Carbon & its Compounds
Isomerism

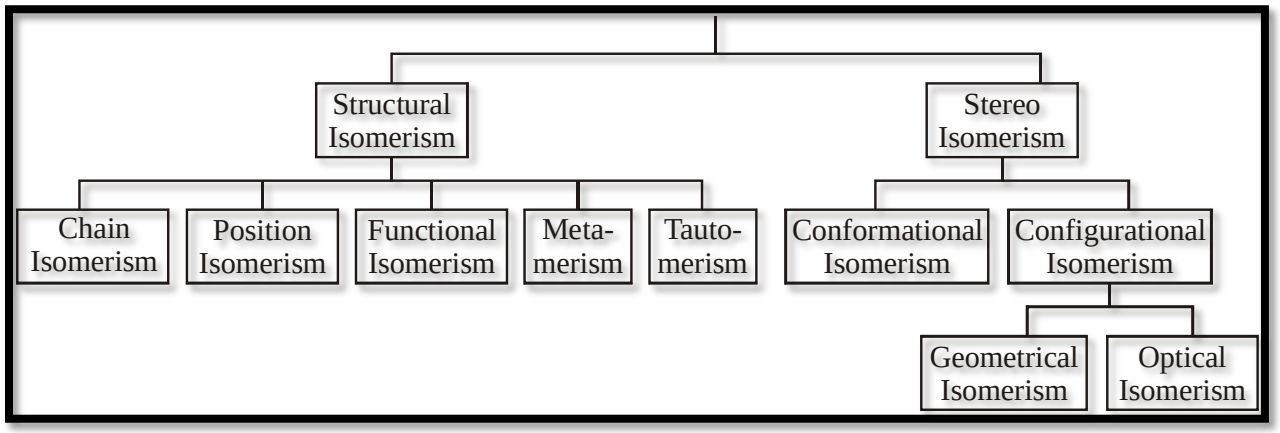
ISOMERISM

Definition: Compounds having same molecular formula show different physical and chemical properties are called isomers and the phenomenon is called isomerism.

The difference in properties of isomers is due to the difference in the relative arrangements of various atoms present in their molecules. Organic compound show following types of structural isomersim on the basis of their difference in structural arrangement of atoms.

➢ **Type of Isomerism**

The following figure shows the pictorial representation of different types of isomerism



Structural Isomerism In this type of isomerism the isomers have different molecular structure due to the different arrangement of atoms in their molecules.

➢ **Chain isomerism :** Organic compounds having same molecular formula but difference in the nature of length carbon chain are called **chain isomers**.

For example, Let us consider the molecular formula of an alkane C_4H_{10}.

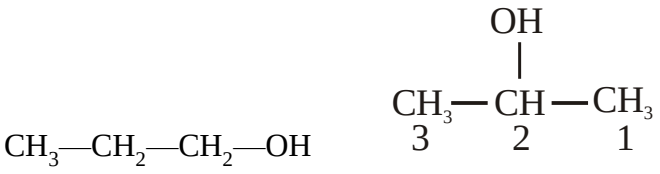
$$\underset{\text{Butane}}{CH_3-CH_2-CH_2-CH_3} \qquad \underset{\text{(2-Methylpropane)}}{\begin{array}{l} CH_3 \\ | \\ CH_3-CH-CH_3 \end{array}}$$

(Here linear chain contains 4 carbon atom) (Here the linear chain contains 3 carbon atom)

➢ **Position isomerism :** Compounds having same molecular formula but differ in the position of functional group, double bond or triple bond in the carbon chain are called **position isomers**.

This type of isomerism is shown by Alkene, Alkyne, Alcohol, Amine, Haloalkane etc.

Ex.1 Let us consider the molecular formula of an alcohol ($C_nH_{2n+2}O$) C_3H_8O



(1-Propanol) (2-Propanol)

The difference only in the position of —OH group in the linear Carbon chain.

Ex.2 Let us consider the molecular formula of alkene C_4H_8 (C_nH_{2n})

(1 - Butene) (2- Butene)

They are differ in the position of double bond in the linear carbon chain.

(i) Chain isomerism is observed when the number of carbon atoms is four or more than four in an organic compound. Chain isomers differ in the nature of carbon chain, i.e. in the length of the carbon chain.

(ii) The isomers showing chain isomerism belong to the some homologous series, i.e. functional group, class of the compound (cyclic or open) remains unchanged.

(iii) Aldehydes, carboxylic acids (and their derivatives) and cyanides do not exhibit positional isomerism.

(iv) Chain and positional isomerism cannot be possible together between two isomerism compounds. If two compounds are chain isomers then these two will not be positional isomers.

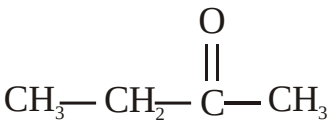
➤ **Functional isomerism :** Compounds having same molecular formula but differ in nature of functional group are called functional isomers.

Ex.1 Alcohol and ether have same molecular formula ($C_nH_{2n+2}O$) but have different functional group hence show functional isomerism. C_2H_6O

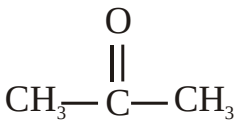
$CH_3—CH_2—OH$ (Ethanol)

$CH_3—O—CH_3$ (Methoxy methane)

Ex.2 Aldehyde and Ketone having same molecular formula ($C_nH_{2n}O$) C_3H_6O



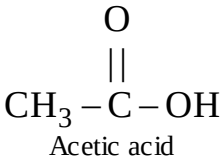
(Propanal)



(Propanone)

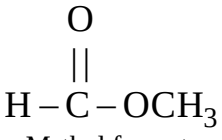
Illustration 4

Which type of isomerism following pair of compound represents?



Acetic acid

and



Methyl formate

Solution

Above pair of compounds represents functional isomerism.

llustration 5

Which type of isomerism is exhibit by following compound

$CH_3 - C \equiv N$ (A)

$CH_3 - N \equiv C$ (B)

Solution

A and B exhibit functional isomerism.

Illustration 6

Give chain isomers in following compound

(A) n-Butane (B) 1-Butanal (C) 1-Butene

Solution

(A) $CH_3–CH_2–CH_2–CH_3$ $(CH_3)_2CHCH_3$

n-Butane 2-Methylpropane or Isobutane

(B) $CH_3CH_2CH_2CH_2OH$ $(CH_3)_2CHCH_2OH$

1-Butanal 2-Methyl-1-butanol

(C) $CH_3CH_2CH = CH_2$ $(CH_3)_2C = CH_2$

1-Butene 2-Methylpropene

Illustration 7

Give position isomers of the following compounds

(A) 1-Butene (B) 1-Butyne

Solution

(A) $CH_3–CH_2 –C \equiv CH$ $CH_3C \equiv C – CH_3$

1-Butyne 2-Butyne

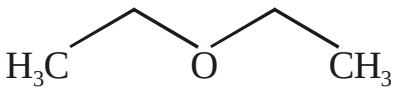
(B) $CH_3–CH_2CH = CH_2$ $CH_3CH = CH–CH_3$

1-Butene 2-Butene

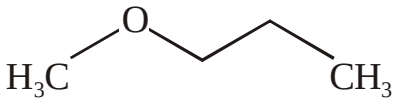
➢ **Metamerism:** The compounds having same molecular formula but different number of carbon atoms (or alkyl groups) on either side of functional group, are called metamers.

e.g. ethers, thioethers, secondary amines, ketones, esters etc.

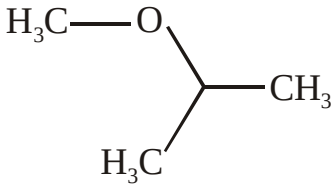
(a)



diethyl ether

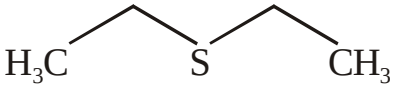


1-methoxypropane



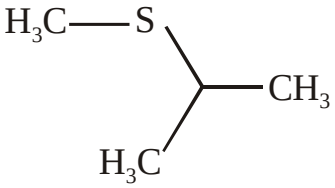
2-methoxypropane

(b)



(ethylthio)ethane

1-(methylthio)propane

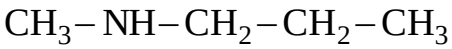


2-(methylthio)propane

Illustration 8

Which type of isomerism is exhibited by following pair of compounds?

N–Ethylethanamine

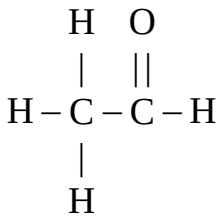


1–(N–Methyl)propanamine

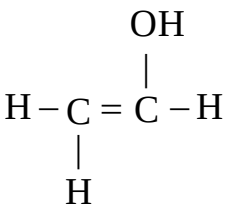
Solution

Above pair of compounds represents metamerism.

➤ **Tautomerism :** This is a special type of functional isomerism in which the isomers differ in the arrangement of atoms but they exist in dynamic equilibrium with each other. For example, acetaldehyde and vinyl alcohol are tautomers.



Acetaldehyde



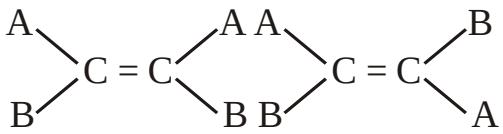
Vinyl alcohol

Tautomerism arises due to 1,3 migration of hydrogen atom from one polyvalent atom to other within the same molecules.

Stereoisomerism was exhibit by compounds which have same structural formula and sequence of bonds but differ in the relative position of atoms or groups of atoms in space. It is majorly of two types

1. Geometrical Isomerism
2. Optical Isomerism

Geometrical Isomerism: also called cis trans isomerism is exhibited by alkanes because of the presence of double bond. This is due to the restricted rotation around carbon-carbon double bond. As a result, the position of the groups attached to these carbons is fixed in space. Here cis-isomer have identical group on either side whereas in trans-isomer identical groups are at opposite side of C = C.



cis trans

Optical Isomerism is shown by substances which can rotate the plane of polarised light. For example, this type of isomerism is shown by amino acid alanine.

Note: You will study about stereoisomerism in detail in higher classes.