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Carbon and its Compounds

Two or more elements combine to form compound. There are two types of compounds- **Organic Compound** and **Inorganic Compounds**. Organic compounds are the one which are made up of carbon and hydrogen.

Covalent Bond

The bond formed by sharing a pair of electrons between two atoms are known as **Covalent Bond**. Carbon forms covalent bond. Carbon exists in two forms- as free state and as combined state. Free form of carbon is found in graphite, diamond and fullerene. In combined state, carbon exists as Carbon-dioxide, Glucose, Sugar etc.

Allotropes of Carbon

Different forms of an element that has same chemical properties but different physical properties are known as **Allotropes**. There are three allotropes of carbon- diamond, graphite and fullerene.

Diamond

Diamond exits as three-dimensional network with strong carbon-carbon covalent bonds. Diamond is hard in nature with high melting point. It shines in presence of light and it is a bad conductor of electricity. The most common use of diamond is in making jewellery. It is also used in cutting and drilling tools.

Graphite

Graphite is made from weak van der wall forces. Each carbon atom is bonded with other three carbon atoms in order to form hexagonal rings. It serves as good conductor of heat and electricity. It is used as dry lubricant for machine parts as well as it is used in lead pencils.

Fullerene

It is a hollow cage which exits in the form of sphere. Its structure is similar to fullerene. But along with hexagonal rings, sometimes pentagonal or heptagonal rings are also present.

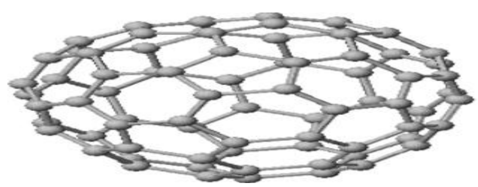


Fig.1 Structure of fullerene

Two Important Properties of Carbon

Catenation and tetravalency are the two important properties of carbon. Catenation is a property of carbon by which carbon atoms can link one another via covalent bond and can form long chains, closed ring or branched chains etc. Carbon atoms can be linked by single, double or triple bonds. Carbon has a valency of 4 due to which it is known to have tetravalency. Due to this one carbon atom can bond with other 4 carbon atoms, with other atoms also such as Oxygen, Nitrogen etc.

Hydrocarbons

Compounds which are made up of carbon and hydrogen they are known as **Hydrocarbons**. There are two types of hydrocarbons found - **Saturated Hydrocarbons** and **Unsaturated Hydrocarbons**. Saturated Hydrocarbons consist of single bonds between the carbon atoms. **For Example**, Alkanes. Alkanes are saturated hydrocarbons represented by a formula, C_nH_{2n+2}.

Unsaturated Hydrocarbons are the one with double or triple bonds between the carbon atoms. **For Example**, Alkenes and Alkynes. Alkenes are represented as C_nH_{2n} whereas alkynes are represented as C_nH_{2n-2}. Some saturated hydrocarbons and unsaturated hydrocarbons are represented as -

- CH_4 methane
- C_2H_6 ethane
- C_3H_8 propane
- C_4H_{10} butane
- C_5H_{12} pentane
- C_6H_{14} hexane
- C_7H_{16} heptane
- C_8H_{18} octane
- C_9H_{20} nonane
- $C_{10}H_{22}$ decane

Fig.2. Saturated hydrocarbons

ethene	C_2H_4
propene	C_3H_6
1-butene	C_4H_8
1-pentene	C_5H_{10}
1-hexene	C_6H_{12}
1-heptene	C_7H_{14}
1-octene	C_8H_{16}

Fig. 3. Unsaturated hydrocarbons

Structure of hydrocarbons can be represented in the form of electron dot structure as well as open structures as shown below-

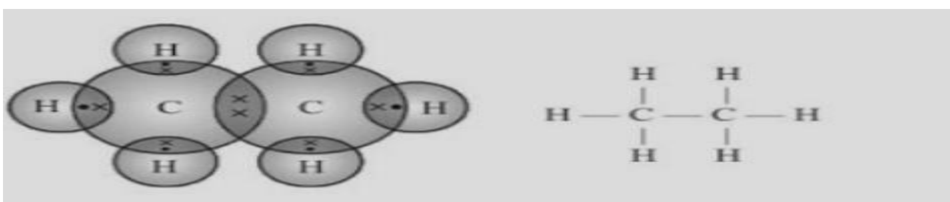


Fig.4. Electron dot structure and open structure of ethane

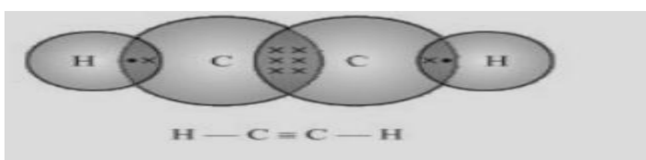


Fig.5. Electron dot structure and open structure of ethyne

Carbons Compounds based on the basis of structure

Carbon Compounds can be classified as straight chain compounds, branched chain compounds and cyclic compounds.They are represented as -

—C—C—C—C—C—

Fig.6. Straight chain carbon compound

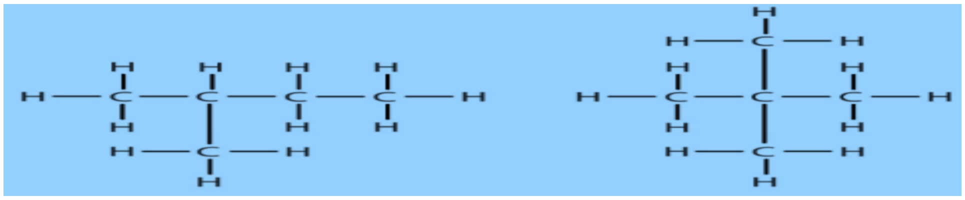


Fig.7. Branched chain compounds

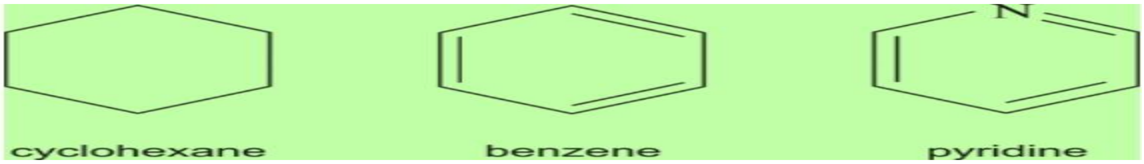


Fig.8. Cyclic carbon compounds

Functional Groups

One of the hydrogen atoms in hydrocarbon can be replaced by other atoms according to their valencies. The atoms which decides the properties of the carbon atoms, are known as **Functional Groups**. **For Example**, Cl, Br, **-**OH, Aldehyde, Ketone, Carboxylic Acid etc.

Homologous Series

Series of compounds in which same functional group substitutes for the hydrogen atom in a chain of carbon.

Homologous Series	General Formula	Functional Group	Example
Alkanes	C_nH_{2n+2}		Methane, CH_4 Ethane, C_2H_6 Propane, C_3H_8 Butane, C_4H_{10}
Alkenes	C_nH_{2n}	C=C	Ethene, C_2H_4 Propene, C_3H_6 Butene, C_4H_8
Alcohols	$C_nH_{(2n+1)}OH$	-OH	Methanol, CH_3OH Ethanol, C_2H_5OH Propanol, C_3H_7OH Butanol, C_4H_9OH
Carboxylic Acids	$C_nH_{(2n+1)}COOH$	-COOH	Methanoic Acid, HCOOH Ethanoic Acid, CH_3COOH Propanoic Acid, C_2H_5COOH Butanoic Acid, C_3H_7COOH

Fig.9. Homologous series

Nomenclature of Carbon Compounds

- First of all, identify the number of carbon atoms in compounds. And in it identify the longest chain
- Then functional group can be indicated by suffix or prefix.
- Cyclic hydrocarbon is designated by prefix cyclo.
- If there are two or more different substituents they are listed in alphabetical order
- If the same substituent occurs more than once, the location of each point on which the substituent occurs is given

Functional Group Name	Suffix Ending	Functional Group Structure
Alkane	-ane	C-H atoms
Alcohol	-ol	--OH
Alkene	-ene	C=C
Alkyne	-yne	HC≡CH
Aldehyde	-al	—C(=O)—H
Amine	-amine	--N--
Ether	-ether	--O--
Ester	-oate	—C(=O)—O—
Ketone	-one	—C(=O)—
Nitrile	-ile	—C≡N

Fig.10. Different functional groups

Chemical Properties of Carbon Compounds

Combustion

Carbon along with its compound is used as a fuel as it burns in presence of oxygen to release energy. Saturated hydrocarbons produce blue and non-sooty flame whereas unsaturated hydrocarbons produce yellow sooty flame.

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

Oxidation

Alcohol can be oxidized to aldehydes whereas aldehydes in turn can be oxidized to carboxylic acid. Oxidizing agent such as potassium permanganate can be used for oxidation.

Addition Reaction

Hydrogenation of vegetable oil is an example of addition reaction. Addition of hydrogen in presence of catalyst such as nickel or palladium. This converts oil into ghee.

Substitution Reaction

When one atom in hydrocarbon is replaced by chlorine, bromine, etc. this is known as **Substitution Reaction**.

$$CH_4 + Cl_2 \xrightarrow{h\upsilon} \underset{\text{Chloromethane}}{CH_3Cl} + HCl$$

Important Carbon Compounds: Ethanol and Ethanoic Acid

Ethanol is a volatile liquid with low melting point. It reacts with sodium to form sodium ethoxide.

$$2Na + CH_3CH_2OH \rightarrow \underset{\text{(Sodium ethoxide)}}{2CH_3CH_2\bar{O}Na^+} + H_2$$

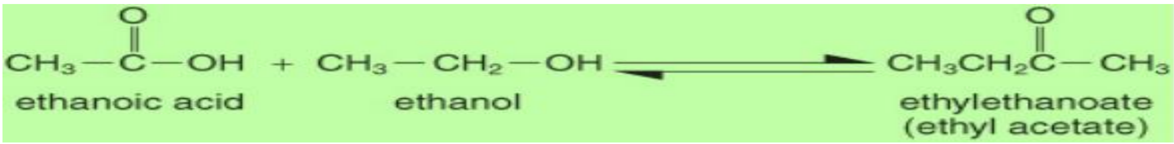
This above reaction is used to test the presence of ethanol by the evolution of hydrogen gas.

Dehydration of ethanol in presence of hot sulphuric acid forms alkene.

$$CH_3CH_2OH \xrightarrow[H_2SO_4]{\text{Hot conc.}} CH_2 = CH_2 + H_2O$$

Ethanoic acid is a colourless liquid. When pure ethanoic acid freeze like ice, it is known as **Glacial Acetic Acid**. It is formed at a temperature of about 16.6 degree centigrade

Ethanoic Acid/Acetic acid when reacts with ethanol it forms an ester. Ester can be identified by its sweet smell.



Reaction of ester with strong base is used to form soap. This is known as **Saponification**. Acetic acid also reacts with strong base to form sodium acetate and water.

$$NaOH + CH_3COOH + CH_3COONa + H_2O$$

Soaps and Detergents

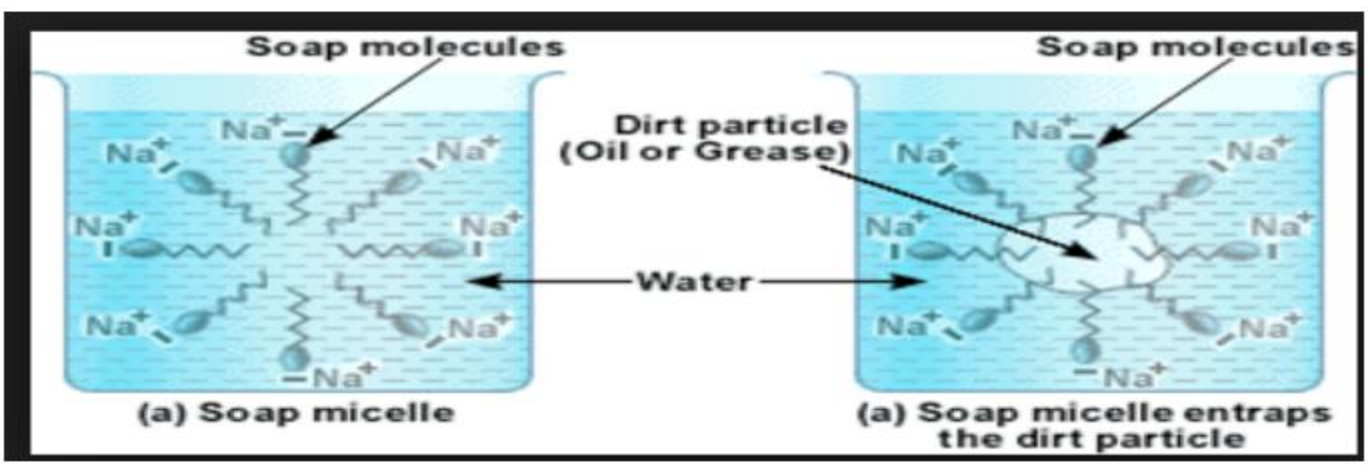
Sodium or potassium salt of carboxylic acid is known as **Soap**. They work most effectively in soap water. Detergents are sulphonate or ammonium salt of long chain of carboxylic acid. They can work effectively on soft as well as hard water.

Cleansing Action of Soaps and Detergents

Cleansing action of soaps and detergents is due to ability to minimize the surface tension of water, to emulsify oil or grease and to hold them in a suspension of water. When soap dissolves in water, it forms soap anions and soap cations. The hydrophobic part of soaps and detergents are soluble in grease and hydrophilic part is soluble in water.

Soap and Micelle Formation

When dirt and grease are mixed with soap water, soap molecules arrange them in tiny clusters known as **Micelle**. The hydrophilic part sticks to the water and form outer surface of the micelle and hydrophobic part binds to oil and grease.



Thank You

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