

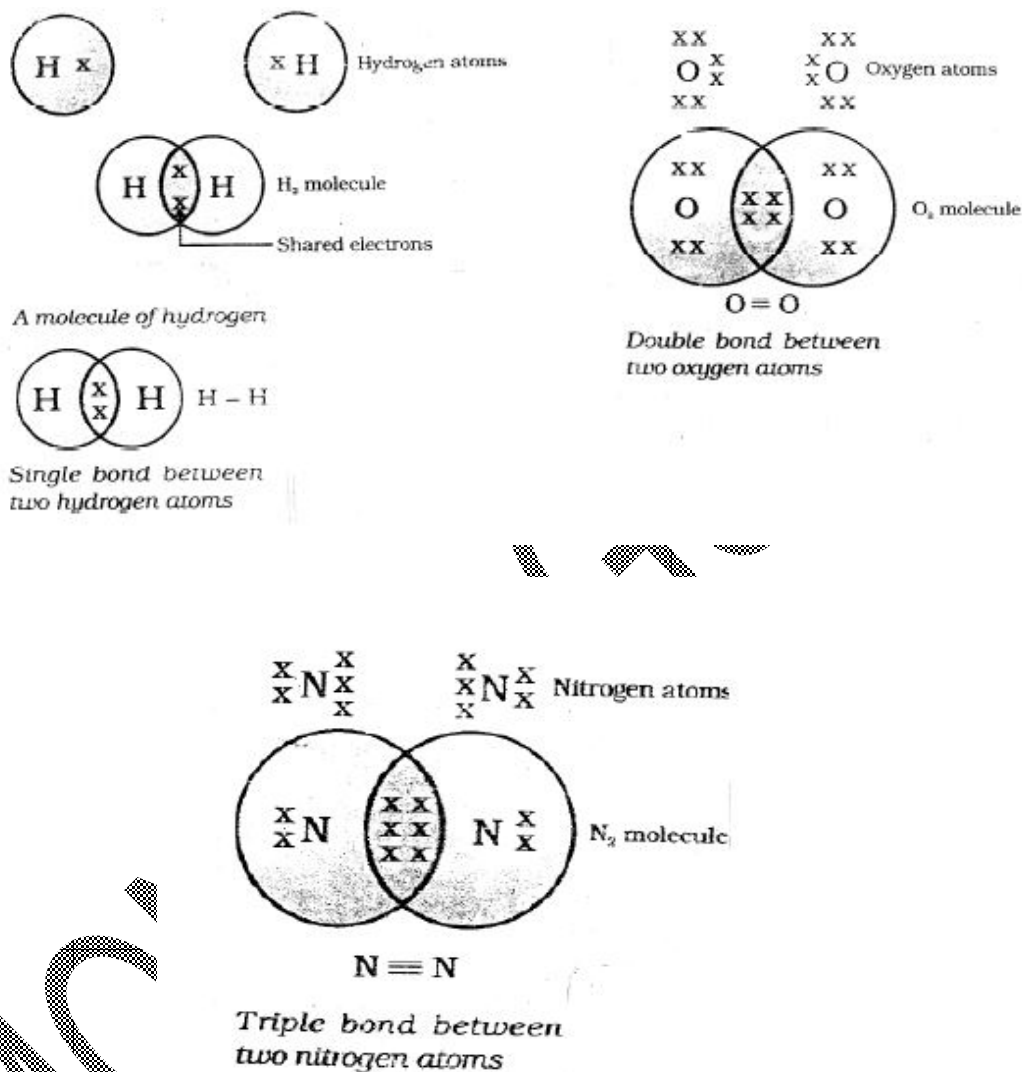
CARBON AND COMPOUNDS

- The atmosphere has only 0.03% of carbon dioxide.
- The number of electrons lost or gained by an atom to complete its octet (or duplet) is called its valency. It depends on the number of valence electrons.
- The tendency to attain a completely filled outermost shell (i.e. noble gas configuration) by gaining or losing electrons is called reactivity.
- The shared pair of electrons belongs to the outer shells of both the atoms so as to attain noble gas configuration.
- The simplest molecule formed by sharing of electrons is hydrogen.
- The bonds which are formed by sharing of electrons between two atoms are known as covalent bonds.
- The compounds which are formed by sharing of electrons pair between two atoms are known as covalent compounds. E.g. CH_4 , H_2 , O_2 , etc. The melting and boiling points of covalent compounds are low because their intermolecular forces are weak and less amount of energy is required to overcome these forces.
- The covalent compounds are generally poor conductors of electricity because the electrons are shared between atoms and no charged particles are formed in their solution.
- Carbon has three allotropes – graphite, diamond and Buckminster Fullerene.
- When a hydrogen atom is removed from an alkane, the group obtained is called an alkyl group.
- Saturated carbon compounds are usually not very reactive because the carbon-carbon single bonds are very strong.
- Unsaturated carbon compounds are very reactive than saturated carbon compounds.

Covalent Bond in Carbon

- The atomic number of carbon is 6 and its electronic configuration is 2, 4. To attain a noble gas configuration it can
 1. Gain 4 electrons. But it would be difficult for nucleus to hold 4 extra electrons.
 2. Lose 4 electrons. But it would require a large amount of energy to remove 4 electrons.
- It is difficult thus for an atom of carbon to either gain or lose electrons.
- Carbon attains the noble gas configuration by sharing its valence electrons with other atoms. Atoms of other elements like hydrogen, oxygen, nitrogen, chlorine also show sharing of valence electrons.

– Formation of H_2 , O_2 and N_2 is shown as below :



– It is evident that the number of shared pair of electrons can be one, two or three. Try making the structures of H_2O and CH_4 .

- Bond formed by the sharing of an electron pair between two atoms is called covalent bond.
- Covalently bonded molecules have low melting and boiling points because of comparatively weaker intermolecular forces, unlike ionic compounds.
- These molecules are generally poor conductor of electricity since no charged particles are formed.

Allotropy

Allotropy The phenomenon in which one element exists in two or more forms having same chemical properties but different physical properties is called allotropy. The substances that show allotropy are carbon, sulphur, etc

Allotropes The different forms of an element having same chemical properties but different physical properties are called allotropes.

Allotropes of Carbon:-

- Graphite
- Diamond
- Buckminster's Fullerene(C-60)

Uses of graphite-

1. It is used in lead pencils as it is soft and leaves black mark on the paper.
2. It, being a good conductor of electricity, is used in making electrode in the cells.
3. Powdered graphite is used as lubricant because it is very soft and can withstand at high temperature.

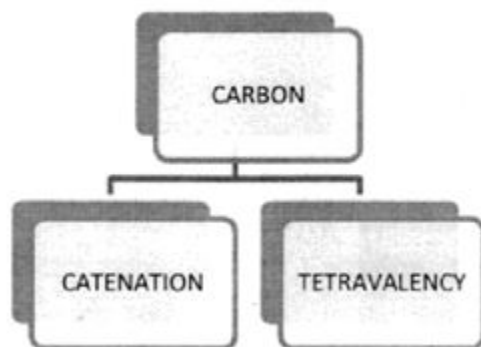
Uses of diamond-

1. It is used in pencils for cutting glass etc because it is the hardest substance known.
2. It is used for making dies for drawing thin wires.
3. It is used in surgical tools.
4. It is used for making jewellery because of high refractive index.

Versatile Nature of Carbon Atoms:

Two important properties of carbon atom enable carbon to form enormously large number of compounds. They are as follows-

- Catenation
- Tetravalency

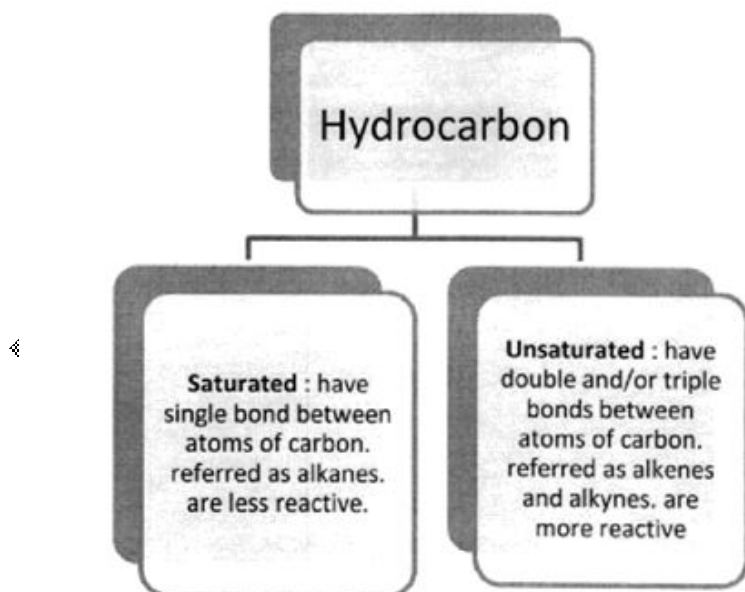


CATENATION : property of carbon atom to form bond with other atoms of carbon is called catenation. Like carbon, silicon forms compounds with hydrogen upto seven or eight atoms of silicon.

TETRAVALENCY : Having a valency of 4, carbon atom is capable of bonding with atoms of oxygen, hydrogen, nitrogen, sulphur, chlorine and other elements.

The smaller size of carbon atom enables nucleus to hold the shared pair of electrons strongly, thus carbon compounds are very stable in general.

Saturated and Unsaturated Carbon Compounds

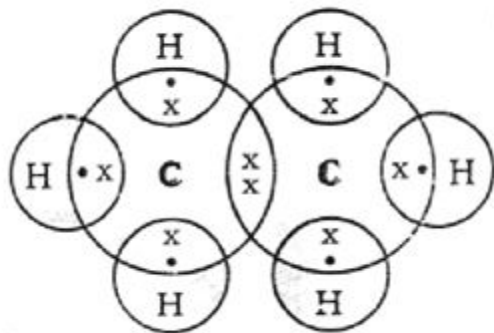


– ALKANE : C_nH_{2n+2}

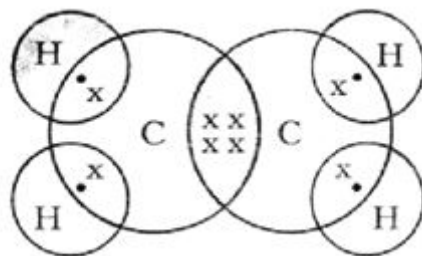
– ALKENE : C_nH_{2n}

– ALKYNE : C_nH_{2n-2}

– Electron dot structure of a saturated carbon compound, ethane is as follows:



– Electron dot structure of an unsaturated carbon compound, ethene is as follows



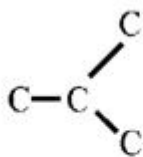
Formulae and Structures of Saturated Compounds of Carbon and Hydrogen

methane CH_4	$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H} \end{array}$	
ethane C_2H_6	$\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array}$	
propane C_3H_8	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array}$	
butane C_4H_{10}	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array}$	

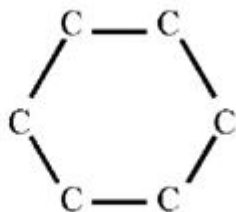
On the basis of structures the hydrocarbons can be:



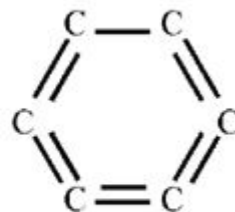
Straight chain



Branched

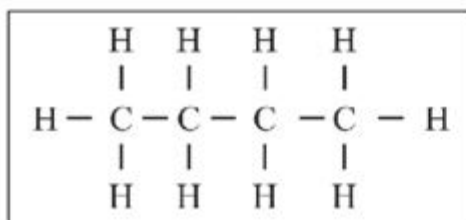


Cyclic saturated

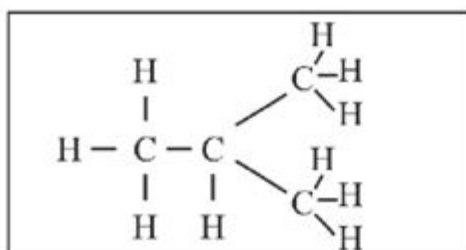


Cyclic unsaturated

Structural isomers : these are the compounds having identical molecular formula but different structures. For example, isomers of butane.



Straight Chain Isomer



Branched Isomer of Butane

Heteroatom and Functional Group :

*In hydrocarbon chain, one or more hydrogen atoms can be replaced by other atoms in accordance with their valencies. The element that replaces hydrogen is called a heteroatom.

*These heteroatoms and the group containing them impart chemical properties to the compound and hence are called functional groups.

Heteroatom	Functional Group	Formula
Cl/Br	Halo-(Chloro/Bromo)	-Cl ₂ , -Br
Oxygen	1. Alcohol	-OH
	2. Aldehyde	$ \begin{array}{c} \text{H} \\ \\ -\text{C} \\ \\ \text{O} \end{array} $
	3. Ketone	$ \begin{array}{c} -\text{C}- \\ \\ \text{O} \end{array} $
	4. Carboxylic acid	$ \begin{array}{c} -\text{C}-\text{OH} \\ \\ \text{O} \end{array} $

Homologous Series:

- It is a series of compounds in which the same functional group substitutes for hydrogen

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in a Carbon chain.

- For instance, the ALCOHOLS: CH_3OH , $\text{C}_2\text{H}_5\text{OH}$, $\text{C}_3\text{H}_7\text{OH}$, $\text{C}_4\text{H}_9\text{OH}$.
- The successive member differs by $-\text{CH}_2-$; unit and 14 units of mass.
- The chemical properties are imparted by the functional group thus all members have similar chemical properties. But the members have different physical properties.
- The physical properties vary among the members of homologous series due to difference in their molecular mass.
- Melting point and boiling point increases with increasing molecular mass.

Nomenclature of Carbon Compounds:

1. Identify the number of carbon atoms in the compound.
2. Functional group is indicated either by prefix or suffix.

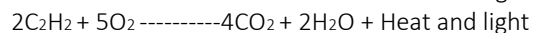
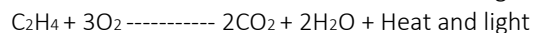
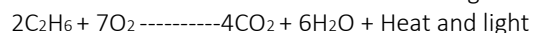
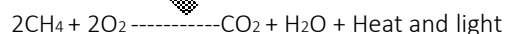
Functional Group	Suffix	Prefix
Alkene	ene	
Alkyne	yne	
Alcohol	ol	
Aldehyde	al	
Ketone	one	
Carboxylic acid	oic acid	
Chlorine		chloro

3. If a suffix is added, then final 'e' is removed from the name eg. methanol (methane-e = methan + ol).

Chemical properties of Carbon compounds :

1. COMBUSTION :

*Carbon compounds generally burn (oxidize) in air to produce carbon dioxide and water, and release heat and light energy.



*Saturated hydrocarbon burns generally with a blue flame in good supply of air and with a yellow sooty flame in limited supply of air.

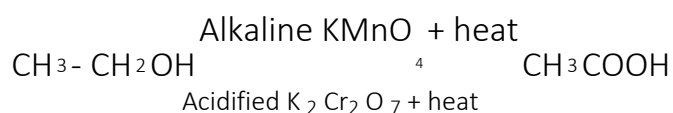
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*Sooty flame is seen when unsaturated hydrocarbons are burnt.

*Burning of coal and petroleum emits oxides of sulphur and nitrogen which are responsible for acid rain.

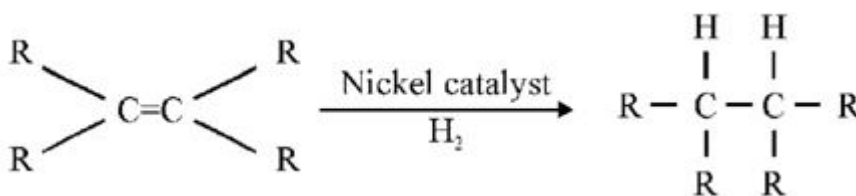
2. OXIDATION :

*Alcohols can be converted to carboxylic acids by oxidizing them using alkaline potassium permanganate or acidified potassium dichromate (they add oxygen to the reactant, thus are called oxidizing agents).



3. ADDITION REACTION:

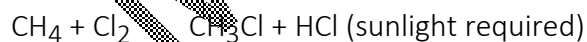
Hydrogen is added to unsaturated hydrocarbon in presence of palladium or nickel as catalyst. Vegetable oils are converted into vegetable ghee using this process.



Saturated fatty acids are harmful for health and oils with unsaturated fatty acids should be used for cooking.

4. SUBSTITUTION REACTION :

In saturated hydrocarbons, the hydrogen attached to carbon can be replaced by another atom or group of atoms in presence of sunlight.

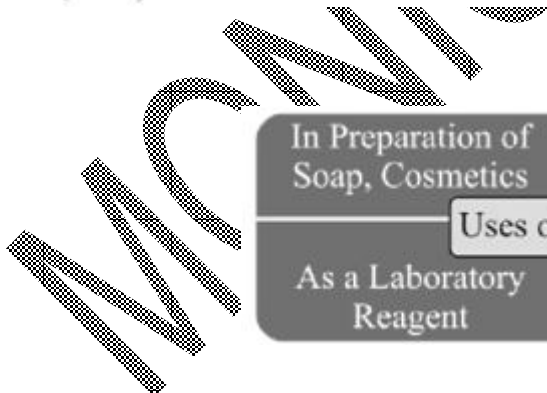


IMPORTANT CARBON COMPOUNDS : Ethanol and Ethanoic Acid

Ethanol :

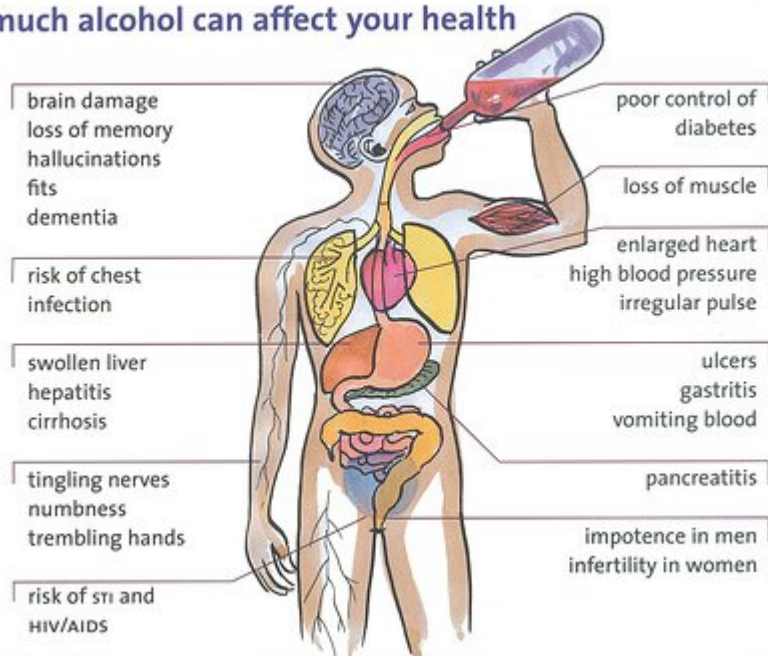
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<p>$\text{C}_2\text{H}_5\text{OH}$ Reacts with Sodium to form Sodium Ethoxide and Hydrogen</p>	<p>When $\text{C}_2\text{H}_5\text{OH}$ is Heated with Concentrated Sulphuric Acid at 443 k, It is Dehydrated to Ethene</p>
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Too much alcohol can affect your health



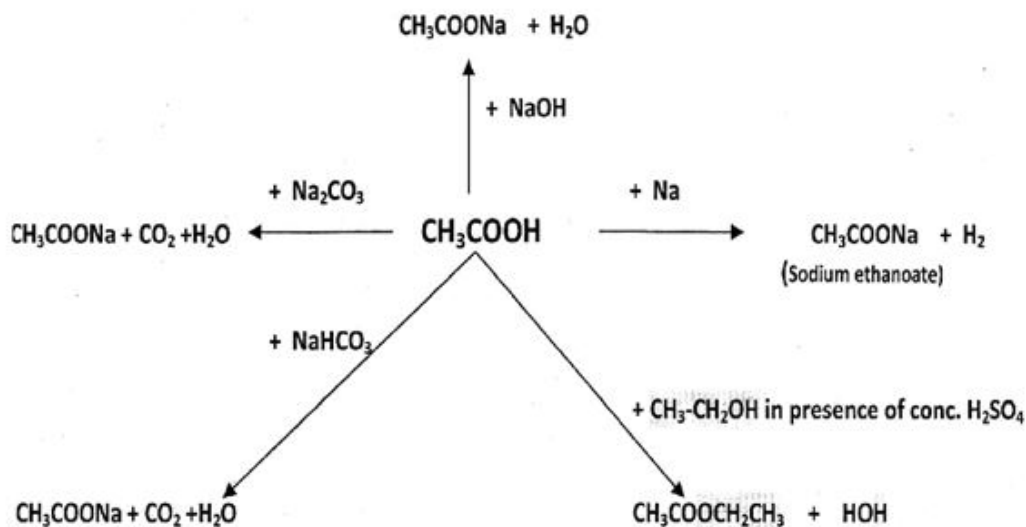
Ethanoic Acid (CH_3COOH) / Acetic Acid :

Freezes at 290 k	Boiling Point 391 k
Ethanol	
Miscible in Water	Sour Taste

*5-8% solution of acetic acid in water is called vinegar.

*Pure acetic acid is called glacial acetic acid

ETHANOIC ACID	REACTS WITH		PRODUCTS
	1	SODIUM Na	SODIUM ETHANOATE AND HYDROGEN
	2	SODIUM CARBONATE Na ₂ CO ₃	SODIUM ETHANOATE, CARBON DIOXIDE AND WATER
	3	SODIUM BICARBONATE NaHCO ₃	SODIUM ETHANOATE, CARBON DIOXIDE AND WATER
	4	ETHANOL(IN PRESENCE OF CONC. SULPHURIC ACID) CH ₃ -CH ₂ OH	ESTER AND WATER

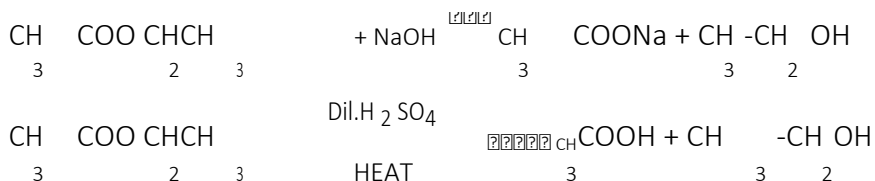


Esterification :

Carboxylic acids react with alcohols in presence of few drops of concentrated sulphuric acid as catalyst and form sweet smelling compounds called ester.

Hydrolysis :

On heating with an acid or a base the ester forms back the original alcohol and carboxylic acid.

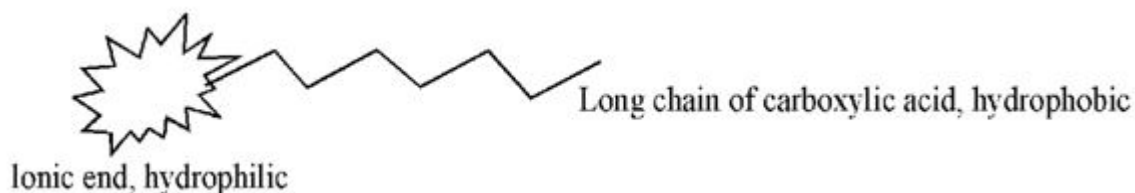


*Alkaline hydrolysis of ester is also called saponification.

Soaps and Detergents

- Soap is sodium and potassium salt of carboxylic acids with long chain.
- Soaps are effective with soft water only and ineffective with hard water.
- Detergents are ammonium or sulphonate salts of carboxylic acids with long chain. They are effective with both soft as well as hard water.

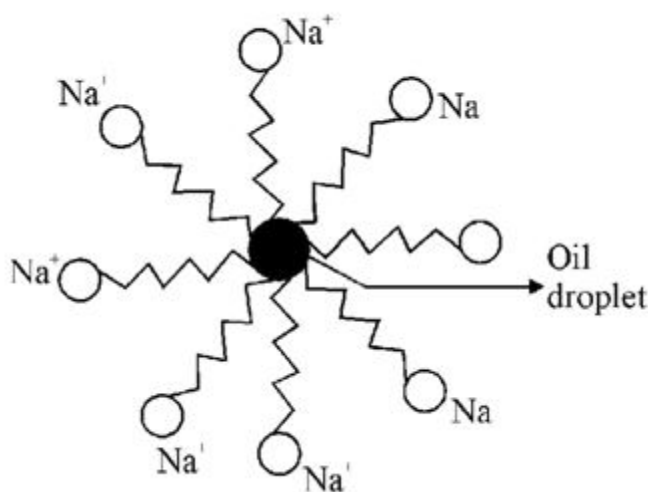
An ionic part (hydrophilic) and a long hydrocarbon chain (hydrophobic) part constitutes the soap molecule.



Structure of a Soap Molecule

Cleansing Action of Soaps :

- Most dirt is oily in nature and the hydrophobic end attaches itself with dirt, while the ionic end is surrounded with molecules of water. This results in formation of a radial structure called micelles.



- An emulsion is thus formed by soap molecule. The cloth needs to be mechanically agitated to remove the dirt particles from the cloth.
- Scum : The magnesium and calcium salts present in hard water reacts with soap molecule to form insoluble products called scum, thus obstructing the cleansing action. Use of detergents overcome this problem as the detergent molecule prevents the formation of insoluble product and thus clothes get cleaned.

IMPORTANT QUESTIONS

Q: Why does Ethanoic acid called glacial acetic acid? (Imp.)

Ans. On cooling, pure Ethanoic acid is frozen to form ice-like flakes. They look like glaciers, so it is called glacial acetic acid.

Q: Why is the conversion of ethanol to ethanoic acid an oxidation reaction? (Imp.)

Ans. When ethanol is oxidized, hydrogen is removed from its molecule and oxygen is added so as to form ethanoic acid. Thus, conversion of ethanol into acetic acid is an oxidation reaction.

Q: A mixture of ethyne and oxygen is burnt for welding. Can you tell why a mixture of ethyne and air is not used? (Imp.)

Ans. Ethyne has only two hydrogen atoms and two carbon atoms in its molecule. It burns in air with a sooty flame, because the oxygen from air is insufficient to burn the carbon completely. Thus, pure oxygen is used which completely burns carbon and hydrogen and produces a very hot flame.

Q: Why is the conversion of ethanol to Ethanoic acid considered an oxidation reaction?

Ans. Conversion of ethanol to Ethanoic acid is considered an oxidation reaction since it involves:

- (i) addition of oxygen to the ethanol molecule
- (ii) removal of hydrogen from the ethanol molecule

Q. An organic compound burns with a sooty flame. Is it saturated or unsaturated compound? Justify

Answer: it is unsaturated compound. Unsaturated compound have low percentage of hydrogen so incomplete combustion takes place and produce sooty flame.

Q. (a) Differentiate between saturated and unsaturated hydrocarbons. Write any two points of difference.

(b) Why are carbon compounds (i) poor conductors of electricity (ii) have low melting and

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boiling points?

(c) Name the simplest hydrocarbon and write its formula

Ans: (a) Compounds of carbon, which are linked by only single bonds between the carbon atoms are called saturated compounds. Compounds of carbon having double or triple bonds between their carbon atoms are called unsaturated compounds.

Saturated hydrocarbons will generally give a clean flame without soot while unsaturated carbon compounds will give a yellow flame with lots of black smoke and soot on combustion.

(b)(i) carbon compounds are poor conductors of electricity because they do not have any free electrons or an overall electric charge

(ii) Carbon compounds have low melting and boiling points this is because the weak intermolecular forces break down easily.

(iii) The simplest hydrocarbon is methane CH_4

Q. (a) Explain with the help of chemical equation the following properties of carbon compounds-

(i) Combustion (ii) Oxidation

(b) How do saturated and unsaturated hydrocarbons can be differentiated on the basis of their combustion?

(c) What are oxidizing agents ?

Ans: (i) carbon compounds burns in oxygen to give carbon dioxide along with the release of heat and light.

For example : $\text{C} + \text{O}_2 \rightarrow \text{CO}_2 + \text{heat and light}$; $\text{CH}_4 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{heat and light}$

$\text{CH}_3\text{CH}_2\text{OH} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{heat and light}$

(ii) Carbon compounds easily oxidised on combustion or in the presence of oxidising agents like Alkaline potassium permanganate or acidified potassium dichromate. For example : alcohols are converted to carboxylic acids.

$\text{CH}_3 - \text{CH}_2\text{OH}$

Alkaline KMnO_4

????

$\rightarrow \text{CH}_3\text{COOH}$

(b) Saturated hydrocarbons will generally give a clean flame without soot while unsaturated carbon compounds will give a yellow flame with lots of black smoke and soot on combustion.

(c) Any substance that add oxygen to others substance is called oxidising agents.

CARBON AND ITS COMPOUNDS IN BRIEF

- Carbon is a versatile non-metal.
- Carbon atom like atoms of other non-metals like oxygen, nitrogen, hydrogen and chlorine shares electrons.
- Carbon forms large number of compounds due to catenation and tetravalency.
- Carbon can form single, double and triple covalent bonds.
- The compounds of hydrogen and carbon are called hydrocarbons, which can be saturated or unsaturated.
- Structurally hydrocarbons can have straight chain, branches or cyclic structure.
- Difference in Structural arrangement of same molecule gives rise to isomerism.
- In a hydrocarbon, a heteroatom can replace the hydrogen atom and imparts its chemical properties.
- Homologous series is a series of compounds with same general formula and same chemical properties but different physical properties.
- Carbon based compounds are excellent fuels.
- Ethanol is an important industrial compound. It reacts with reactive metals and is also dehydrated to ethene.
- Ethanoic acid is another important compound. It combines with ethanol to form sweet smelling esters.
- Soaps and detergents are used as cleansing agents. Detergents efficiently cleanse with soft and hard water.

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