

# SYNOPSIS

## (ORGANIC CHEMISTRY)

### Introduction

Organic chemistry is mainly the chemistry of carbon compounds, but not all carbon compounds are organic in nature. Organic chemistry basically deals with animate substances but lately inanimate substances have also become a part of organic chemistry like plastics, polymers. Organic chemistry deals with the study of the structure, composition, preparation and properties of the carbon containing compounds vast in number, This is due to the ability of carbon to show tetravalency and the ability to form bond with itself (called Catenation).

Most of the organic compounds contains carbon and hydrogen but can include other elements also like nitrogen, sulphur, halogens and phosphours. As we know organic compounds are all around us. Organic chemistry is used in number of industries like biotechnology, health care, environmental sector, biofuels, crop productions and agriculture, biodegradable polymers.

To study and understand organic chemistry, the students should have a very clear idea chemical bonding, acid-base concepts and equilibrium.

Class 11 organic chemistry deals with the basic concepts used in organic chemistry like nomenclature, isomerism, mechanism of organic reactions and types of organic reactions, the various reagents used in organic synthesis.

There are two chapters of organic chemistry in class 11.

1. **Some basic concepts of organic chemistry or general organic chemistry**
2. **Hydrocarbons**

This chapter deals with the

- (i) Sources of hydrocarbons,
- (ii) Synthesis of alkanes, alkenes, alkynes and aromatic hydrocarbons
- (iii) Properties and reactions of these hydrocarbons

## Some basic concepts of organic chemistry or general organic chemistry

Organic compounds are formed due to covalent bonding which can be explained in terms of orbital hybridization. On the basis of hybridization, carbon can be  $sp$ ,  $sp^2$  or  $sp^3$  hybridised.

The tetrahedral shape of methane, trigonal planar shape of ethene and linear shape of ethyne can be explained only on the basis of hybridization.

Organic compounds can be represented by various structural formulae including **complete, condensed or bond-line structural formula**.

Organic compounds are named by following a set of rules laid down by IUPAC, the names are correlated with the structure and one can deduce the structure from the name.

Sometimes, organic compounds are also given common or trivial names. Organic compounds can be classified into various families on the basis of functional group they contain. A functional group is an atom or group of atom bonded together in a unique fashion and having characteristic chemical properties.

The existence of two or more chemical compounds with the same molecular formula but having different properties due to the different arrangement of atoms within the molecule is called **isomerism**.

**There are two main types of isomerism:**

### 1. Structural isomerism (or constitutional isomerism)

- (i) Chain
- (ii) Position
- (iii) Functional
- (iv) Metamerism
- (v) Tautomerism

### 2. Stereoisomerism

- (i) Geometrical isomerism
- (ii) Optical isomerism

In polar covalent bond, bonding electron are unequally shared and the electrons are drawn closer to the more electronegative atom of the bond. Polarisation of one  $\sigma$  bond caused by the polarization of an adjacent  $\sigma$  bond is referred to as the **inductive effect**. The magnitude of inductive effect diminishes as the number of intervening  $\sigma$  bonds increases. The atom or groups which are electron withdrawing exerts  $-I$  effect and atoms or groups which are electron donating are known to exert  $+I$  effect. The inductive effect can be used to explain the stability of carbocations and carbanions.

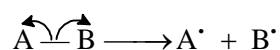
**Hyperconjugation** describes the orbital interactions between the  $\pi$  system and the adjacent  $\sigma$  bonds of the substituent group ( $\sigma$ ) in organic compounds. Hyperconjugation is the delocalisation of  $\sigma$  bonds and is used to explain the stability of carbocation.

**Resonance** is a phenomenon in which the molecule/ion is represented by two or more Lewis structures. No individual structure is a true representation of the actual molecule. The actual molecule is a hybrid of all the possible resonance structures. Any atom/group which enhances the resonance by withdrawing electrons exerts  $-R$  effect and any atom or group which enhances the resonance by donating electrons exerts  $+R$  effect.

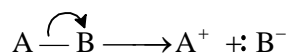
Resonance is also used to explain the stability of carbocation and carbanion.

Organic reactions involve breaking and making of bonds. A covalent bond can be cleaved.

(i) **Homolytically** (equal distribution of electrons) and this results in the formation of free radicals



(ii) **Heterolytically** (unequal distribution of electron) and result in the formation of carbocations and carbanions.



Free radicals, carbocations and carbanions are the three **reaction intermediates**.

**Nucleophiles** are electron pair donor ( $\text{H}_2\text{O}$ ,  $\text{:}\ddot{\text{O}}\text{H}^-$ ) and **electrophiles** are electron pair acceptors ( $\text{H}^+$ ,  $\text{Cl}^+$ ). Organic reactions can be broadly divided into the following **reactions types**:

- (i) Substitution
- (ii) Addition
- (iii) Elimination
- (iv) Condensation
- (v) Rearrangement
- (vi) Isomerisation

Qualitative analysis of an organic compound in its pure form is done to detect the presence of carbon, hydrogen, nitrogen, halogens, sulphur and phosphorus. Carbon and hydrogen are detected by converting them to carbon dioxide and water respectively. Nitrogen, halogen, sulphur and phosphorus are detected by **Lassaigne's Test**.

Carbon and hydrogen are estimated quantitatively by determining the amounts of carbon dioxide and water produced on their oxidation with  $\text{CuO}$ .

Nitrogen is estimated by Dumas method as  $\text{N}_2$  gas or by Kjeldahl's method as  $\text{NH}_3$ .

Halogens are estimated as AgX in Carius method. Sulphur and phosphorus are estimated by oxidizing them to sulphuric acid and phosphoric acids respectively. The percentage of oxygen is usually determined by difference between the total percentage (100) and the sum percentage of all other elements.

Direct estimation of oxygen of a compound involves the use of iodine pentoxide ( $I_2O_5$ ). Once we know the percentage of each and every element in the organic compound, empirical and molecular formula of organic compound can be derived.

## Hydrocarbons

Alkanes and aliphatic saturated hydrocarbons are classified as straight chain and branched chain alkanes. The types of carbon atoms present in alkanes are primary, secondary, tertiary and quaternary. Alkanes exhibit chain isomerism. Prefixes like n, iso and neo are used in common names of alkanes. Alkanes show conformational isomerism due to free rotation about C – C sigma bond. Staggered conformation is more stable than eclipsed conformation.

Alkanes can be prepared by

- (i) Decarboxylation method using either soda lime or electrolysis of sodium/potassium salt of carboxylic acids.
- (ii) Using Wurtz reaction

**Alkanes** have very low chemical reactivity and undergo free radical substitution reactions like halogenations in the presence of light or high temperature.

**Alkenes** are unsaturated hydrocarbons containing carbon-carbon double bond. Alkenes exhibit chain, position as well as geometrical isomerism. Alkenes can be mainly prepared by elimination reactions like

- (i) Dehydrohalogenation of haloalkanes
- (ii) Dehydration of alcohols.

Also, alkenes can be prepared by selective catalytic reduction of alkynes.

Alkenes undergo mainly addition reaction in which the first step is the addition of an electrophile to form carbocation which then combines with the nucleophile to give the final product. These reactions are called **electrophilic addition reaction**. Oxidation of alkene can take place with

- (i) cold dilute alkaline  $KMnO_4$
- (ii) Ozone followed by  $Zn/H_2O$
- (iii) hot alkaline  $KMnO_4$

Alkenes also undergo polymerization reaction to form important polymers like polythene, polypropene.

**Alkynes** are also unsaturated hydrocarbons containing  $C \equiv C$  bond. The simplest alkyne is ethyne. Ethyne can be prepared by the hydrolysis of calcium carbide. Alkynes can also be prepared by dehalogenation of dihalides. Alkynes shows chain isomerism and position isomerism.

Since alkynes are unsaturated hydrocarbons and undergo addition reaction with  $H_2$ ,  $X_2$ ,  $H_2O$  and  $HX$ . Alkynes also undergo oxidation with ozone and  $KMnO_4$ . Alkynes also undergo linear polymerization as well as cyclic polymerization.

Ethyne on cyclic polymerization gives benzene.

**Benzene and benzenoid compounds** show aromatic character. Aromaticity is a function of specific electronic structure symbolized by Huckel  $(4n+2)$  rules. In spite of  $C = C$  bonds and unstauration in benzene, benzene does not undergo addition reactions under normal conditions, this is due to extra stability involving resonance.

The main reactions of the benzene ring are electrophilic substitution reaction and proceeds via benzene carbocation. More the electron density on benzene ring, more the reactivity towards electrophilic substitution reactions. The nature of groups or substitutents attached to benzene ring is responsible for activation (+R groups) or deactivation (-R groups) of the ring towards electrophilic substitution and also for orientation of the incoming group.

Some non-benzenoid structures also show aromaticity like pyridine, pyrrole, thiophene, etc.

