Chapter 12

Organic Chemistry-Some Basic Principles and Techniques

GENERAL INTRODUCTION

Introduction

History And Introduction

Nicholas Lemley, in 1675 had divided chemical substance into 3 parts.

(i) **Mineral substance**: which are obtained from minerals.
E.g., gold, silver, iron etc.

(ii) **Vegetable substance:** which are obtained from vegetables.
E.g., sugar, citric acid etc.

(iii) **Animal substance**: which are obtained from animals.
E.g., albumin, gelatin etc.

After some time when many of the chemical substance were discovered, it was found that some of them can be obtained from both vegetables and animals. So, this classification was failed. So chemical substance was then divided into two parts:

(i) **Organic compounds**: which are obtained from living organism.

(ii) **Inorganic compounds**: compounds which are obtained from any other sources except living organisms.

Vital Force Theory

- Berzelius in 1815 suggested that there is a mysterious force in living organisms which was named as Vital Force and said that organic compounds cannot be synthesized in lab. Before this any organic compound could not be synthesized in lab.
- In 1828 Wholer (German Scientist) synthesized an organic compound in lab which was urea.
- Urea was synthesized in lab by heating of Ammonium cyanate (NH_4CNO). So VFT was failed.

$$\underset{\text{Ammonium Cyanate}}{NH_4CNO} \xrightarrow{\Delta \text{ Re arrangement}} \underset{\text{Urea}}{NH_2 - \underset{\underset{O}{\|}}{C} - NH_2}$$

Kekune's Principle

- Carbon has four valencies.
- Carbon has a property of catenation. It can make large chain with addition of other carbons.
- A carbon atom can share, 2, 4 or 6 electrons with other carbons & can form single, double or triple bond.
- For a carbon atom, it is not possible to make more than 3 bonds with adjacent carbon atom because a carbon atom completes its octet from overlapping which consists directional property.

Some Important Definitions

(1) **Catenation:** The property of atoms of an element to link with one another forming chains of identical atoms is called catenation.

(2) **Homologous series**: Homologous series may be defined as

a) series of similarly constituted compounds in which the members possess the same functional group.
b) have similar chemical characteristics.
c) have a regular gradation in their physical properties.
d) The two consecutive members differ in their molecular formula by CH_2.

(3) **Isomerism:** The name was given by Berzelius. The organic compounds having some molecular formula and molecular weight but different properties (chemical and physical) and the phenomenon is called isomerism. Isomerism is actually permutation and combination of arrangement of atoms in different style either structurally or 3 –dimensionally to form molecules by the nature.

Homologous Series

The organic compounds which are structurally similar having same functional groups, combinedly gives a series known as homologous series and the members as homologues. The homologous series is characterised by:

(i) The two adjacent members are differing by a $-CH_2-$ group or 14 atomic mass unit.

(ii) All the members of a series have same general formula, general methods of preparation and similar chemical properties due to same functional group.

(iii) The homologues show difference in physical properties due to change in molecular mass and structural arrangement of molecule.

Isomerism
- Sawhorse Projections
- Newman Projections
- Relative Stability of Conformations
- Cyclo Alkanes
- Chiral Carbon
- Enantiomers
- Diastereomers

Some standard Homologous Series Are

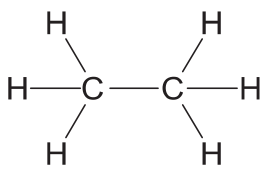
S.No.	Name of Series	General Formula	I-homologue	II-homologue
1	Alkane	C_nH_{2n+2}	CH_4	$CH_3–CH_3$
2	Alkene	C_nH_{2n}	$CH_2 = CH_2$	$CH_2 = CH – CH_3$
3	Alkyne	C_nH_{2n-2}	$HC \equiv CH$	$HC \equiv C – CH_3$
4	Halo alkane	$C_nH_{2n+1}X$	$CH_3– X$	$CH_3– CH_2– X$
5	Alcohol	$C_nH_{2n+2}O$	$CH_3– OH$	$CH_3– CH_2– OH$
6	Ether	$C_nH_{2n+2}O$	$CH_3 – O – CH_3$	$CH_3– O – CH_2–CH_3$
7	Aldehyde	$C_nH_{2n}O$	H–CHO	$CH_3– CHO$
8	Ketone	$C_nH_{2n}O$	$CH_3 - \underset{\underset{O}{\Vert}}{C} - CH_3$	$CH_3 - \underset{\underset{O}{\Vert}}{C} - CH_2 - CH_3$
9	Carboxylic acid	$C_nH_{2n}O_2$	H–COOH	$CH_3–COOH$
10	Ester	$C_nH_{2n}O_2$	$C - \underset{\underset{O}{\Vert}}{C} - O - CH_3$	$H - \underset{\underset{O}{\Vert}}{C} - O - CH_2CH_3$ & $CH_3 - \underset{\underset{O}{\Vert}}{C} - O - CH_3$
11	Amide	$C_nH_{2n+1}NO$	$H–CONH_2$	$CH_3– CONH_2$
12	Nitro alkane	$C_nH_{2n+1}NO_2$	$CH_3—N(\rightarrow O)(=O)$	$CH_3—CH_2—N(\rightarrow O)(=O)$
13	Amine	$C_nH_{2n+3}N$	$CH_3–NH_2$	$CH_3–CH_2–NH_2$

STRUCTURAL REPRESENTATIONS OF ORGANIC COMPOUNDS

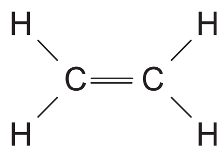
Complete, Condensed and Bond Line Structural Formulas

A molecular formula tells us what atoms are in a molecule and how many of each. There are different ways to show the structures of organic compounds, and the easiest one is the Lewis structure. This method shows how electrons are shared between atoms in a molecule. But we can make it even simpler by using dashes to represent certain kinds of bonds. A single dash (–) means a single bond, a double dash (=) means a double bond, and a triple dash (≡) means a triple bond. Sometimes, we also show lone pairs of electrons on atoms. This simplified way of showing the structure is called the structural formula.

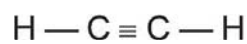
For instance, the structural formulas for ethane (C_2H_6), ethene (C_2H_4), ethyne (C_2H_2), and methanol (CH_3OH) can be shown like this.



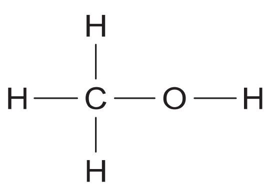
C_2H_2 (Ethane)



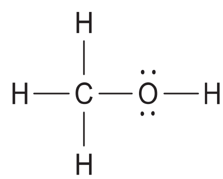
(C_2H_4)Ethene



(C_2H_2)Ethyne
0

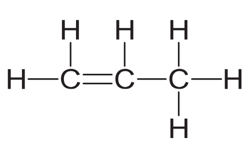


Or

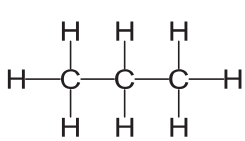


(CH_3OH)Methanol

The illustrated structural formulas above can be time-consuming. They can be streamlined in a condensed formula, where the arrangement of atoms is depicted, but the bonds between them (some or all) may be excluded. The number of identical groups attached to an atom is indicated by a subscript, as exemplified below:



can be shown as $CH_2 = CH - CH_3$



can be shown as $CH_3 - CH_2 - CH_3$ or $CH_3CH_2CH_3$

The extended condensed formulas can be further simplified whenever feasible.

As an instance, $CH_3CH_2CH_2CH_2CH_2CH_2CH_2COOH$ can be condensed to $CH_3(CH_2)_6COOH$.

To make the formula simpler, organic chemists use a different way of drawing called bond line representation. In this style, they don't show the carbon and hydrogen atoms, and the lines between carbon-carbon bonds are drawn in a zig-zag.

For instance, hexane, which has a chain of six carbon atoms in a row, can be shown like this:

$CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3$

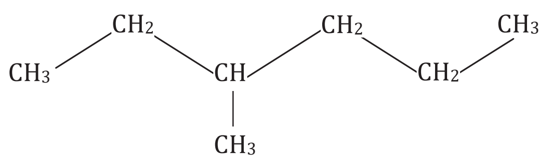
Hexane

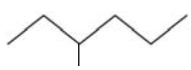
Those atoms which are different from hydrogen or carbon are written. The terminals denote methyl (-CH3) groups unless indicated otherwise by a functional group while the line junctions denote carbon bonded to appropriate number of hydrogen atoms required to satisfy the valence of the carbon atoms.

For example, you can represent the molecule $CH_2CH_2CH_2CH_2COOH$ in bond line formula like this:

For instance, we can show 3-Methylhexane using these forms:

(i) $CH_3CH_2\underset{\displaystyle CH_3}{\underset{|}{C}}HCH_2CH_2CH_3$

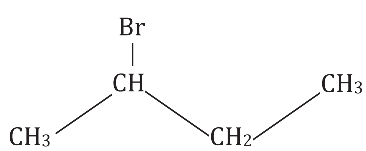
(ii) 

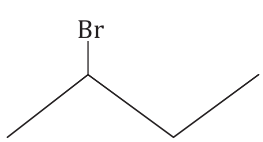
(iii) 

(Terminal represents methyl group)

Likewise, you can represent 2-Bromobutane as:

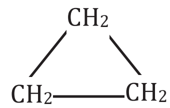
(i) $CH_3\underset{\displaystyle Br}{\underset{|}{C}}HCH_2CH_3$

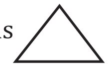
(ii) 

(iii) 

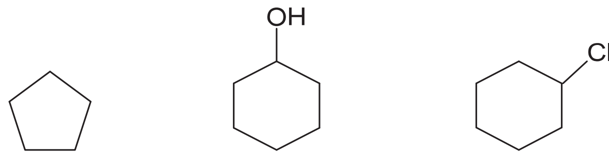
Many organic compounds have carbon atoms connected in rings. These compounds, with one or more rings, are called cyclic compounds. To represent them, you draw the ring without showing the carbon and hydrogen atoms. In this representation, the corners of the ring stand for carbon atoms, and the sides of the shape show carbon-carbon bonds.

The atoms or groups other than hydrogen are shown in the structure.



is represented as


Here are some more examples of cyclic compounds:



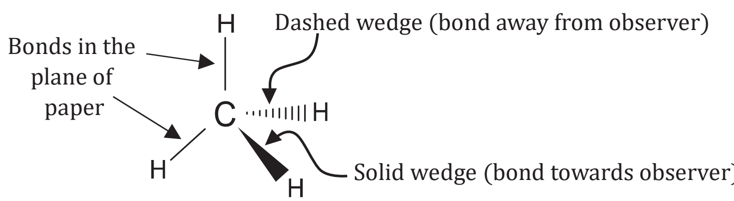
Cyclopentane Cyclohexanol

Three-dimensional representation of organic molecules

The three-dimensional (3-D) structure of organic molecules can be represented on paper by using certain conventions.

For example, using solid ( ) and dashed wedge ( ) formula, 3-D image of a molecule from a two-dimensional picture can be perceived. In these formulae, the thick solid (or heavy) line or the solid wedge indicates a bond lying above the plane of the paper and projecting towards the observer while a dashed wedge is used to represent a bond lying below the plane of the paper and projecting away from the observer. Wedges are used in such a way that the broad end is towards the observer. The bonds lying in the plane of the paper are depicted by using a normal or an ordinary line.

The 3-D representation of methane molecule on paper is shown in the following figure.



Wedge-and-dash representation of CH_4

A representation that fully describes the real positions of different atoms in a molecule in space is known as a spatial formula or three-dimensional structure, abbreviated as 3-D structure.