Thus, the number of moles of hydrogen consumed is different for the two reactions, with ethene consuming 1 mole and ethyne consuming 2 moles. However, both reactions produce the same amount of the saturated compound ethane; hence, the number of moles of the saturated compound formed is the same. Therefore, the correct answer is that only the number of moles of hydrogen consumed will be different for the two reactions.

10. Option (A) is correct.



Explanation: In an oxygen molecule (O_2), each oxygen atom has 6 valence electrons and requires 2 more electrons to complete its octet. To achieve this, the two oxygen atoms share two pairs of electrons, forming a double covalent bond. This double bond allows both oxygen atoms to have a stable octet configuration. Additionally, each oxygen atom retains two lone pairs of electrons (4 non-bonding electrons). The correct Lewis structure therefore shows a double bond between the oxygen atoms and two lone pairs on each atom, as depicted in option (A).

ASSERTION-REASON QUESTIONS (1 Mark)

1. Option (A) is correct.

Explanation: The assertion states that some vegetable oils are healthy, which is true because unsaturated fats found in vegetable oils are considered healthier than saturated fats due to their positive effects on heart health and cholesterol levels. The reason also supports this by explaining that vegetable oils generally have long unsaturated carbon chains, as they are composed of fatty acids with long chains of carbon atoms and a carboxyl group at one end. These chains often contain double bonds, making them unsaturated and contributing to their health benefits. Therefore, both the assertion and the reason are true, and the reason correctly explains the assertion.

2. Option (A) is correct.

Explanation: The assertion that soaps do not form lather with hard water is true. This is because hard water contains dissolved salts of calcium and magnesium, which interfere with soap's ability to form foam. Instead of producing lather, soap reacts with these salts to form an insoluble precipitate called scum. Thus, both the assertion and the reason are true, and the reason is the correct explanation of assertion.

3. Option (B) is correct.

Explanation: Ethyne, also known as acetylene, produces a high-temperature flame (approximately 3200°C) when burned in oxygen. This makes it suitable for cutting and welding metals.

Reason is true because ethyne is a member of the alkyne family, characterised by a carbon-to-carbon triple bond, but this fact about its unsaturation and triple bond does not explain why it is used for cutting and welding. The primary reason ethyne is used for welding is its high heat of combustion and not its molecular strucrture.

Level - 2

CASE BASED QUESTIONS (4 Marks)

1. (i) The first two members of the homologous series having the functional group —Br are:

- CH_3Br (methyl bromide)
- C_2H_5Br (ethyl bromide)

(ii) (a) Aldehyde group

(b) Ketone group

(iii) (a) When 5% alkaline potassium permanganate is added drop by drop to warm ethanol, the purple colour of $KMnO_4$ is gradually decolourised. This indicates that ethanol is being oxidised.

$$CH_3CH_2OH + [O] \xrightarrow{\text{alkaline } KMnO_4} CH_3COOH + H_2O$$

$KMnO_4$ acts as an oxidising agent in the reaction, converting ethanol into acetic acid.

OR

(b) When ethanol is heated at 443 K with excess concentrated H_2SO_4, ethene is formed.

$$C_2H_5OH \xrightarrow{\text{Conc. } H_2SO_4\text{, 443K}} CH_2 = CH_2 + H_2O$$

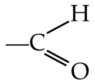
Conc. H_2SO_4 acts as a dehydrating agent, removing water from ethanol to form ethene.

2. (i) Hydrocarbons are organic compounds that consist only of carbon and hydrogen atoms only. They can be classified as alkanes, alkenes or alkynes, depending on the type of bonding between carbon atoms. For example, methane (CH_4) and ethene (C_2H_4) are hydrocarbons.

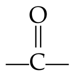
(ii) The two properties of carbon by virtue of which it can form a large number of compounds:

1. **Catenation:** Carbon atoms can form long chains or rings by bonding with other carbon atoms.
2. **Tetravalency:** Carbon has a valency of four, allowing it to form stable covalent bonds with other elements like oxygen, hydrogen, nitrogen, sulphur, and chlorine.

(iii) 1. **Aldehydes:** Functional group is —CHO.



2. **Ketones:** Functional group is —C = O.

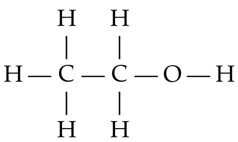


When ethanoic acid reacts with ethanol in the presence of an acid catalyst (like concentrated H_2SO_4), an ester is formed:

$$CH_3COOH + C_2H_5OH \xrightarrow{\text{Conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$$

This reaction is called esterification.

3. (i) $CH_3—CH_2—OH$



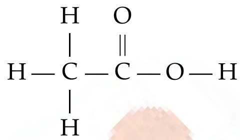
(ii) When ethanol burns in the presence of sufficient oxygen, it undergoes complete combustion to form Carbon dioxide (CO_2) and water (H_2O).

(iii) (a) When 5% solution of alkaline potassium permanganate is added to warm ethanol, ethanol is oxidised to ethanoic acid (acetic acid) and the purple colour of potassium permanganate is decolourised.

$$CH_3CH_2OH + [O] \xrightarrow{KMnO_4\text{/alkaline}} CH_3COOH + H_2O$$

Structure of the product (ethanoic acid):

$CH_3—C=O — OH$



Role of $KMnO_4$: Potassium permanganate acts as an oxidising agent, supplying oxygen for the reaction.

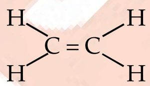
OR

(b) When ethanol is heated with excess conc. H_2SO_4 at 443 K, ethanol is dehydrated (loses water) to form ethene.

$$CH_3CH_2OH \xrightarrow{\text{Conc. } H_2SO_4\text{, 443K}} CH_2 = CH_2 + H_2O$$

Structure of the product (ethene):

$CH_2 = CH_2$



Role of Conc. H_2SO_4: Concentrated sulfuric acid acts as a dehydrating agent, removing water from ethanol to produce ethene.

Level - 3

VERY SHORT ANSWER TYPE QUESTIONS (2 Marks)

1. A commercially important carbon compound having the functional group —OH is ethanol. Its molecular formula is C_2H_5OH.

2.

Saturated hydrocarbons	Unsaturated hydrocarbons
Burns in air with a clean, blue flame due to complete combustion.	Burns in air with a sooty, yellow flame. The soot is caused by incomplete combustion due to a higher carbon content.

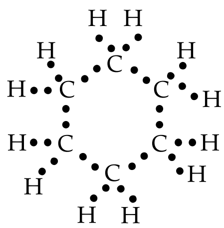
When a saturated hydrocarbon (alkanes) undergoes complete combustion, it produces carbon dioxide (CO_2), water (H_2O) and energy (heat and light).

3. Carbon compounds generally have low melting and boiling points because they are covalent in nature, with weak intermolecular forces such as Van der Waal's forces, which require less energy to break. Additionally, carbon compounds are non-conductors of electricity because they lack free ions or electrons to carry charge, as covalent bonds involve the sharing of electrons, keeping them tightly bound.

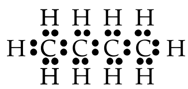
4. (i) CH_4

(ii) C_3H_8

5. (i)



(ii)



SHORT ANSWER TYPE QUESTIONS (3 Marks)

1. The conversion of ethanol (C_2H_5OH) to ethanoic acid (CH_3COOH) is considered an oxidation reaction because the process involves the addition of oxygen to ethanol. The hydroxyl group (—OH) in ethanol is oxidised to a carboxylic group (—COOH). Alkaline potassium permanganate ($KMnO_4$) is used as the oxidising agent for this reaction.

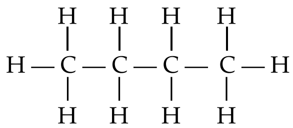
$$CH_3CH_2OH + 2[O] \xrightarrow{KMnO_4} CH_3COOH + H_2O$$

The reaction in which ethanol is converted to ethanoic acid is a controlled oxidation reaction that occurs in the presence of an oxidising agent such as potassium permanganate ($KMnO_4$), resulting in the formation of ethanoic acid (CH_3COOH). In contrast, when ethanol burns in the presence of oxygen, it undergoes complete combustion, producing carbon dioxide (CO_2) and water (H_2O) along with the release of energy as heat and light. The conversion to ethanoic acid is a mild reaction that changes the functional group, whereas combustion is an exothermic reaction that completely breaks down ethanol into simpler molecules. The former adds oxygen selectively to ethanol, while the latter completely oxidises it.

2. (i) (I) Heteroatom is oxygen O.

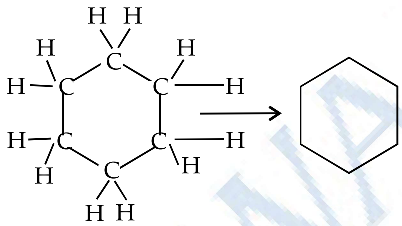
(II) Functional group is alcohol —OH.

(ii)



Butane (C_4H_{10}): $CH_3—CH_2—CH_2—CH_3$

(iii) (I)



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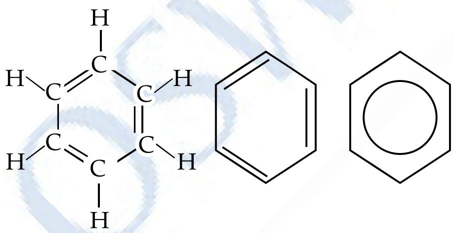
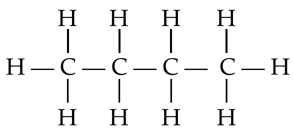


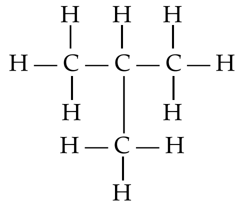
Benzene is unsaturated because it contains alternating double bonds within its ring structure.

3. Two different possible structures of a saturated hydrocarbon having four carbon atoms in its molecule are shown below:

(i) ***n*-butane**



(ii) Isobutane



These structures having same molecular formula and different structural formula are called isomers.

Molecular formula—C_4H_{10}

Common Name—Butane

Molecular formula of its alkyne—C_4H_6 [Butyne]

4. (i) Carbon compounds generally have low melting points and boiling points because the force of attraction between the molecules of carbon compounds is not very strong. These weak intermolecular forces make them very easy to pull apart from each other.

(ii) Carbon compounds are covalent in nature. Covalent compounds do not dissociate into ions in aqueous solution and also it does not have free electrons. Since there is no flow of charge, it is a poor conductor of electricity.

(iii) The most common type of bond formed by carbon is a covalent bond. In most cases, carbon shares electrons with other atoms. This is because carbon has 4 valence electrons and so to complete its octet configuration, either it need to gain 4 more electron or lose 4 electron.

5. (i) The organic compound 'X' is ethanol (C_2H_5OH)

(ii) Reaction of Ethanol with Sodium:

$$2C_2H_5OH + 2Na \rightarrow 2C_2H_5ONa^+ + H_2$$

$$C_2H_5OH \xrightarrow[443\ K]{Conc.\ H_2SO_4} CH_2 = CH_2 + H_2O$$

Role of Concentrated Sulphuric Acid: Concentrated sulphuric acid acts as a dehydrating agent in the second reaction, removing a water molecule from ethanol (C_2H_5OH) to facilitate the formation of ethene ($CH_2 = CH_2$).

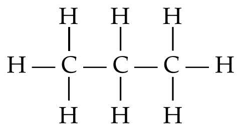
6. (i) Carbon compounds are exceptionally stable due to carbon's ability to form strong covalent bonds, its small atomic size, and its unique property of catenation (bonding with other carbon atoms). Additionally, the high bond energies of carbon-carbon and carbon-hydrogen bonds contribute to their stability.

(ii)

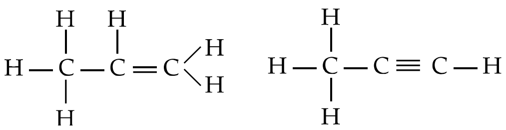
Saturated Organic Compounds	Unsaturated Organic Compounds
1. These organic compounds contain single carbon-carbon covalent bond (C – C).	These organic compounds contain at least one double (C=C) or triple covalent bond (C≡C).

2.	Due to the presence of all single covalent bonds, these compounds are less reactive.	Due to the presence of double and triple bonds, these compounds are more reactive.
3.	Saturated compounds undergo substitution reactions.	Unsaturated compounds undergo addition reactions.
	Example, $CH_4 + Cl_2$ $\rightarrow CH_3Cl + HCl$ Chloromethane	Example, $C_2H_4 + Cl_2 \rightarrow C_2H_4Cl_2$ Ethene Dichloroethene
4.	The number of hydrogen atom is more when compared to its corresponding unsaturated hydrocarbon.	The number of hydrogen atom is less when compared to its corresponding unsaturated hydrocarbon.

Structure of saturated hydrocarbon:

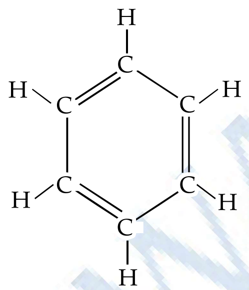


Structure of unsaturated hydrocarbon:



7. (i) Molecular formula of benzene—C_6H_6

Structure of benzene:



(ii) In the structure formula of benzene there are 3 double bonds and 9 single bonds present.

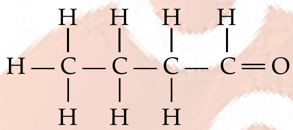
(iii) Organic compounds of carbon and hydrogen containing one or more triple bonds are called alkynes. Their general formula is C_nH_{2n-2}.

8. (A) Functional group: Aldehyde

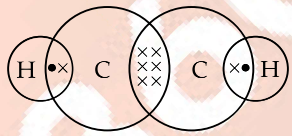
(B) General formula: $C_nH_{2n}O$

(C) It forms the part of the homologous series of the aldehydes as these compounds differ from each other by —CH_2 unit.

Structure of 4th member of this series is:



9. (i) **Electron Dot Structure of Ethyne**



(ii)

Property	Ionic Compounds	Covalent Compounds
Electrical Conductivity	Poor conductors in solid state, but conduct electricity in molten state or aqueous solutions.	Bad conductors of electricity.
Melting and Boiling Points	High melting and boiling points due to strong ionic bonds.	Relatively low melting and boiling points due to weaker intermolecular forces.

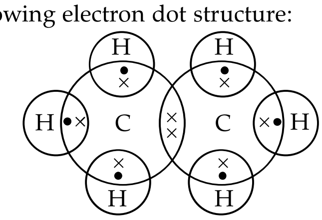
LONG ANSWER TYPE QUESTIONS (5 Marks)

1. (i) Keerthi's thinking is correct. Substitution reactions occur in saturated hydrocarbons (alkanes) because they have single bonds between carbon atoms. In these reactions, one or more hydrogen atoms in the hydrocarbon are replaced by another atom or group of atoms, typically by halogens, through the process of substitution.

On the other hand, unsaturated hydrocarbons (alkenes and alkynes), which have double or triple bonds, generally undergo addition reactions rather than substitution reactions. In addition reactions, atoms or groups are added to the carbon atoms involved in the multiple bonds.

(ii) Methane (CH_4) and Propane (C_3H_8), along with their isomers, are used as fuels because combustion of these hydrocarbons produces carbon dioxide (CO_2), water (H_2O), and a large amount of heat energy, which makes them efficient fuels for cooking, heating, and industrial purposes.

The lower homologue of propane is ethane has the following electron dot structure:



Characteristics of Homologues of a Given Homologous Series:

(1) Homologues in a homologous series have the same functional group, giving them similar chemical properties.

(2) Each successive homologue in the series differs by a —CH_2 group in their molecular formula, leading to a gradual change in physical properties such as melting point, boiling point, and solubility.

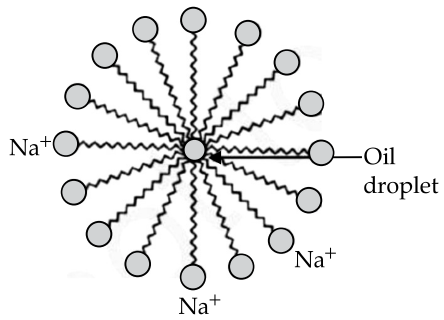
(iii) The mixture of ethyne and oxygen in sufficient amounts undergoes complete combustion to fire a clean blue flame. This oxygen-ethyne flame is extremely hot and generates a very high temperature, making it suitable for welding metals. In contrast, a mixture of ethyne and air is not used for welding because when ethyne burns in air, it undergoes incomplete combustion, resulting in a sooty flame. This flame is not hot enough to melt metals, making it unsuitable for welding purposes.

2. (i) 'B' (the sodium salt of a long-chain sulphonic acid) is preferred for cleansing action in the presence of hard water (which contains calcium and magnesium ions). This is because the calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions in underground water form insoluble salts with carboxylic acids (in soap, 'A'), leading to the formation of scum, which reduces its effectiveness.

However, the Ca^{2+} and Mg^{2+} salts of sulphonic acid (in detergent, 'B') are soluble in water, meaning that 'B' does not form scum and remains an effective cleansing agent even in hard water. Therefore, 'B' is more effective in the presence of calcium and magnesium salts.

(ii) Soaps are molecules with two distinct ends that have different properties. One end is hydrophilic (water-attracting) and dissolves in water, while the other end is hydrophobic (water-repelling) and dissolves in hydrocarbons or oils.

Soap molecules are sodium or potassium salts of long-chain carboxylic acids. The ionic end of the soap dissolves in water, while the hydrocarbon chain dissolves in oil. As a result, soap molecules form structures called micelles, where the hydrophobic ends surround the oil droplet and the ionic, hydrophilic ends face outward into the water. This creates an emulsion of oil in water. The formation of soap micelles enables the dirt and grease to be suspended in water, allowing them to be washed away, leaving clothes clean.



(iii) $CH_3COOCH_3 + NaOH \rightarrow CH_3COONa + CH_3OH$

This process is called saponification, where the ester reacts with sodium hydroxide (NaOH) to produce soap sodium salt of carboxylic acid (CH_3COONa) and methanol (CH_3OH).

3. (i) A functional group is a specific group of atoms within a molecule that is responsible for the molecule's characteristic chemical reactions.

Functional Groups in the given Compounds:

Compound (I): —C=O group (Ketone functional group).

Compound (II): —COOH group (carboxylic acid functional group).

(ii) Ethanol (C_2H_5OH) is oxidised to acetic acid (CH_3COOH) in the presence of acidified potassium dichromate ($K_2Cr_2O_7$).

$$C_2H_5OH + 2[O] \xrightarrow{K_2Cr_2O_7./H_2SO_4} CH_3COOH + H_2O$$

This reaction is considered an oxidation because ethanol (C_2H_5OH) loses hydrogen atoms and the oxygen atoms from the oxidizing agent are added to the alcohol molecule to form acetic acid.

(iii) $CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$

Ethanoic acid | Sodium hydroxide | Sodium ethanoate | Water

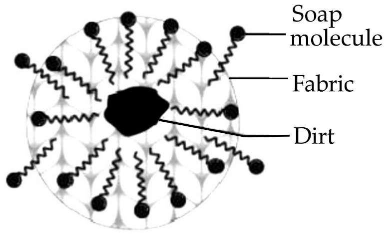
4. (i) Preparation of Soap: Soap is prepared through a process called saponification, which involves the hydrolysis of fats or oils (esters) with an alkali like sodium hydroxide (NaOH). When animal fat or vegetable oil (ester) is heated with a concentrated sodium hydroxide solution, the ester breaks down into soap and glycerol (an alcohol).

The chemical equation is as follows:

$$C_3H_5(OOCC_{17}H_{35})_3 + 3NaOH \rightarrow C_3H_5(OH)_3 + 3C_{17}H_{35}COONa^+$$

Esters of Fatty Acids + Sodium hydroxide → Glycerol + Sodium stearate

(ii) Cleansing Action of Soaps: The cleansing action of soap works due to its unique molecular structure, with a hydrophilic (water-attracting) head and a hydrophobic (water-repelling) tail. When soap is added to water, the hydrophobic tails attach to the oily dirt, while the hydrophilic heads remain in the water. This creates spherical structures called micelles, where the dirt is trapped in the centre. These micelles remain suspended in water as a colloidal solution, allowing the dirt and grease to be emulsified and washed away during rinsing. This mechanism helps soap effectively remove oily dirt from surfaces or clothes.



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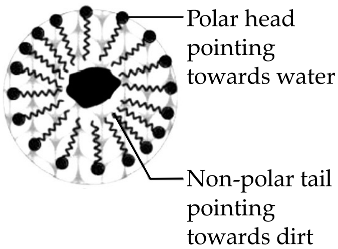

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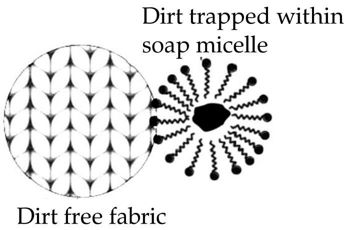
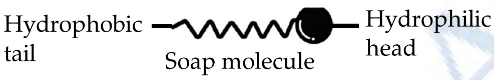


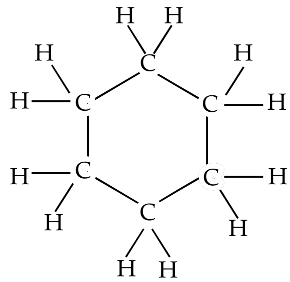
(3)



5. (i) Carbon has 4 electrons in its outermost shell and requires 4 more electrons to complete its octet. To form a C^{4+} cation, carbon would need to lose 4 electrons. However, removing 4 electrons requires a large amount of energy, making it energetically unfavourable. Whereas, to form a C^{4-} anion, carbon would need to gain 4 electrons. This would create strong repulsion among the electrons, and the nucleus cannot stabilize such a high negative charge. Instead, carbon forms covalent bonds by sharing electrons with other atoms, fulfilling the octet rule without gaining or losing electrons.

(ii) A homologous series is a group of organic compounds with the same general formula and similar chemical properties. Each successive member differs by a —CH_2 unit (methylene group). The molecular formula of any two consecutive members of homologous series of aldehydes are: CH_3—CHO (ethanal) and CH_3—CH_2—CHO (proponal).

(iii)



6. (i) Compound A is ethanol (C_2H_5OH).
Compound B is ethene (C_2H_4).
Compound C is ethane (C_2H_6).

(ii) $$\underset{(A)}{C_2H_5OH} \xrightarrow[443\ K]{H_2SO_4} \underset{(B)}{C_2H_4} + H_2O$$

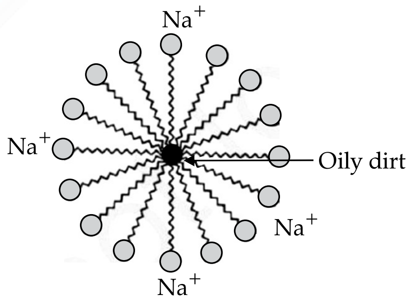
(iii) When ethane undergoes combustion, it reacts with oxygen to produce carbon dioxide, water, and heat.

$$2C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O + \text{heat}$$

(iv) One industrial application of the hydrogenation reaction is the conversion of unsaturated vegetable oils into saturated fats (vanaspati ghee). This is done by adding hydrogen (H_2) to the double bonds in the presence of a nickel (Ni) catalyst, turning the liquid oil into a semi-solid fat.

(v) When compound A (ethanol) reacts with sodium, the products formed are sodium ethoxide (C_2H_5ONa) and hydrogen gas (H_2).

7. (i) Soap has unique molecular structure with a hydrophobic part tail and a hydrophilic part head. When the soap comes in the contact with oily dirt, then hydrophobic tail attach to the oily dirt. This creates a spherical structure called micelles.



(ii) (1) In test tube Y more amount of foam will form, because detergents are better cleansing agent than soap. Detergents do not form insoluble calcium and magnesium salts with hard water.

(2) Curdy scum is formed in the test tube X because soap droplet forms insoluble precipitate of calcium and magnesium ion present in hard water.

8. **X:** The acid X is likely to be a carboxylic acid, such as acetic acid (CH_3COOH).

Y: The alcohol Y is likely to be a simple alcohol, such as ethanol (C_2H_5OH).

Z: The sweet-smelling substance Z is an ester, specifically ethyl ethanoate ($CH_3COOC_2H_5$).

Chemical Equation:

$$\underset{\substack{\text{Acetic acid}\\ X}}{CH_3COOH} + \underset{\substack{\text{Ethanol}\\ Y}}{C_2H_5OH} \xrightarrow[\text{heat}]{H^+} \underset{\substack{\text{Ethyl ethanoate}\\ Z}}{CH_3COOC_2H_5} + H_2O$$

The reaction is Esterification Reaction.

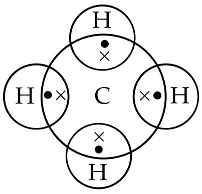
The substance Z, ethyl acetate, on treatment with sodium hydroxide (NaOH) produces the alcohol (Y) ethanol, and sodium ethanoate (CH_3COONa). This reaction is called as saponification reaction. The chemical equation for the reaction can be represented as:

$$\underset{Z}{CH_3COOC_2H_5} + NaOH \rightarrow \underset{Y}{C_2H_5OH} + \underset{\text{Sodium ethoxide}}{CH_3COONa}$$

The term "saponification" comes from the Latin word "sapo", which means soap. This is because the reaction is commonly used in the production of soap, where fats (which are esters) are hydrolysed by a strong base (such as NaOH) to form soap and glycerol.

9. (i) The simplest saturated hydrocarbon is methane (CH_4).

Electron Dot Structure



Each hydrogen atom shares one electron with the carbon atom, forming covalent bond with single bond.

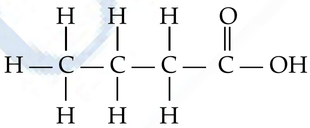
Type of bond: Covalent bond.

(ii) Natural Gas and CNG

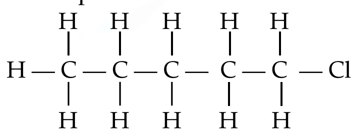
(iii) Methane belongs to the homologous series of alkanes. The general formula for alkanes is C_nH_{2n+2}, where n is the number of carbon atoms.

(iv) Methane burns with a clean blue flame. This indicates complete combustion, producing mainly carbon dioxide and water as it reacts efficiently with oxygen.

10. (i) (A) Butanoic acid



(B) Chloropentane



(ii) Structure (i) represents 2,3-dimethyl butane, while Structure (ii) corresponds to 2,2-dimethyl butane. Both are isomers of the compound with the chemical formula C_6H_{14}. Another isomer of this compound is 3-methylpentane, as shown below:

$$CH_3 - CH_3 - \underset{\substack{|\\ CH_3}}{CH} - CH_2 - CH_3$$

3-methyl pentane

(iii)

Saturated Carbon Compounds	Unsaturated Carbon Compounds
Saturated carbon compounds always follow the general formula C_nH_{2n+2}.	Unsaturated carbon compounds follow specific general formulae depending on the type of bond present. If there is a carbon-carbon double bond, they adhere to the formula C_nH_{2n}. If a carbon-carbon triple bond is present, the formula becomes C_nH_{2n-2}.

11. (i) Alcohols react with sodium leading to the formation of sodium ethoxide and evolution of hydrogen gas.

$$2Na + 2\,CH_3CH_2OH \longrightarrow \underset{\text{(Sodium ethoxide)}}{2CH_3CH_2O^-Na^+} + H_2\uparrow$$

(ii) The melting point of pure ethanoic acid is 290 K and hence it often freezes during winter in cold climates. This gave rise to its name glacial acetic acid.

(iii) Reaction to give unsaturated hydrocarbon: Heating ethanol at 443 K with excess concentrated sulphuric acid results in the dehydration of ethanol to give ethene—

$$CH_3{-}CH_2OH \xrightarrow[443\text{ K}]{\text{Hot Conc. }H_2SO_4} \underset{\text{Ethene}}{CH_2 = CH_2} + H_2O$$

The concentrated sulphuric acid can be regarded as a dehydrating agent which removes water from ethanol.

(iv) When treated with sodium hydroxide, which is an alkali, the ester is broken down into an alcohol and the sodium salt of a carboxylic acid. This reaction is called saponification as it is widely used in soap production. Soaps are essentially sodium or potassium salts of long-chain carboxylic acids. The reaction is as follows:

$$CH_3COOC_2H_5 + NaOH \xrightarrow{\text{heat}} CH_3COO^-Na^+ + C_2H_5OH$$

Ethyl ethanoate Sodium hydroxide Sodium ethanoate (Ethyl alcohol)
Ethanol
(Ethyl acetate) (Sodium acetate)

12. (i) **'X':** Ethanol (C_2H_5OH)

'Y': Ethanoic acid (CH_3COOH)

'Z': Ethyl ethanoate ($CH_3COOC_2H_5$)

(ii) (1) Conversion of 'X' (ethanol) to 'Y' (ethanoic acid):

$$C_2H_5OH + [O] \xrightarrow{\text{acidified } K_2Cr_2O_7} CH_3COOH + H_2O$$

(2) Formation of 'Z' (ethyl ethanoate) from 'X' and 'Y':

$$C_2H_5OH + CH_3COOH \xrightarrow{\text{conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$$

(iii) (1) Acidified potassium dichromate acts as an oxidising agent, converting ethanol to ethanoic acid.

(2) Concentrated sulphuric acid acts as a dehydrating agent and a catalyst, promoting the esterification reaction between ethanol and ethanoic acid.

(iv) Saponification reaction.

13. (i) $C_2H_5OH \xrightarrow[443\,K]{\text{conc.}H_2SO_4} C_2H_4 + H_2O$

(ii) $H_2C = CH_2 \xrightarrow[Ni/Pd]{H_2} CH_3 - CH_3$

(iii) $C_2H_6 + Cl_2 \xrightarrow{\text{Sunlight}} C_2H_5Cl + HCl$

(iv) $CH_3CH_2OH \xrightarrow[\text{or Acidified } K_2Cr_2O_7]{\text{Alkaline } KMnO_4} CH_3COOH$

(v) $CH_3COOH + C_2H_5OH \xrightarrow[\text{heat}]{\text{Acid}} CH_3COOC_2H_5 + H_2O$

14. (i) Since acid and base react to form salt and water, compound A will naturally be acidic due to the presence of a carboxylic acid group.

Chemical equation for acid and base reaction:

Acid + Base $\longrightarrow$ Salt + Water

$HX + M\,OH \longrightarrow MX + HOH$

$CH_3COOH(aq) + NaOH(aq) \longrightarrow CH_3COONa\,(aq) + H_2O$ (1)

Thus, Compound A is CH_3COOH (acetic acid). It is acidic in nature containing a carboxyl functional group.

(ii) (1) **Compound B:** C_2H_6O, identified as ethanol (CH_3CH_2OH).

Compound C: The sweet-smelling compound formed is ethyl acetate ($CH_3COOCH_2CH_3$).

(2) The acid (e.g., HCl) acts as a catalyst in the esterification process, facilitating the reaction between the carboxylic acid (A) and alcohol (B) to form the ester (C).

(3) $CH_3COOH + CH_3CH_2OH \xrightarrow{H^+} CH_3COOCH_2CH_3 + H_2O$

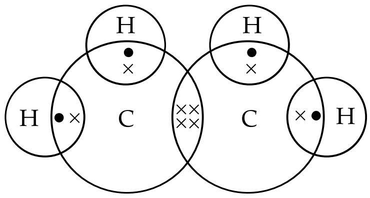
This is an example of Fischer esterification.

15. (i) **Compound Formed:** Ethene (C_2H_4) is formed when ethanol is heated at 443 K in the presence of concentrated H_2SO_4.

$C_2H_5OH \xrightarrow{\text{conc. } H_2SO_4,\ 443\,K} C_2H_4 + H_2O$

Role of H_2SO_4: Concentrated H_2SO_4 acts as a dehydrating agent as it removes a water molecule (H_2O) from ethanol, facilitating the formation of ethene.

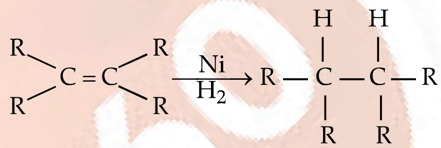
Electron dot structure of Ethene C_2H_4



(ii) Hydrogenation is the process of addition of hydrogen (H_2) to unsaturated compounds like alkenes or alkynes in the presence of a catalyst (such as nickel, palladium, or platinum).

$C_2H_4 + H_2 \xrightarrow{Ni} C_2H_6$

In this reaction, ethene (C_2H_4) reacts with hydrogen to form ethane (C_2H_6). This process converts the double bond in ethene into a single bond in ethane.



Industrial Applications:

- **Petrochemical Industry:** Hydrogenation is used to convert unsaturated hydrocarbons (alkenes and alkynes) into saturated hydrocarbons (alkanes like paraffin or cycloalkanes).
- **Food Industry:** Hydrogenation is used to convert vegetable oils (unsaturated fats) into solid or semi-solid fats, such as margarine and vanaspati (vegetable ghee).

16. A: Propionic acid (CH_3CH_2COOH) – a carboxylic acid, as it reacts with sodium and NaOH.

B: Sodium propanoate (CH_3CH_2COONa) – a sodium salt formed when A reacts with sodium or NaOH.

C: Ethanol (C_2H_5OH) – an alcohol

D: Ethyl propanoate ($CH_3CH_2COOC_2H_5$) – an ester formed when A reacts with C in the presence of concentrated H_2SO_4.

Chemical Reactions:

1. **Reaction of A (Propionic acid) with Sodium:**
   $CH_3CH_2COOH + 2Na \rightarrow CH_3CH_2COONa + H_2$
2. **Reaction of A (Propionic acid) with NaOH:**
   $CH_3CH_2COOH + NaOH \rightarrow CH_3CH_2COONa + H_2O$
3. **Esterification of A with C (Ethanol) to form D (Ethyl propanoate):**
   $CH_3CH_2COOH + C_2H_2OH \xrightarrow{\text{conc. } H_2SO_4} CH_3CH_2COOC_2H_5 + H_2O$
4. **Saponification of D (Ethyl propanoate) with NaOH:**
   $CH_3CH_2COOC_2H_5 + NaOH \rightarrow CH_3CH_2COONa + C_2H_2OH$