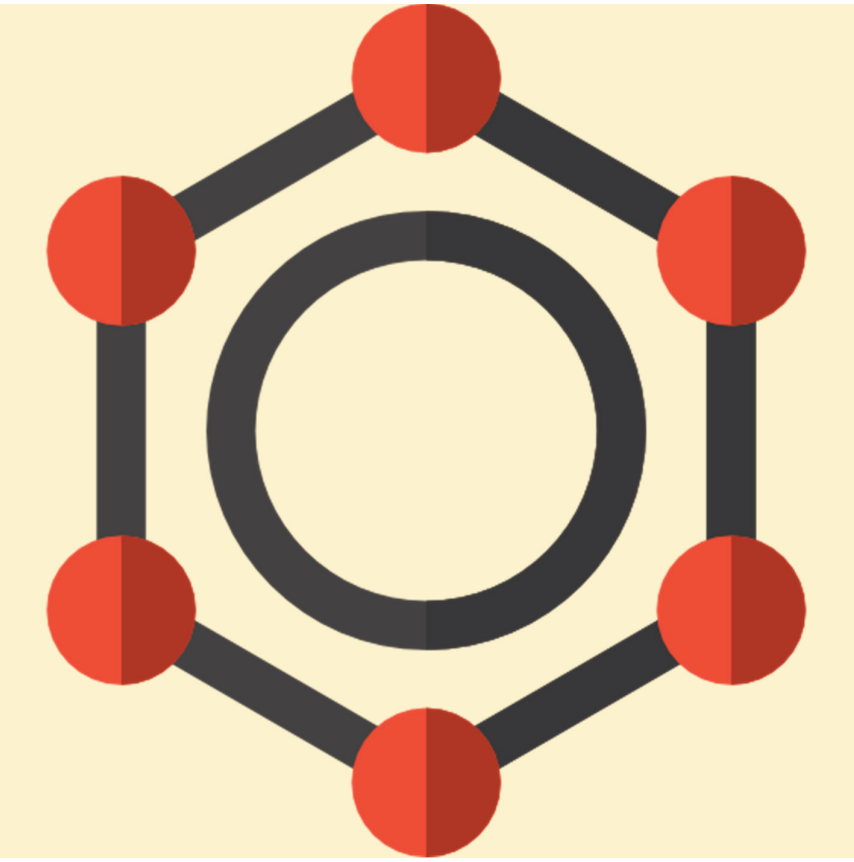
HYDROCARBONS



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HYDROCARBONS

Introduction

The term 'hydrocarbon' is self-explanatory meaning compounds of carbon and hydrogen only. Hydrocarbons hold economic potential in our daily life. Natural gas and petroleum are chief sources of aliphatic hydrocarbons at the present time, and coal is one of the major sources of aromatic hydrocarbons. Petroleum is a dark, viscous mixture of many organic compounds, most of them being hydrocarbons, mainly alkanes, cycloalkanes and aromatic hydrocarbons.

Classification

As we are quite aware that there are different types of hydrocarbons. Depending upon the types of carbon-carbon bonds present, they can be classified into three main categories:

1. Saturated hydrocarbons.
2. Unsaturated hydrocarbons.
3. Aromatic hydrocarbons.

Saturated hydrocarbons contain carbon-carbon and carbon-hydrogen single bonds. If different carbon atoms are joined together to form open chain of carbon atoms with single bonds, they are termed as alkanes. On the other hand, if carbon atoms form a closed chain or ring, they are termed as cycloalkanes. Unsaturated hydrocarbons contain carbon-carbon multiple bonds – double bonds, triple bonds or both. Aromatic hydrocarbons are a special type of cyclic compounds.

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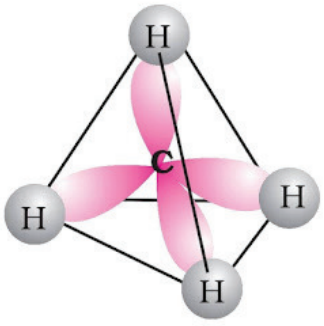
ALKANES

These are the saturated chains of hydrocarbons containing carbon-carbon single bonds. Methane (CH_4) is the first member of this family containing single carbon atom. Since it is found in coal mines and marshy areas, is also known as 'marsh gas'. These hydrocarbons exhibited low reactivity or no reactivity under normal conditions with acids, bases and other reagents, they were earlier known as paraffins. The general formula for alkane is C_nH_{2n+2}, where n stands for number of hydrogen atoms in the molecule.



Structure of Methane

1. Nomenclature

For nomenclature of alkanes in IUPAC system, the longest chain of carbon atoms containing the single bond is selected. Numbering of the chain is done from the one end so that maximum carbon will be included in chain. The suffix 'ane' is used for alkanes. The first member of the alkane series is CH_4 known as methylene (common name) or methene (IUPAC name). IUPAC names of a few members of alkenes are given below:

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

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2. Preparation of Alkanes

Though petroleum and natural gas are the main sources of alkanes, it can be prepared by several other methods as well.

i. **From unsaturated hydrocarbons:** The addition of dihydrogen to unsaturated hydrocarbons like alkenes and alkynes in the presence of a suitable catalyst under a given set of conditions produces saturated hydrocarbons or alkanes. This process of addition of dihydrogen is known as hydrogenation process.

$CH_2{=}CH_2 + H_2 \longrightarrow CH_3\text{-}CH_3$

$CH{\equiv}CH + 2H_2 \longrightarrow CH_3\text{-}CH_3$

ii. From alkyl halides

a) **Reduction:** Alkyl halides undergo reduction with zinc and dilute hydrochloric acid to give alkanes. In general, the reaction can be represented as

$CH_3\text{-}Cl \longrightarrow CH_4$

b) **Wurtz reaction:** Alkyl halides on treatment with sodium metal in dry ether give higher alkanes. This reaction is known as Wurtz reaction.

$CH_3Br + 2Na + BrCH_3 \longrightarrow CH_3\text{-}CH_3 + 2NaBr$

iii. From carboxylic acids

a) **By decarboxylation of carboxylic acids:** Sodium salts of carboxylic acids on heating with soda lime give alkanes containing one carbon atom less than the carboxylic acid. A molecule of carbon dioxide is eliminated which dissolves in NaOH to form sodium carbonate.

$CH_3COONa + NaOH \longrightarrow CH_4 + Na_2CO_3$

b) **Kolbe's electrolytic method:** An aqueous solution of sodium or potassium salt of a carboxylic acid on electrolysis gives alkane containing even number of carbon atoms at anode.

$CH_3COONa + 2H_2O \longrightarrow CH_3\text{-}CH_3 + 2CO_2 + H_2 + NaOH$

3. Properties of Alkanes

I. **Physical Properties**

i. **State:** Due to the weak van der Waals forces, the first four members C1 to C4 i.e., methane, ethane, propane and butane are gases. From C5 to C17 are liquids and those containing 18 carbon atoms or more are solids at 298 K. They all are colourless and odourless.

ii. **Solubility:** Alkanes are generally insoluble in water or in polar solvents, but they are soluble in non-polar solvents like, ether, benzene, carbontetrachloride etc. The solubility of alkanes follow the property "Like Dissolves like".

iii. **Boiling point:** The boiling points of straight chain alkanes increase regularly with the increase of number of carbon atoms. This is due to the fact that the intermolecular van der Waals forces increase with increase in the molecular size or the surface area of the molecule.

II. **Chemical Properties**

Generally, alkanes show inertness or low reactivity towards acids, bases, oxidizing and reducing agents at ordinary conditions because of their non-polar nature and absence of π bond. The C–C and C–H bonds are strong sigma bonds which do not break under ordinary conditions but they undergo certain reactions under given suitable conditions.

i. **Halogenation reaction:** When hydrogen atom of an alkane is replaced by a halogen, it is known as halogenation reaction. Halogenation takes place either at high temperature (300–500°C) or in the presence of diffused sunlight or ultraviolet light.

$CH_4 + Cl_2 \longrightarrow CH_3Cl + HCl$

ii. **Combustion:** Alkanes on heating in presence of air gets completely oxidized to carbon dioxide and water. It burns with a non-luminous flame. The combustion of alkanes is an exothermic process i.e., it produces a large amount of heat.

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

iii. **Controlled oxidation:** When methane and dioxygen compressed at 100 atm are passed through heated copper tube at 523K yield methanol.

$2CH_4 + O_2 \longrightarrow 2CH_3OH$

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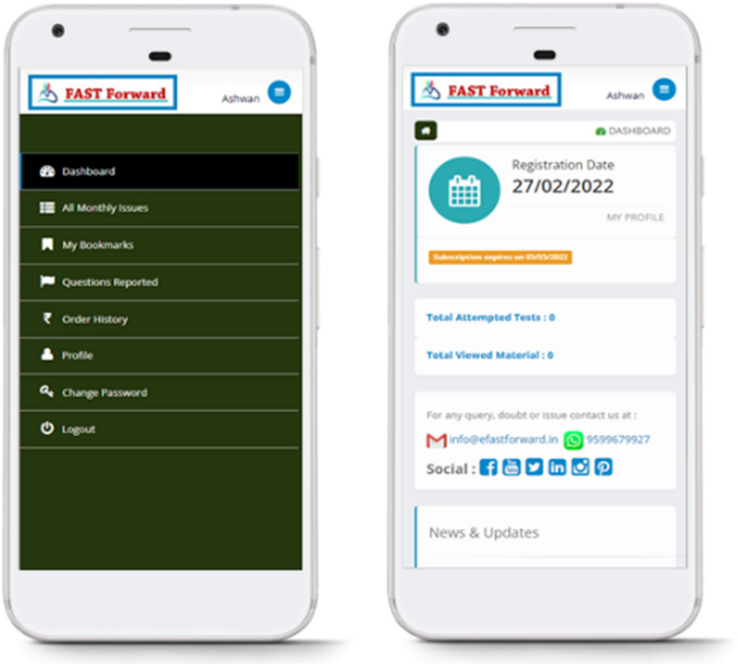

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