CLASS 10 NOTES

SCIENCE

Carbon and It's Compound

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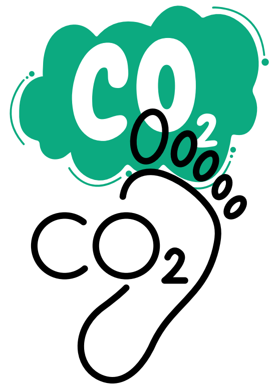
Atomic Number of Carbon → 6

Carbon achieves stability with 4 electrons in its outermost shell. While it could gain four electrons to form a carbon anion, removing electrons poses challenges due to the substantial energy requirement. Gaining or losing electrons influences the formation of bonds in chemical compounds.



To solve this issue, carbon shares its outer electrons with other carbon or different atoms. This sharing helps both atoms reach a stable configuration, similar to noble gases. This sharing is called covalent bonding.

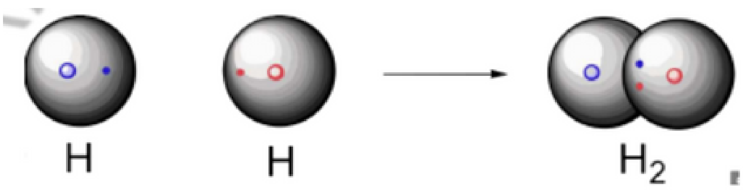
Examples of Covalent Bonding:

Formation of Hydrogen Molecule:

The hydrogen molecule (H_2) forms when two hydrogen atoms come close together. Each hydrogen atom shares its electron with the other, creating a covalent bond. This sharing completes their outer electron shells, making the molecule stable. The chemical equation for this process is $H + H \rightarrow H_2$

(H---H)

*Single Covalent Bond

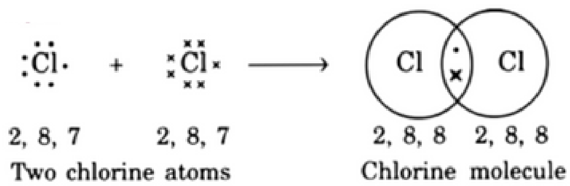


Formation of chlorine Molecule (Cl_2):

Chlorine gas (Cl_2) forms when two chlorine atoms combine. Each chlorine atom contributes one electron, creating a covalent bond. This shared electron pair satisfies the octet rule, making the molecule stable. The chemical equation

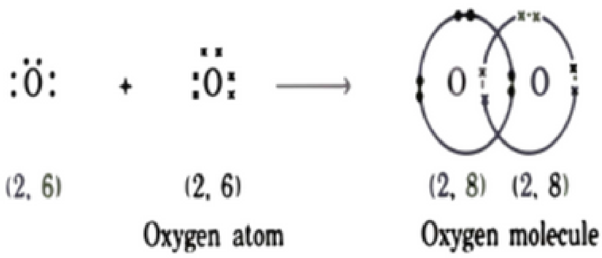
(Cl----Cl)

*Single covalent Bond



Formation of Oxygen Molecule (O_2):

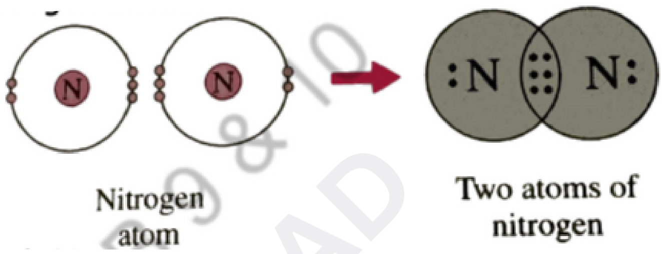
Two oxygen atoms combine to form an oxygen molecule (O_2). The chemical equation is $2O \rightarrow O_2$ showing that two oxygen atoms come together to create one oxygen molecule.



Formation of Nitrogen Molecule (N_2):

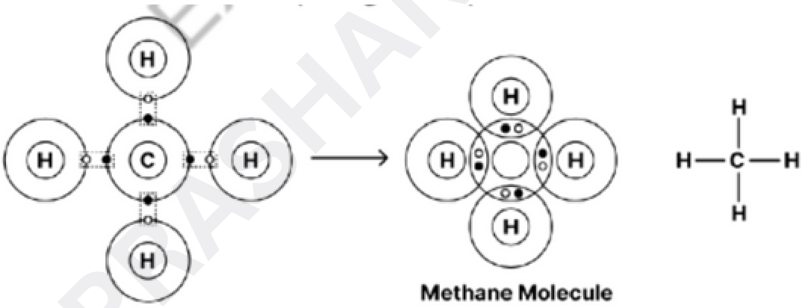
Two nitrogen atoms combine to form a nitrogen molecule (N_2). The chemical equation is $N + N \rightarrow N_2$ indicating that two nitrogen atoms come together to create one nitrogen molecule.

*Triple covalent Bond



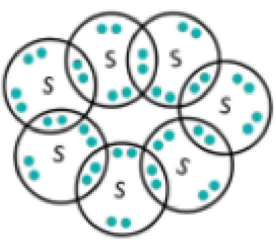
Formation of Methane (CH_4):

Methane CH_4 forms when one carbon atom combines with four hydrogen atoms. The chemical equation for this is $C + 4H_2 \rightarrow CH_4$ indicating the combination of carbon and hydrogen to produce methane.

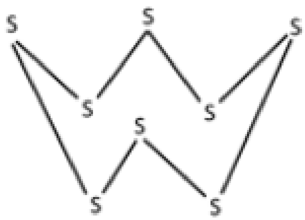


Methane, or marsh gas, is a vital fuel used in CNG and Biogas. It not only serves as a potent energy source but also participates in reactions forming essential compounds like (Ammonia NH_3),(Water H_2O), and (Carbon Dioxide CO_2) This versatility underscores its significance in both energy and environmental contexts.

Formation of Sulphur (S_8):



Ring structure of S_8 molecules



Crown shape of S_8 molecule

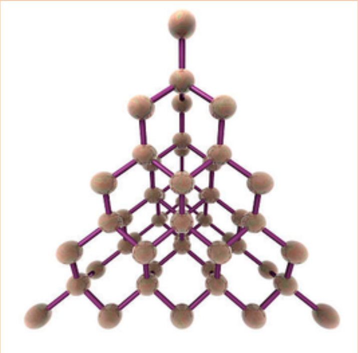
Properties of covalent Bond: EMA

- Low Melting and Boiling Points: Covalent compounds have low melting and boiling points due to weak intermolecular forces.
- Weak Intermolecular Forces: Covalent compounds exhibit weak forces between molecules.
- Electron Sharing Between Atoms: Electrons are shared between atoms in covalent bonds.
- No Charged Particles Formed: Covalent compounds do not form charged particles; electrons are shared, not transferred.

Allotropes of carbon: EMA

Allotropy is the characteristic of an element to exist in multiple forms, where each form possesses distinct physical properties while maintaining identical chemical properties.

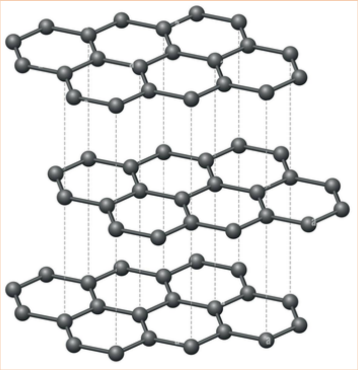
DIAMOND:



Properties:
- Very Hard
- Does not conduct Electricity
- Transparent and colorless.

Uses:
- Industrial cutting tools due to hardness.
- Jewelry and gemstones.

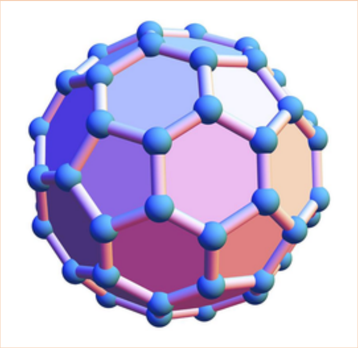
GRAPHITE:



Properties:
- Conductivity: Excellent electrical conductivity.
- Thickness: Single layer of carbon atoms arranged in a hexagonal lattice.
- Strength: Exceptionally strong.

Uses:
- Lubricants and as a dry lubricant in locks and mechanisms.
- Electrodes in batteries.
- Pencils (as pencil lead).
- Moderators in nuclear reactors.

FULERENES:



The fullerene C60 was named "Buckminsterfullerene" after Buckminster Fuller. The initial discovered fullerene is C60, also known as Buckminsterfullerene, and it comprises 60 carbon atoms.

Versatile Nature of carbon: EMA

The versatile nature of carbon is attributed to its ability to form a wide variety of compounds, owing to the following characteristics:

- Tetravalency: Carbon can form four covalent bonds, allowing it to bond with various other atoms, including itself, to create diverse molecular structures.
- Catenation: Carbon exhibits a high degree of catenation, meaning it can form long chains, branched structures, or rings, contributing to the diversity of carbon-based molecules.
- Allotropy: Carbon exists in different allotropes, such as diamond, graphite, graphene, fullerenes, and carbon nanotubes, each with distinct properties and applications.
- Isomerism: Carbon compounds can have different structural or spatial arrangements, leading to the existence of isomers—molecules with the same molecular formula but different structures.
- Polymerization: Carbon is integral to the formation of polymers, enabling the creation of a wide range of synthetic materials with diverse applications.

These characteristics collectively contribute to carbon's versatility, making it a cornerstone of organic chemistry and a crucial element for the existence of life as we know it.

HYDROCARBONS

SATURATED

Compounds of carbon are linked only by single bonds between the carbon atoms.
-Type of Saturated Hydrocarbon: Alkanes

UNSATURATED

It is the electric current which reverses its direction after every fixed interval of time.
-Types of Unsaturated Hydrocarbons: Alkenes and Alkynes

ALKANES:

- Hydrocarbons with all carbon atoms linked by single covalent bonds are alkanes or paraffins.
- General formula: CnH2n+2.

ALKENES:

- Unsaturated hydrocarbons with at least one double bond along with single bonds are called alkenes or olefins.

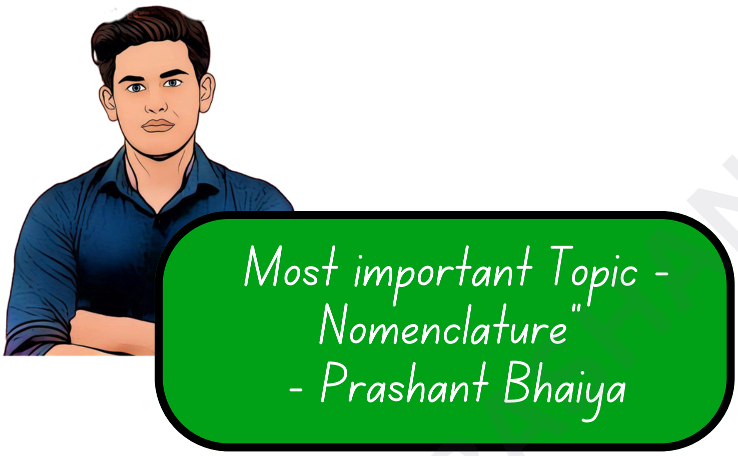
- General formula: C_nH_{2n} where n≥2

ALKYNES:
- Unsaturated hydrocarbons with one or more triple bonds along with single bonds are alkynes.
- General formula: CnH2n-2

Note: For alkenes, n must be greater than 2, and for alkynes, n must be greater than or equal to 2 to ensure a minimum number of carbon atoms for a double or triple bond.

IUPAC Nomenclature of Hydrocarbons:

IUPAC (International Union of Pure and Applied Chemistry) nomenclature is a systematic method used to name organic compounds, including hydrocarbons.



No. of C atoms	Name of alkane	Molecular formula
1	Methane	CH_4
2	Ethane	C_2H_6
3	Propane	C_3H_8
4	Butane	C_4H_{10}
5	Pentane	C_5H_{12}
6	Hexane	C_6H_{14}
7	Heptane	C_7H_{16}
8	Octane	C_8H_{18}
9	Nonane	C_9H_{20}
10	Decane	$C_{10}H_{22}$

Alkanes (Saturated Hydrocarbons):
- End the name with "-ane."
- Number the carbon atoms in the longest continuous chain.
- Identify and name any substituents (side branches).
- Combine the names of the substituents with the chain name.
- Example: CH3CH2CH2CH3 is butane.

Alkenes (Unsaturated Hydrocarbons with Double Bonds):
- End the name with "-ene."
- Number the carbon atoms in the longest continuous chain.
-Identify the location of the double bond and include it in the name.
- Example: CH2=CH-CH3 is propene.

Alkynes (Unsaturated Hydrocarbons with Triple Bonds):

End the name with "-yne."
- Number the carbon atoms in the longest continuous chain.
- Identify the location of the triple bond and include it in the name.
- Example: CH≡C–CH2–CH3 is propyne.

Remember to follow the IUPAC rules for numbering and prioritizing substituents. The goal is to provide a systematic and unique name for each hydrocarbon based on its structure.

Steps for writing IUPAC Names:

1. Identify the Longest Carbon Chain:
- Locate the longest continuous chain of carbon atoms in the molecule.
2. Number the Carbon Chain:
- Number the carbon atoms in the chain from the end that gives substituents the lowest numbers.
3. Identify and Name Substituents:
- Identify and name any substituents (groups attached to the main carbon chain).
4. Combine Chain and Substituent Names:
- Combine the names of the main carbon chain and substituents, alphabetizing them.
5. Add Prefixes and Suffixes:
- Add prefixes and suffixes based on the type of compound (alkane, alkene, alkyne).

Examples:

1. $CH_3CH_2CH_2CH_2CH_3$:
   - Longest Chain: 5 carbon atoms (Pentane).
   - IUPAC Name: Pentane.

2. $CH_3CH_2CH_2OH$:
   - Longest Chain: 3 carbon atoms (Propane).
   - Substituent: OH (Hydroxy group at the 1st carbon).
   - IUPAC Name: Propan-1-ol (or simply Propanol).

3. $CH_2{=}CHCH_3$:
   - Longest Chain: 3 carbon atoms (Propene).
   - IUPAC Name: Propene.

4. $CH_3CH_2CH_2COOH$:
   - Longest Chain: 4 carbon atoms (Butane).
   - Substituent: COOH (Carboxyl group at the 1st carbon).
   - IUPAC Name: Butanoic acid.

Drawing Structures of Saturated and Unsaturated Compounds:

- Connect All Carbon Atoms with Single Bonds:

- Use single bonds to link all carbon atoms together in the molecule.

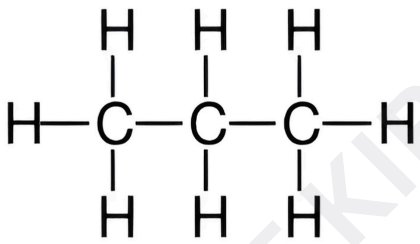
- Satisfy Remaining Valencies of Carbon with Hydrogen Atoms:

- Attach hydrogen atoms to each carbon atom to fulfill their valency.
- Carbon typically forms 4 bonds due to its 4 valencies.

- If Available Hydrogen Atoms are Insufficient:

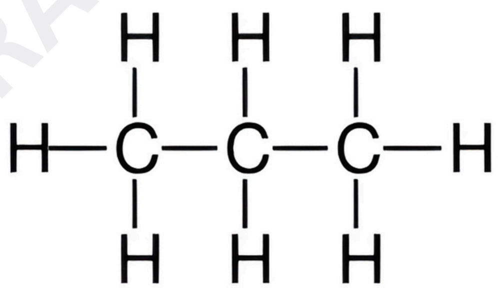
- If the number of available hydrogen atoms is less than required, use double or triple bonds to satisfy the remaining valency of carbon.

1.The structural formula for propane is:



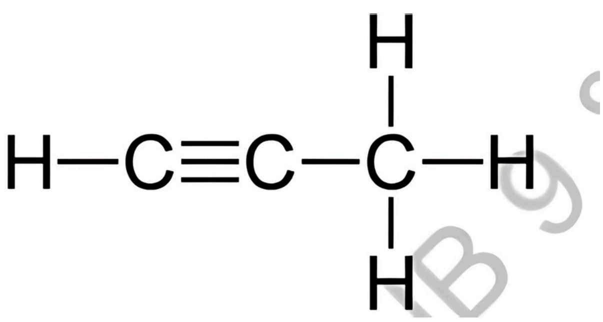
This represents a straight-chain alkane with three carbon atoms, each bonded to two hydrogen atoms. The carbon atoms are connected by single bonds.

2. The structural formula for ethene (also known as ethylene) is:



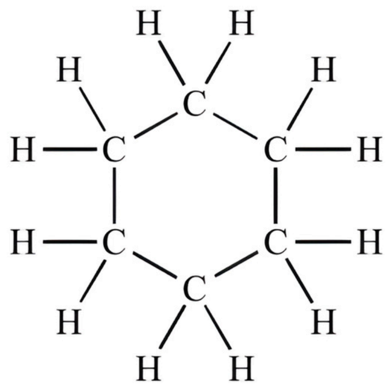
This represents an alkene with two carbon atoms and a double bond between them. Each carbon atom is bonded to two hydrogen atoms.

3. The structural formula for propyne is:



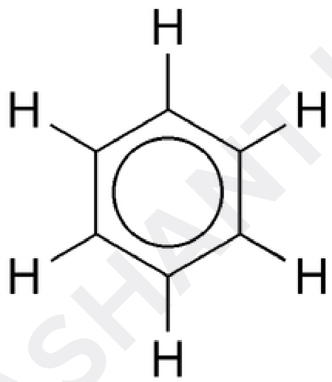
This represents an alkyne with the carbon atoms. The triple bond is between the first and second carbon atoms. Each carbon atom is bonded to one hydrogen atom.

4. The structural formula for cyclohexane is represented as a hexagon:



Cyclohexane is a cyclic alkane with six carbon atoms forming a ring, and each carbon is bonded to two hydrogen atoms. The bond angles in the ring are approximately 109.5 degrees, creating a stable and symmetrical structure.

5. The structural formula for benzene is represented as a hexagon with a circle inside:



This representation indicates that benzene has a stable and symmetrical ring structure with six carbon atoms. The circle inside the hexagon signifies the delocalized pi electrons, highlighting the resonance structure of benzene. Each carbon atom is bonded to one hydrogen atom, and all carbon-carbon bonds in benzene are equivalent.

Functional Groups: EMA

A functional group is an atom or group of atoms within a carbon compound that imparts reactivity and determines its chemical properties. When a compound contains a functional group, it is denoted in the compound's name through the use of either a prefix or a suffix.

Hetero atom	*Class of compounds*	*Formula of functional group*	
Cl/Br	Halo- (Chloro/bromo) alkane	—Cl, —Br (substitutes for hydrogen atom)	Prefix = Chloro/Bromo
Oxygen	1. Alcohol	—OH	Suffix -ol
	2. Aldehyde	$-\mathrm{C}(\mathrm{H})=\mathrm{O}$	Suffix -al
	3. Ketone	$-\mathrm{C}(=\mathrm{O})-$	Suffix -one
	4. Carboxylic acid	$-\mathrm{C}(=\mathrm{O})-\mathrm{OH}$	Suffix -oic acid

Homologous Series:

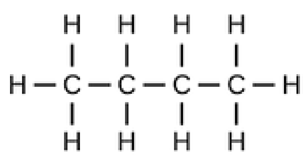
A homologous series is a group of organic compounds sharing similar structure and chemical properties, where successive members in the series differ by the addition of a common CH2 group. For example, CH4, C2H6, and C3H8

- All members have the same general formula.
- Successive members differ by a CH2 group.
- Two adjacent members differ by molecular masses of CH2.
- All members exhibit similar chemical properties (though not necessarily identical physical properties).

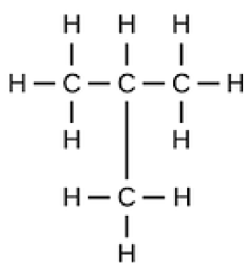
Structural Isomerism:

Structural isomerism refers to compounds sharing the same molecular formula but exhibiting distinct arrangements of atoms or bonds within their structures.

Butane



Isobutane



Examples:

Ethanol:

- A liquid compound, soluble in water.
- Commonly referred to as alcohol, it serves as the active ingredient.
- Due to its excellent solvent properties, ethanol is employed in various medicines such as tincture iodine, cough syrups, and many tonics.

Acetic Acid ($C_2H_4O_2$): -

-- Commonly known as acetic acid.
- A 5-8% solution of acetic acid in water is termed vinegar and is used as a preservative in pickles.
- With a melting point of 290 K, it tends to freeze during winter.
- Carboxylic acids, including acetic acid, are categorized as weak acids.

Denatured Alcohol:

Denatured alcohol is a form of alcohol that is rendered unsuitable for consumption in large quantities due to its adverse effects on health. Excessive alcohol intake can impede metabolic processes and suppress the central nervous system, leading to issues such as lack of coordination and drowsiness. To prevent the misuse of alcohol, it is intentionally altered by incorporating toxic substances like methanol and pyridine, as well as colored dyes. This modified form of alcohol, known as denatured alcohol, is specifically designed to deter ingestion.

Chemical Properties of Carbon Compounds:

1. Combustion:

Combustion is a chemical reaction that releases heat and light.

Combustion of Carbon: $C\ (s) + O_2\ (g) \rightarrow CO_2\ (g)$ + Heat + Light

Combustion of Hydrocarbon: $CH_4\ (g) + O_2\ (g) \rightarrow CO_2\ (g) + H_2O\ (g)$ + Heat + Light

Combustion of Alcohol: $C_2H_5OH\ (g) + O_2\ (g) \rightarrow CO_2\ (g) + H_2O\ (g)$ + Heat + Light

In each case, the combustion process involves the reaction of the substance with oxygen to produce carbon dioxide (CO_2) and water (H_2O) accompanied by the release of heat and light.

Nature of Flame:

- Saturated hydrocarbons such as methane and ethane burn with a clear blue flame in the presence of sufficient oxygen.
- Limited oxygen availability for saturated hydrocarbons results in a sooty flame.
- Unsaturated hydrocarbons like ethene and ethyne burn with a yellow flame and significant black smoke.
- Kerosene, when burned with sufficient oxygen, produces a clear, blue flame.
- Some hydrocarbons like benzene and naphthalene burn with a sooty flame.
- Combusting coal and petroleum primarily yields CO_2, CO, nitrogen oxides, and sulfur oxides. The latter contributes to air pollution.

2. Oxidation:

Carbon compounds readily undergo oxidation during combustion.

$$2C\ (s) + O_2\ (g) \rightarrow 2CO\ (g)$$

(Limited Oxygen, Carbon Monoxide)

$C(s) + O_2(g) \rightarrow CO_2(g)$

(Excess Oxygen, Carbon Dioxide)

Different amounts of oxygen yield different products.

Oxidation of Alcohol:

$$CH_3-CH_2OH \xrightarrow[\text{Or acidified } K_2Cr_2O_7 \text{ + Heat}]{\text{Alkaline } KMnO_4 \text{ + Heat}} CH_3COOH$$

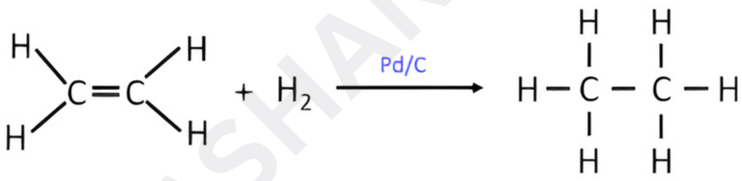
Both alkaline $KMnO_4$ and acidified $K_2Cr_2O_7$ act as oxidizing agents, supplying oxygen for the oxidation process.

3. Addition Reaction:

In the presence of catalysts like palladium or nickel, unsaturated hydrocarbons undergo addition reactions, where hydrogen is incorporated, leading to the formation of saturated hydrocarbons. Catalysts are substances that facilitate a reaction to take place at a different rate, without being consumed in the process.

Hydrogenation Reaction:

This process is employed in the hydrogenation of vegetable oil. Vegetable oils typically consist of long unsaturated carbon chains, whereas animal fats possess saturated carbon chains. Animal fats commonly contain saturated fatty acids, which are detrimental to health.



Ethene Ethane

4. Substitution Reaction:

A substitution reaction is a chemical process in which one functional group in a chemical compound is exchanged with another functional group.

$CH_3OH + HBr \rightarrow CH_3Br + H_2O$

$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$

In these reactions, one functional group is substituted for another, resulting in the formation of new compounds.

Reactions of Ethanol:

i. Reaction with Sodium:

$2Na + 2CH_3CH_2OH \rightarrow 2CH_3CH_2O^-Na^+ + H_2$

(sodium ethoxide)

ii. Reaction to Form Unsaturated Hydrocarbons:

$$CH_3CH_2OH \rightarrow CH_2 = CH_2 + H_2O$$

Hot concentrated H_2SO_4 acts as a dehydrating agent (which removes water), facilitating the reaction.

Reactions of Ethanoic Acid:

i. Esterification Reaction:

$$\text{Acid} + \text{Alcohol} \xrightarrow{\text{Esterification}} \text{Ester}$$

Esters are pleasant-smelling substances used in the production of perfumes and as flavoring agents.

ii. Saponification Reaction:

$$\text{Ester} + \text{Base} \xrightarrow{\text{Saponification}} \text{Alcohol} + \text{Carboxylic Acid}$$

$$CH_3COOC_2H_5 \xrightarrow{NaOH} C_2H_5OH + CH_3COONa$$

(alcohol) (sodium acetate)

$$NaOH + CH_3COOH \rightarrow CH_3COONa + H_2O$$

iii. Reaction with Carbonates and Hydrogen Carbonates:

$$2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + H_2O + CO_2$$

$$CH_3COOH + NaHCO_3 \rightarrow CH_3COONa + H_2O + CO_2$$

In these reactions, ethanoic acid participates in esterification, and saponification, and reacts with carbonates and hydrogen carbonates to yield different products.

Soaps and Detergents:

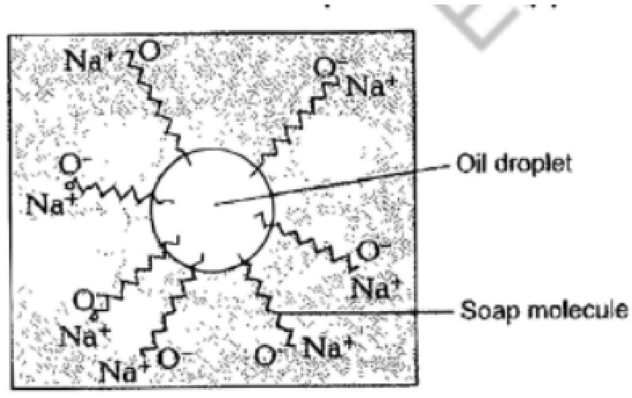
Soaps consist of sodium or potassium salts of long-chain carboxylic acids. The ionic end of the soap dissolves in water, while the carbon chain dissolves in oil.

Soap molecule

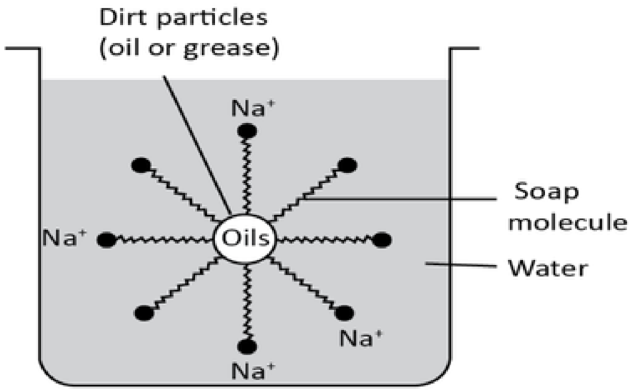
Detergents are typically ammonium or sulphorate salts of long-chain carboxylic acids.

Cleaning Action of Soap:

- Most of the dirt is oily, and oil does not dissolve in water.
- Soap molecules form Structures called micelles.
- In micelles, one end is oriented towards the oil droplet, while the other, which is ionic, faces Outward.
- Soap, in the form of a micelle, resides in the center of the micelles.
- The micelles remain in the solution as a colloid, preventing them from coming together and precipitating due to ion-ion repulsion.
- Soap micelles are large enough to scatter light; therefore, a soap solution appears cloudy.



Micelle formation



Hardness of Water:

- Hard water refers to water with a high mineral content, particularly calcium and magnesium salts. Soap molecules react with these salts, leading to the formation of precipitates, also known as scum.
- Soft water, which lacks calcium and magnesium salts, does not form scum with soap.
- Detergents are generally ammonium or sulphonate saltsof long-chain carboxylic acids. The charged ends of these compounds do not form insoluble precipitates with hard water, allowing them to remain effective in such conditions.

TOP 7

IMPORTANT QUESTIONS

1) A compound X on heating with an excess of cone. H2 SO4 at 443 K gives an unsaturated compound Y. X also reacts with sodium metal to evolve a colorless gas Z. Identify X, Y, and Z. Write the equations of the chemical reaction of formation of Y and also write the role of conc. sulphuric acid in the reaction. [CBSE 2016]

Solution:

X is CH_3CH_2OH, Ethanol Y is Ethene, Z is H_2.

$$\underset{X}{C_2H_5OH} \xrightarrow[443K]{Conc \cdot H_2SO_4} CH_2 \underset{Y}{=} CH_2 + H_2O$$

$$\underset{\text{Ethanol}}{2CH_3CH_2OH} + 2Na \longrightarrow \underset{\text{Sodium ethoxide}}{2CH_3CH_2ONa} + \underset{Z}{H_2}$$

Cone. H_2SO_4 acts as dehydrating agent.

2) Distinguish between esterification and saponification reactions with the help of equations for each. State one use of each
(i) ester
(ii) saponification process.

Solution:

Esterification

$$C_2H_5OH + CH_3COOH \xrightarrow{\text{Con. } H_2SO_4} \underset{\text{Ester}}{CH_3COOC_2H_5} + H_2O$$

Saponification

$$CH_3COOC_2H_5 + NaOH \longrightarrow CH_3COONa + C_2H_5OH$$

Esters are used in synthetic flavours, perfumes, etc.
Saponification process is used for manufacture of soaps.

3) Explain giving reasons, why carbon can neither form C4+ cation nor C4- anion but forms covalent compounds which are bad conductors of electricity and have low melting and boiling points. [CBSE 2017]

Solution:

Carbon cannot lose four electrons because high energy is needed to remove four electrons. It cannot gain 4 electrons because 6 protons cannot hold 10 electrons. It can share 4 electrons to form covalent bonds. Covalent compounds do not conduct electricity because these do not form ions. They have low melting and boiling points due to the weak force of attraction between molecules.

4) Write the chemical equation of the reaction of ethanoic acid with the following:
a. Sodium
b. Sodium hydroxide,
c. Ethanol.
Write the name of one main product of each reaction.

Solution:

a. $$CH_3COOH + 2Na \longrightarrow \underset{\text{Sodium ethanoate}}{2CH_3COONa} + H_2$$

b. $$CH_3COOH + NaOH \longrightarrow \underset{\text{Sodium ethanoate}}{CH_3COONa} + H_2O$$

c. $$CH_3COOH + C_2H_5OH \xrightarrow{\text{Conc.} H_2SO_4} \underset{\text{Ethyl ethanoate}}{CH_3COOC_2H_5} + H_2O$$

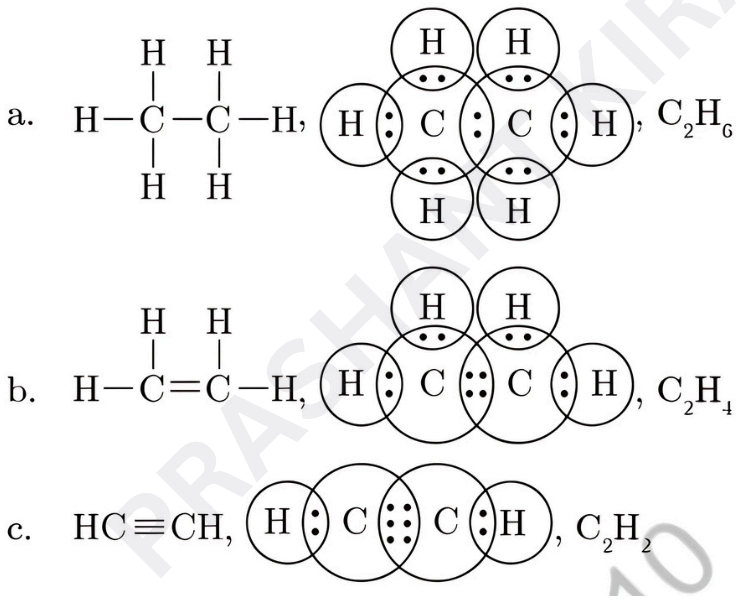
5) What is the difference between the molecules of soaps and detergents, chemically? Explain the cleansing action of soap. [CBSE 2015]

Solution:

Soaps are sodium or potassium salts of fatty acids. They contain the —COONa group. Detergents are sodium or potassium salts of sulphonic acids. They contain —SO3 Na or —SO4 Na group. Soap has an ionic end which is hydrophilic, and interacts with water while the carbon chain is hydrophobic and interacts with oil and grease. The soap molecules orient themselves in a cluster in which hydrophobic tails are inside the cluster and ionic ends face outside. These clusters are called micelles. These attract oil which is washed away by water.

6) Write the molecular formula of the following compounds and draw their electron dot structures:
(a) Ethane
(b) Ethene
(c) Ethyne

Solution:



7). What are micelles? Why does it form when soap is added to water? Will a micelle be formed in other solvents such as ethanol also? State briefly how the formation of micelles helps to clean the clothes having oily spots.

Solution:

Micelles are clusters of molecules in which hydrophobic tails are inside the cluster 3 and the ionic ends are at the surface of clusters. Soap molecules when dissolved in water they form a cluster due to the hydrophobic part of molecules orienting themselves away from water. So they arrange towards the inside of the cluster while the hydrophilic part remains outside of the cluster. No, micelles will not be formed in alcohol. Soap in the form of micelles can be cleaned because the oily dirt will be collected in the center of the micelle which is rinsed away by water.