CHAPTER TWENTY THREE

ORGANIC CHEMISTRY

Introduction:

Organic chemistry is the chemistry of carbon compounds. Compounds of carbon are more numerous than the compounds of all the other elements put together, and this is due to the fact that carbon can form a variety of strong covalent bonds. Carbon has four electrons in its valence shell, and it is these electrons which are used in forming these covalent bonds. Some organic compounds contain interlinked carbon atoms, and these open-chain compounds are called aliphatic compounds. An example of such a compound is pentene C_2H_5. When all the carbon bonds between the carbon atoms in a hydrocarbon (i.e. a compound containing carbon and hydrogen) are single C – C bonds, then the hydrocarbon is said to be saturated. When there is at least a double bond (C = C) or a triple bond (C ≡ C) between two carbon atoms, then the hydrocarbon is said to be unsaturated. While saturated compounds contain as many hydrogen atoms as possible, unsaturated compounds or hydrocarbons contain a fewer hydrogen atoms. When an organic compound contains rings of carbon atoms based on benzene (C_6H_6), it is classified as an aromatic compound. The presence of a benzene ring in a compound endows the compound with aromatic character. There are very important differences between the properties of aliphatic and aromatic compounds. In short all what is being said is that, carbon atoms have an exceptional tendency to form stable links or bonds with each other and with other elements. This may result in compounds with long and straight chains, branched chains, or even rings of carbon atoms. This means that carbon atoms can arrange themselves in different ways, and each different atomic arrangement gives rise to a molecule with distinctive properties.

Homologous Series:

- This is a group which contains a number of closely related compounds.-

- Such a series or all the compounds in any one homologous series, has the following characteristics:

(1) All the members conform to or can be represented by a general formula, and such an example is the alkane series which have a general formula of C_nH_{2n+2}.

(2) All members show similar chemical reactions, though varying in strength.

(3) General methods of preparation are known, which can be used to prepare any member of the series.

(4) Members of a series, show or exhibit a regular gradation of physical properties.

(5) Members of a series also have similar chemical properties.

The alkyl Groups: These are:

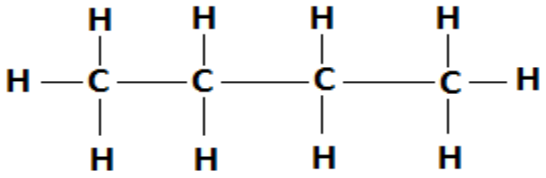
(1) CH_3 …… methyl.

(2) C_2H_5 …… ethyl.

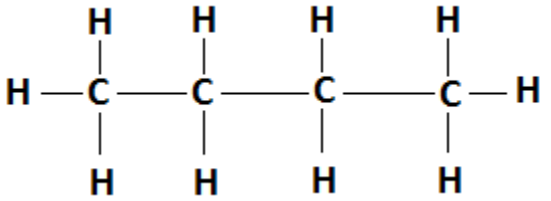
(3) C_3H_7 …… propyl.

Chemical Formulae:

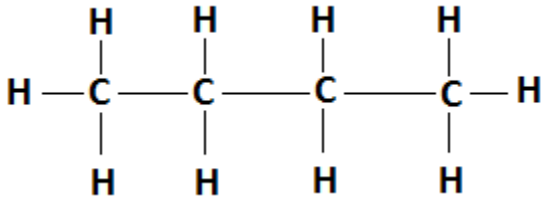
- Organic compounds can be represented by a chemical formula.
- If the formula shows the actual number of atoms of each element present in one molecule of the compound, it is known as the molecule formula.
- If the formula shows the simplest ratio of atoms of the elements present in one molecule of the compound, it is known as the empirical formula.
- Examples are butane …… C_2H_5 and ethyne …… CH.
- The structural formula of an organic compound is a graphical representation of a molecule of the compound, showing which atom is linked to which.
- An example is butane



Isomerism:



Butane C_4H_{10}



Butane C_4H_{10}

- The two given compounds have the same molecular formula, but different structural formula or arrangement of atoms.
- One is said to be an isomer of the other and the two compounds are said to exhibit isomerism.
- Isomerism is therefore the occurrence of two or more compounds, which have the same molecular formula but different structural formula.
- Isomerism occurs among organic compounds.

The hydrocarbons:

- These are compounds which contain only hydrogen and carbon.
- They therefore have the molecular formula C_XH_Y, where X and Y are whole numbers.
- Examples are methane (CH_4), ethane (C_2H_4) and propane (C_3H_8).
- The hydrocarbons can be grouped into families of compounds which are alike in certain ways, with the most familiar families being the alkanes, the alkenes and the alkynes.
- The covalent bonding is the type of bonds within the hydrocarbons.

The alkanes:

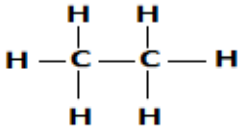
- These are hydrocarbons which contain only single covalent bonds.- They have the general molecular formula C_nH_{2n+2}.

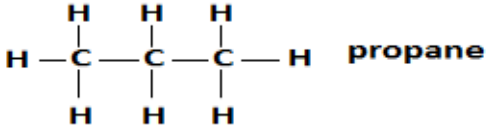
- Because they do not contain carbon – carbon double bonds, but rather carbon – carbon single bonds, the alkanes are said to be saturated hydrocarbons, and they also form a homologous series. --
- The first member of the series (n=1) is methane, CH_4, and the second member (n=2) is ethane, C_2H_6.
- Both are gases at room temperature, with methane being the main constituent of natural gas.
-The first few members of the alkane series are shown next:

Name	**Molecular Formula**	**Melting Point / ^{0}C**	**Boiling Point / ^{0}C**
Methane	CH_3	-183	-162
Ethane	C_2H_4	-172	-89
Propane	C_3H_8	-188	- 42
Butane	C_4H_{10}	-135	-1
Pentane	C_5H_{12}	-130	36
Hexane	C_6H_{14}	-95	69
Heptane	C_7H_{16}	-91	98
Octane	C_8H_{18}	-57	126
Nonane	C_9H_{20}	-54	151
Decane	$C_{10}H_{22}$	-30	174

Structure of the alkanes:

- The simplest alkane has the molecular formula CH_4 (methane).





Physical Properties:

- While the first four members are gases, the fifth to the seventh members are liquids, with the rest being solids.
- For this reason, they show a gradation in their physical nature.
- The alkanes also show a similar gradation in other physical properties such as the boiling and the melting points.
- The boiling and the melting points of the alkanes, increases steadily as we move down the series, or as the number of carbon atoms increases.
- This is due to the fact that the intermolecular forces of attraction, which binds the molecules together increases as we move down the series.
- All alkanes are slightly soluble in water, and because they are less dense than water, the liquid and the solid alkanes will float on water.
- This slight solubility generally decreases up the series.

Chemical Properties:

- Because the alkanes are unreactive compounds, they are unaffected under normal conditions by most acids, alkalis as well as reducing agents. Alkanes will only react under special conditions.
- They burn in plentiful supply of oxygen with a smoky flame to form carbon (IV) oxide (CO_2) and steam, i.e $\mathrm{CH}\mathrm{H}_{4(g)} + 20_{2(g)} \rightarrow \mathrm{C}O_{2(g)} + \mathrm{H}_2O_g$.

- This reaction is exothermic.
- Alkanes do not react at all or react very slowly with chlorine at room or normal temperature, when the environment is dark.
- It must be noted that explosions in most coal mines is due to the presence of a lot of methane gas in these mines, and such explosions occurs when methane reacts with oxygen gas.

Importance / uses of alkanes:

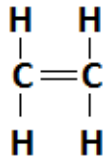
- Both propane and butane are used as campaign gas and in gas cylinders and lighters.
- Natural gas which is largely made up of methane is used for cooking and heating homes.
- They form part of crude oil.

The alkenes:

- Like the alkanes, the alkenes form a homologous series with the general formula of C_nH_{2n}.
- The most important alkene is ethene or ethylene (C_2H_4), which is a gas at room temperature and pressure.
- Because the alkenes contain a carbon-carbon double bond, i.e. C = C, it is said to be unsaturated.
- Due to the presence of the carbon-carbon double bond (between the two carbon atoms), the simplest or the first possible member (n = 2) is therefore C_2H_4.

- Ethene can be represented as

$H_2C = CH_2$ or



The first few members of this series are presented or shown in the next given table:

Name	**Formula**	**Number of carbon atoms**	**Boiling Point / ^{0}C**
Ethene	C_2H_4	2	-102
Propene	C_3H_6	3	- 48
Butene	C_4H_8	4	- 65
Pentene	C_5H_{10}	5	30
Hexene	C_6H_{12}	6	63.5
Heptene	C_7H_{14}	7	93
Octene	C_8H_{16}	8	123

Polyethene (Polythene):

- If ethane with a trace of oxygen present, is pressurized to about 100 atmosphere and heat is applied to start the reaction, the ethane is polymerized to form polyethene.
- Polymerization is the combination of two or more molecules to form a complex molecule without a gain or a loss of material.
- The original material is called the monomer.
- Consider nA -> A_n.
- The product, A_n is called the polymer of the original compound A.
- Polyethene is very resistant to the common types of chemical actions, and can be moulded (whilst still hot) into a variety of domestic and scientific articles such as buckets, bowls, bags and funnels.
- Due to the presence of the double bond, the alkene molecules can be added or joined to each other to form a large molecule called polymer.
- Because polythene is easy to be molded, it is called plastics.
- Polymers which are man-made are referred to as synthetic polymers.
- Examples of synthetic polymers are:

(a) Plastics such as polythene, P.V.C, nylon and polystryrene.

(b) Synthetic rubber.

- There are two types of plastics and these are thermoplastic polymers and thermosetting plastics.
- Thermoplastic polymers are those polymers, that become soft on heating and hardens on heating.
- Because plastics are tough man-made materials which can easily be molded into different shapes, they are used widely as heat insulators, drain pipes and rain coats.
- As already seen, plastics are polymers which are made by joining together the appropriate monomers.
- These monomers are organic compounds and as such contain atoms.
- Because in plastics these carbon atoms are linked together by covalent bonds, plastics can be regarded as long chain covalent compounds.
- And as already stated, these monomers are brought together through polymerization.
- Natural rubber which is a soft polymer can be hardened by a process called vulcanization.
- This is the process in which raw rubber is hardened by heating it with sulphur.
- Vulcanized rubber is used in the manufacture of lorry tyres.