Class 10
Physical Science

Lesson Summary : Carbon Compounds

INTRODUCTION

- ❖ Study of carbon compounds - Organic compounds
- ❖ C is a non-metal. It belongs to the 14th group, 2nd period. Configuration - $1s^2\ 2s^2\ 2p^2$
- ❖ Name "*carbon*" is derived from latin word "*carbo*" which means coal.
- ❖ Valency of C is 4 (tetravalent). It combines with other elements by sharing 4 electrons. Carbon forms covalent bonds.

- ❖ Due to its low electronegativity value-2.5 , Carbon cannot gain 4 electrons (to satisfy its valency). Thus carbon does not from C^{4-}
- ❖ C does not lose 4 electrons (to satisfy its valency). Losing four electrons requires lots of energy and is not a likely process.
- ❖ All living things are made up of carbon based compounds, a large number of things that we use in our daily life are made of carbon compounds.
- ❖ Composition of most organic compounds is confined to a few elements like carbon, hydrogen, oxygen, nitrogen, halogen and sulphur.

UNIQUE PROPERTIES OF CARBON

- ❖ Catenation
    - ➢ Self-Linking property- Carbon can have form covalent bonds with other carbon atoms, forming long-chain compounds.
    - ➢ Catenation property of carbon is due the C-C bond strength
    - ➢ Strong bonds are formed due to the small size of carbon. Nuclei of the bonding carbon atoms, can hold the shared pair of electrons effectively.
- ❖ Formation of Multiple Bonds
    - ➢ Carbon can form double and triple bonds with carbon, oxygen, nitrogen, sulphur.

ALLOTROPE

- ❖ The various physical forms in which an element can exist are called allotropes of the element.
- ❖ Carbon has 3 allotropes - Diamond, Graphite and Fullerene
- ❖ Diamond
  - ➢ Colourless, Transparent, Shiny
  - ➢ sp^3 hybridisation
  - ➢ Each carbon atom in diamond is bonded to 4 other carbon atoms.
  - ➢ Rigid, tetrahedral, covalent network structure.
  - ➢ Has high density, high melting point
  - ➢ Hardest natural substance (structural arrangement)
  - ➢ Does not conduct electricity (absence of free electrons)
  - ➢ Used for making jewellery, rock borers for oil drilling, as glass cutters etc.
  - ➢ Sharp-edge diamonds are use for cataract removal
- ❖ Fullerene
  - ➢ Spherical cluster formed by 60 carbon atoms, arranged like a football.
  - ➢ sp^2 hybridisation
  - ➢ Has 20 hexagons and 12 pentagons.
  - ➢ Structure of fullerene resembles the framework of dome shaped halls designed by architect Buckminister. Hence, fullerenes are also referred to as Buckminister Fullerene.
- ❖ Graphite
  - ➢ Greyish-black, opaque, soft and slippery substance
  - ➢ sp^2 hybridisation. Delocalised pi electron system
  - ➢ Each carbon atom in graphite is bonded to 3 other carbon atoms forming flat sheets of hexagonal rings
  - ➢ Various sheets/layers of carbon atoms are held together by van der Waals forces. Unlike covalent bond, van der Waals force is a weak force and hence makes graphite a soft and slippery substance.
  - ➢ In graphite, each carbon uses only 3 of its valence electrons to form bonds with other carbon atoms. Hence, each carbon possess one free electron. Presence of free electron makes graphite a good conductor.
  - ➢ Graphite is used as dry lubricant for machine parts.
  - ➢ Graphite is used as electrodes in dry cells.

➢ Graphite is mixed with clay to make pencil leads. When we write with pencil, the force applied by us breaks the inter-layer attraction of graphite in the pencil lead and leaves graphite particles on paper. Graphite particles do not adhere strongly with the paper and hence can be easily remove by erasing.

➢ Fullerenes are being studied for its potential use in targeted drug delivery

HYDROCARBONS

- ❖ A class of organic compounds that contain only carbon and hydrogen.
- ❖ Classification - Aliphatic or Open chain - Saturated and Unsaturated
                            Cyclic or Closed chain
- ❖ Examples

FUNCTIONAL GROUPS

Group	Formula	Suffix	Prefix	Example
Alkene		-ene		
Alkyne		-yne		
Halohydrocarbons			Halo-	
Alcohol		-ol	hydroxy	
Aldehyde		-al		
Ketones		-one		
Acid		-oic acid		
Esters		-oate		
Ether		-oxy-		
Amine		amine	amino	
Acid Halide		Carbonyl halide		
Nitriles		nitrile	cyano	
Alkane (only when it is as a substituent)			Alkyl	

IUPAC Nomenclature

❖ Select the longest carbon chain-
  ➢ This is the parent hydrocarbon chain. Based on the number of carbon atoms in the parent hydrocarbon chain, a root word is assigned.
  ➢ Hydrocarbons which do not fall within the parent chain are considered as substituents
❖ Numbering
  ➢ Assign numbers to the carbons in the parent hydrocarbon chain such that the carbon with functional group/substituent gets lowest possible number.
❖ If two or more groups are present, then numbering is decided based on priority

❖ If two or three of the substituent/functional group is present, then prefix like di- or tri- is mentioned prior to the substituent name/functional group suffix, respectively.
❖ Substituents are written in alphabetical order
❖ IUPAC name is obtained by writing

   "position and name of substituent/functional group"-"Parent hydrocarbon root word"-"position and functional group suffix"

Types of Reaction

❖ Combustion Reaction
  ➢ Burning of carbon compounds burn in air to give H_2O and CO_2, heat and light.
  ➢ Carbon and its compounds are used as **fuels** as they burn in air releasing lot of energy. Eg: LPG contains mainly of butane.
  ➢ Saturated hydrocarbon
    ■ Clear blue flame
    ■ If combustion is incomplete, then sooty flame, smoke
    ■ Gas stove at home has tiny holes for air so that sufficient oxygen is available for combustion. Usually, we observe blue flame.
    ■ When air holes of the gas stove gets blocked, the fuel does not undergo complete combustion, resulting in sooty flame which deposits as black layer at the bottom of the vessel.
  ➢ Unsaturated hydrocarbon
    ■ Yellow, sooty flame
  ➢ When coal or charcoal burns in air, it produces pollutants
  ➢ Incomplete combustion results in soot which blocks chimneys, soot is also a pollutant. Incomplete combustion also produces CO which is a harmful gas.

❖ Substitution Reaction
  ➢ Reaction in which one or more hydrogen atoms of a hydrocarbon is replaced by some other atoms.

- ➢ Alkanes / saturated hydrocarbons are also known as paraffins (parum = little, affins =affinity) as they are less reactive.
- ➢ Alkanes undergo substitution with chlorine in the presence of sunlight

- ❖ Addition Reaction
  - ➢ Unsaturated hydrocarbons + X ---> Saturated hydrocarbon
  - ➢ X = H2, Cl2, Br2 etc
  - ➢ Hydrogenation
    - ■ Addition of hydrogen.
    - ■ Takes place in the presence of catalyst like Ni, Pd, Pt and at high temperature.

    - ■ Used to prepare vegetable ghee(solid) from vegetable oil (liquid).
      - ● Vegetable oil = Unsaturated long chain Fatty acids
      - ● Vegetable ghee = Saturated long chain Fatty acids
      - ● In general, Unsaturated Fatty acids are considered good for health and recommended for cooking, whereas saturated fatty acids(ghee, dalda, butter etc) are said to be harmful to health when consumed in large quantities.

- ❖ Oxidation Reaction
  - ➢ Alcohol ---> Aldehyde---> Acid

  - ➢ This reaction happens in the presence of oxidising agent like **Alkaline.KMnO$_4$** or **Acidified.K$_2$Cr$_2$O$_7$**
  - ➢ Oxidizing agent oxidizes other substances by undergoing reduction
  - ➢ Breath Analyser
    - ■ Police catch hold of drunk driving suspects by using breath analyser.
    - ■ Breath analyser has crystals of **K$_2$Cr$_2$O$_7$.**
    - ■ **K$_2$Cr$_2$O$_7$ is orange in colour.**
    - ■ If alcohol is present, **K$_2$Cr$_2$O$_7$** oxidizes **alcohol to acid**. In this process, Cr gets reduced from **Cr^{+6} to Cr^{+3}**. Thus **orange crystals turn green in colour.**
    - ■ Electronic devices with fuel cells are also used for detecting presence of alcohol.
    - ■ IR spectra is also used to confirm the presence of C-OH bond.

Ethanol

❖ Second member in the alcohol homologous series
❖ C2H5OH
❖ Electron dot structure

❖ Preparation
  ➢ Addition of H_2O to Ethene in the presence of P_2O_5 or W and heat

  ➢ Fermentation process

❖ Physical Properties
  ➢ Colourless liquid, sweet odour
  ➢ Boiling point - 78.3^0C
❖ Chemical Properties
  ➢ Reaction with Na - Forms **Sodium Ethoxide and H_2. (test for alcohol)**

  ➢ Reaction with Conc.H_2SO_4 - Forms **Ethene.**
    ■ Conc.H_2SO_4 is a dehydrating agent, ethanol loses 1 molecule of H_2O

❖ Uses
  ➢ Good solvent. Used in medicine- Cough syrup, tincture of iodine
  ➢ 10% of ethanol in gasoline = Gasohol, fuel
❖ Harm
  ➢ Denatured alcohol = Ethanol + Methanol + isobutyl ketone
  ➢ Denatured alcohol is toxic and fatal

Ethanoic Acid

❖ Second member in the alcohol homologous series
❖ C2H5OH
❖ Electron dot structure

❖ Physical Properties
  ➢ Colourless liquid, Unpleasant oour
  ➢ Boiling point = 118^0C
  ➢ Weak acid, pH = 4, orange-yellow colour on pH paper.

❖ Chemical Properties
  ➢ Reaction with Metal - Metal Salt + H_2

  ➢ Reaction with Metal Carbonate/ Metal Bicarbonate **(test for acid)**
    ■ Releases CO_2, which turns lime water milky

  ➢ Reaction with Base

Esterification Reaction
❖ Reaction between carboxylic acid and alcohol in presence of conc.H_2SO_4 ---> esters
❖ 1 ml of ethanol is added to 1 ml of ethanoic acid, few drops of Conc.H_2SO_4 is added and warmed in water bath for few minutes and then poured into a test tube containing water.
❖ The resulting mixture has sweet smell. This is due to the formation of ester

Saponification Reaction
❖ Formation of soap
❖ Fats are esters of high fatty acids and trihydroxy alcohols
❖ When fats are treated with NaOH, sodium salt of corresponding acids and alcohols are formed. Soap = sodium salt of high fatty acids
❖ High fatty acids- Eg:
❖ Soap in water
  ➢ In low concentration, soap forms true solution in water
  ➢ At Critical Micelle Concentration, soap forms colloidal dispersion
  ➢ Micelle - colloidal spherical aggregate of soap molecules in water
❖ Cleansing Action of Soap
  ➢ Dirty is grease or oily substance
  ➢ Soap molecules has a polar head (COO$^-$Na$^+$) and a non-polar tail (hydrocarbon)
  ➢ Polar end is hydrophilic in nature and is directed towards water
  ➢ Non-polar end is hydrophobic in nature and is directed towards grease
  ➢ Hydrophobic ends gets attached to dirt and form aggregated micelle.
  ➢ On agitation, dirt comes out of the cloth along with micelle
  ➢ Micelles do not precipitate as the spherical aggregates carry the same charge and repel each other.