# **1. INTRODUCTION**

- (a) In the early discoveries of quantitative analysis of organic compounds it was found that two or more compounds possess the same atomic compositions, but were quite different in their chemical and physical properties such compounds were first discovered in the 1820's by Liebig and Wohler when they found that silver cyanate (AgNCO) and silver cynate (AgCNO) have the same chemical compositions.
- (b) In order to account for the relationship between such compounds Berzelius proposed the term 'isomerism' (greek iso = equal meros = parts). Berzelius then suggested that isomerism could be explained only when atoms have different arrangements with in the molecule.

### 2. DEFINITION

- (a)To find out structure of any compound it is not sufficient to find out its molecular formula, because a molecular formula may represent structure of many compound. They possess difference in physical and chemical properties. Such different type compounds are called isomers.
- (b) Isomers are defined as compounds that have the same molecular formula but differ in the nature of sequence of bonding of their atoms or in the arrangement of their atoms or groups in space. Such phenomenon is called isomerism.
- (c)The simplest example to explain it is as follows - Ethyl alcohol and dimethyl ether both have the same molecular formula  $C_2H_6O$ , but different structural formulae as.

 $CH_3 - CH_2 - OH$ 

ethyl alcohol

CH<sub>3</sub>-O-CH<sub>3</sub> dimethyl ether

as there is difference in the arrangement of atoms in these compounds, they have different physical and chemical properties.

### 3. CLASSIFICATION OR TYPES OF ISOMERISM

The following figure shows the pictorial representation of different types of isomerism. Structural isomerism Stereoisomerism



# Broadly speaking, isomerism is of two types -

(i) Structural isomerism(ii) Stereoisomerism

# 3.1 Structural isomerism -

Structural isomers possess the same molecular formula but different connectivity of atoms. The term constitutional isomerism is a more modern term of structural isomerism. It arises because of the difference in the sequence of covalently bonded atoms in the molecule without reference to space.

It is sub-classified into following types.

# 3.1.1 Chain Isomerism -

The different arrangement of carbon atoms gives rise to chain isomerism. Chain isomers possess different lengths of carbon chains (straight or branched). Such isomerism is shown by each and every family of organic compounds.

(i) Butane : 
$$C_4H_{10}$$

 $CH_3 - CH_2 - CH_2 - CH_3$  n- butane iso butane

n-butane has the chain of four carbon while isobutane has three. Hence they are chain isomers.

(ii) Pentane :  $C_5H_{12}$   $CH_3CH_2CH_2CH_2CH_3$  n-Pentane isopentane Neopentane

n-Pentane, isopentane and neopentane possess the chain of five, four and three carbons, respectively, hence they are chain isomers.

(iii) Butyl alcohol :  $C_4H_9OH$ 

 $CH_3 - CH_2 - CH_2 - CH_2OH$  n-Butyl alcohol Isobutyl alcohol

These two butyl alcohols are chain isomers.

# 3.1.1.1 Ring chain isomerism -

Such isomerism arises because of the difference of carbon-chain or ring.

For example :



$$CH_3 - CH = CH - CH_3$$
  $CH_3$   
Methylcyclopropane

each of 1-butene and 2-butene is the chain isomer of 2-methylpropene while cyclobutane is the ring-chain isomer of each of 1-butene, 2butene and iso-butylene. Several similar





 $CH_3CH_2 - NH - CH_2CH_3$ Diethyl amine  $CH_3 CH_2 CH_2 - NH - CH_3$ Methyl propyl amine

### 3.1.5 Tautomerism -

(i) Tautomerism is a special type of functional group isomerism which arises due to the transfer of H- atom as proton from a polyvalent atom to other polyvalent atom.

(ii) Such isomers are directly and readily inter convertible under ordinary conditions, and the isomers are called tautomers.

(iii) Tautomers exist in dynamic equilibrium.

(iv) They have no separate existence under ordinary conditions like other isomers mentioned above.

(v) The other names of tautomerism are 'desmotroprism' or 'prototropy'.

(vi) Tautromerism is thus the property shown by certain compounds exhibiting different properties, as if they posses different structures and these constitutional isomers are called tautomers.

### 3.1.5.1 Keto - Enol Tautomerism -

(i) When the tautomers exist in the two forms keto & enol then, such type of tautomerism is called keto-Enol tautomerism'.

(ii) It was discovered by the scientist 'Knorr' in 1911 in acetoacetic ester.

(iii) The Keto means the compound has a Keto group > C = O, and the enol form has both double bond and OH (hydroxy) group Joined to the same carbon.

OH



Keto forms Enol forms

**NOTE** : It is important to recognise that the enol is a real substance capable of independent existence it is not a resonance form of the carbonyl compound. For eq.

(i)  $CH_2=C-OH \Leftrightarrow CH_3-C-H$ Vinyl alcohol Acetaldehyde

(ii)  $CH_3 = C = CH = COOC_2H_5$ Aceto acetic ester Keto form  $\Leftrightarrow$ OH

н





(Keto form)

(Enol Form)

### NOTE :

(a) In order for conversion of a keto form to its enol form it must have an  $\alpha$ -hydrogen (i.e., hydrogen attached to the carbon adjacent to the carbonyl group). Thus benzaldehyde, m-chlorobenzaldehyde (in general, aromatic aldehydes) formaldehyde, trimethylacetaldehyde do not exist as their enol forms.





Benzaldehyde

m-Chlorobenzaldehyde



CH<sub>3</sub> − CH<sub>3</sub>−C −− C−H − CH<sub>2</sub> O

Methanal

Trimethyl-acetaldehyde

(b) From the structure of keto-enol tautomers of a particular compound it would be apparent that a direct intramolecular "proton jump" occurs from the  $\alpha$ -carbon to the carbonyl oxygen, but it is not always the fact. Keto-enol interconversion is subject to catalysis by acid or base, or a combination there of. The process may occur in a single step of stepwise. The process by which it occurs may be depicted as



Keto form Enol form Enol form the  $\alpha$ -hydrogen of the keto form behaves as an acid because of the adjacent electron-withdrawing carbonyl group.

(c) It should be noted that methylencyclohexane and 1-methylcylo-hexene are simply constitutional isomers, not tautomers.



Methylenecyclohexane 1-Methylcylohexene

### 3.2 Stereo or space isomerism -

Compound having same molecular formula and structure formula but differ due to spatial arrangement of group or atom is said to be stereo isomers and phenomenon is termed as stereo isomerism.

It is divided into two parts

(1) Configuration isomerism

(2) Confermational isomerism

Configurational isomerism is further divided into two parts

(A) Geometrical isomerism

(B) Optical isomerism

### 3.2.1 Geometrical Isomerism:

Compound having same molecular formula but differ in their properties due to the difference in the direction of attachment of same atoms or group in their molecule.

 $\Rightarrow$ It is caused due to the restricted rotaion about double bond i.e., alkene (>C = C<), oxime (>C = N - OH), azocompound (- N = N -).

⇒ In cyclo alkane rotation also restricted about – C – C – single bond, thus they also show Geometrical Isomerism.

### Geometrical isomerism in alkene :

Generally alkene show Geometrical Isomerism because by the overlapping of two unhybridised carbon, formation of  $\pi$  bond takes place which produce restricted rotation.



All alkene do not show Geometrical Isomerism but not those in which both the double bonded carbon attach with different group or atoms.



### Gemetrical isomer is of two type.

**Cis form :** Such isomer in which at least one pair of similar atom attach on the same side of double bonded carbon, is said to be as form.



**Trans form :** Such isomer in which at least one pair of similar atom attach on the opposite side of double bonded carbon, is said to be as form.



Properties of cis-trans isomer :
(1) Stability : Cis < Trans
Cis form is comparatively less stable because of
the mutual repulsion between the group.eq</pre>

H - C - OOH Less distance H - CH - OOH High repulsion

(2) Dipole moment : Symmetrical trans molecule have zero dipole moment, even if trans molecule is not symmetrical then it dipole moment less than cis isomer.  $\mu$  (Sym trans) = 0

 $(unsym trans)_{ii} < cis isomer$ 

 $CH_{3} \xrightarrow{C} = \begin{array}{c} CH_{3} \\ H \\ \mu \neq 0 \end{array} \xrightarrow{C} H \\ \mu \neq 0 \end{array} \xrightarrow{C} CH_{3} \\ H \\ \mu \neq 0 \\ \mu \neq 0 \\ H \\ \mu \neq 0 \\ \mu \neq 0 \\ CH_{3} \\ \mu \neq 0 \\ \mu \neq 0 \\ H \\ \mu \neq 0 \\$ 

- (3) Polarity : Cis > trans
- (4) Solubility : In polar solvent Cis > trans
- (5) Boiling point :

Cis > trans (due to high polarity)

# (6) Melting point : Cis < Trans

It is due to better packing in crystal due to symmetry.

But heat of hydrogination, heat of combution, density refractive index is higher in cis isomer than trans.

# **Chemical properties :**

(1) Heating effect



But fumaric acid form anhydride at very high temperature.

 $\begin{array}{c} H-C-COOH \\ \parallel \\ HOOC-C-H \end{array} \xrightarrow{240^{\circ}C} H-C-COOH \\ \parallel \\ H-C-COOH \end{array} \longrightarrow$ 



At room temperature,  $\pi$  bond is not break thus Geometrical Isomerism are not interconvrtable. (2) With dilute KMnO<sub>4</sub>



A such type of compound Geometrical Isomer is not express by cis trans nomonclature, thus a better system E-Z, is applicable. E-Z system E  $\rightarrow$  entegen (opposite) Z  $\rightarrow$  Zusamann (same)

**E-form :** when two same proirity goup attach on the opposite side of double bonded carbon, then it is called as E-form.

$$\frac{1}{2}C = C < \frac{2}{1}$$

**Z-form :** When two same proirity group attach on the same side of double bonded carbon, then it is called as Z-form

$$\frac{1}{2}C = C < \frac{1}{2}$$

**Proirity rule : chann, ingold & prelong** proposed a sequence rule.

**Rule-1** when atom or group of atom which are directly attach to the stereogenic centre have higher atomic number will have higher proirity. Example



$$(2)_{NH_{2}} C = C C_{CH_{3}}^{NO_{2}} C C_{H_{3}}^{(1)}$$

**Rule-2** When the atomic number will be same, then higher atomic weight or group of atom have higher proirity

$$(1)_{\text{NH}_2} \xrightarrow{\text{C} = C} \stackrel{\text{H}}{\longrightarrow} (2)$$

$$(2)_{\text{CH}_3 - \text{CH}_2} \xrightarrow{\text{C} = C} \stackrel{\text{H}}{\longrightarrow} (1)$$
E-form

**Rule-3** When both atomic number and atomic weight are same then proirity will be decided by the next joining atom.





**Rule-4** If multiple bonded group attach to the double bonded carbon, then they consider in following manner.



# \* Assign E-Z configuration of following compounds Ex.-1

 $(2)_{\text{NC}} \rightarrow C = C \stackrel{\text{CH} = CH_2^{(2)}}{(2)_{\text{C}} \stackrel{\text{CH}}{=} CH_{(1)}^{(2)}}$   $(2)_{\text{C}} \stackrel{\text{CH} = CH_2^{(2)}}{(2)_{\text{C}} \stackrel{\text$ 



**3.2.1.3-** No. of geometrical isomers in polyenes : Case-1 If  $R_1 \neq R_2$  ( $R_1 - CH = CH - CH = CH - R_2$ )

**ase-1** If 
$$R_1 \neq R_2$$
 ( $R_1 - CH = CH - CH = CH - R_2$ )

no. of G.I. =  $2^n$  n  $\rightarrow$  no of stereogenic centre

**Ex.**  $CH_3 - CH = CH - CH = CH - CH_2 - CH_3$ N =  $2^n = 2^2 = 4$ .

**Case-2**If  $R_1 = R_2 (R_1 - CH = CH - CH = CH - R_2)$ no.of G.I.=2<sup>n-1</sup>+2<sup>P-1</sup>

if n is even no. then , P =  $\frac{n}{2}$ 

if n is odd no. then, P =  $\frac{n+1}{2}$ Ex.- CH<sub>3</sub> - CH = CH - CH = CH - CH = CH - CH<sub>3</sub>

here 
$$\begin{vmatrix} n = 3 \\ P = \frac{3+1}{2} \end{vmatrix}$$
  
N = 2<sup>2</sup> + 2<sup>1</sup> = 6

**Note :**  $CH_2 = CH - CH = CH_2$ Then type of compound show Geometrical Isomerism due to resonance.

$$CH_2 = CH \stackrel{\checkmark}{=} CH \stackrel{\sim}{=} CH \stackrel{\sim}{=} CH_2 \longleftrightarrow$$

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### **Geometrical Isomerism oxime**

$$C = O + H_2 - N - OH \longrightarrow$$

$$C = N + OH \qquad \text{Oxime of aldehyde}$$
and oxime of unsym

= N – OH Oxime Oxime of aldenyde and oxime of unsymmetrical ketone also show Geometrical Isomerism

Aldoximes



When –OH group and H atom is same side, then it is syn form otherwise anti form

In unsymmetrical Ketoxime, if-OH and the alphabetically alkyl present on the same side of double bond, then it is called as syn form and other isomer is anti form

Geometrical in AZO compound :

Eq. Ph - N = N - Ph



# All azo substance will be show geometrical isomerism

#### Geometrical Isomerism cyclo alkane :

In cyclic compound the rotation about C - C single bond is not free because of the regidity caused by the presence of other carbon of the ring which keep them tightly held, thus a disubstituted cyclic compound (having the two substitution at the separate carbon) will also show Geometrical Isomerism.



### 3.2.2 Optical Isomerism

In optical isomerism we have a much more suitable phenomenon than even the geometrical isomerism. While the geometrical isomers differ in physical properties such as melting point, boiling point, density etc. and also in certain chemical properties, the optical isomers will have the same chemical reactions and will be alike in all physical properties mentioned above they can only be distinguished by their action on plane polarized lights this property which is often referred to as the optical activity requires a brief discussion.

What is optical activity ?. Light is propagated by vibratory motion of the 'ether' particles present in the atmosphere. thus in ordinary light vibrations occur in all planes at right angles to the line of propagation. In plane polarized light the vibrations takes place only in one plane.

Certain organic compounds, when their solutions are placed in the path of a plane polarized lights have the remarkable property of rotating its plane through a certain angle which may be either to the left or to the right if the polarized light has its vibrations in the plane AB before entering such a solution, the direction on leaving it will be changed to say A'B', the plane have been rotated through the angle  $\alpha$  (fig). this property of a substance of rotating the plane



polarized light is called optical activity and the substance passing it is said to be optically active.

The observed rotation of the plane of polarised light produced by a solution depends upon -(a) The amounts of the substance in tube.

- (b) On the length of the solution examined.
- (c) The temperature of the experiment &
- (d) The wavelength of the light used.

# 3.2.2.1 Definition and examples of optical Isomerism

The simple organic compounds which show optical activity are :

(a) Lactic acid CH<sub>3</sub> - CH (OH) - COOH

(b) Isovaleric acid

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CH<sub>3</sub>
  сн-соон
Ć2H5
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(c) Isoamyl alcohol

сн–сн₂он

All these substances are known to exist in three stages .

(1) One rotating the plane of polarised light to the left this form is named laevorotatory. (Latin, laevous = left) or direction (-) – form

(2) One rotating the plane of polarized light exactly to the some extent but to the right. This form is named dextroro tatory (Latin, Dexter - right) or direction (+) — form.

(3) An inactive form which does not rotate the plane polarized light at all this is mixture of equal amounts of (+) and (-) forms and hence it is optical inactive. It is named (±) mixture or Racemic mixture.

(Latin, Racemic - mixture of equal compounds) Thus three lactic acids are known they are : (a) (+) - lactic acid, (b) (-) - lactic acid and (c)  $(\pm)$  mixture since the  $(\pm)$  acid is only a mixture of (+) – and (-) – forms, in reality lactic acid exists in two forms, the (+) - lactic acid and the (-) - lactic acid. These two acids are exactly identical in physical and chemical properties but dilute in their action on the plane polarized light they have different sign of specific rotation . Such forms of the some compounds which differ only in their optical properties are called optical isomers and phenomenon is termed optical Isomerism.

### Table – Physical properties of Lactic acids

Name M.P. (do	)	Density	$[\alpha]_{\rm D}^{25^{\circ}}$
(+) -lactic acid	26	1.248	+ 2.240
(-) -lactic acid	26	1.248	- 2.240
(±) lactic acid	26	1.248	0.000

### 3.2.2.2 Asymmetric carbon atom

A carbon atom is described as being asymmetric when four different atoms or groups are bonded to it thus an asymmetric carbon in formulas is usually indicated by on asterisk (\*) placed near it.

All organic compounds containing on asymmetric carbon atom (lactic acid, amyl alcohol etc) are optically active.



(optically active)

amyl alcohol (optically active)

**3.2.2.3 Asymmetric or Dissymmetric molecules** Those molecules which have asymmetric or dissymmetric molecular structure in tetrahedral perspective, are called asymmetric molecules. The two features of such structures are -

(i). No plane of symmetry - A 'Plane' of symmetry' is a plane which divides an object in such a way that the part of it on one side of the plane is the mirror image of that on the other side for eq. a ball is symmetrical while a hand is asymmetric

Similarly, an organic molecule is asymmetric if there is no plane (or centre) of symmetry for example.

(ii).Non superimposable on its mirror image: An asymmetric object cannot be superimposed on its mirror image thus right hand produces a mirror image which is identical with your left hand. The two hands are non superimposable which is clearing evident if your right and in the left handed glove. On the other hand, asymmetric object like a ball can be superimposed its mirror image which is another similar ball.



non-superimposable mirror image



**Chirality** : - This term has been recently used to describe such molecules as have no elements of symmetry, thus a symmetrical molecules are also called chiral molecules and optical activity is attributed to certain chiral centres in them. An asymmetrical carbon is a chiral contane. Chirality is lost when the two atoms bonded to an asymmetric carbon become similar thus lactic acid is optically active but propionic acid is inactive.

# 3.2.2.4 Chirality or molecular dissymmetry cause of optical Isomerism

The necessary condition for a molecule to exhibit optical isomerism is dissymmetry or chirality Thus all organic compounds which contain asymmetric carbon (c\* abde) are chiral and exist in two tetrahedral forms.

Although the two forms (I and II) shown in fig. (a) have the same structure, they have different arrangements of groups a,b,d,e about the asymmetric carbon in fact, they represent asymmetric molecules they do not have a plane of symmetry they are related to each other as an object to its mirror image and are non superimposable.

The two models or structures (I and II) actually stand for dextro or (+) and laevo or (-) isomers. Since they are related to each other as mirror images, they are commonly called Enantiomers (Gr, enantio = opposite, morph - form) or enantiomers thus optical isomerism is now often reflected to as an enantiomers.

It is obvious that optical isomers or enantiomers due to the presence of an asymmetric carbon atom in a compound differ only in the arrangement or configuration of groups in tetrahedral perspective this may be illustrated by taking a few examples of compounds which exist as (+) and (-) enantiomers.



(+) and (-) lactic acid



(+) and (-) -1-chloro-1-phynyl ethane

### 3.2.2.5 Number of optical isomers :

**Case - 1** When the molecule is unsymmetrical. (It cannot be divided into two halves) Number of d and l isomers =  $2^n$ Number of meso form = 0 Total number of optical isomers =  $2^n$ Where n is the number of chiral carbon atoms. **For eg.** 2, 3 - Pentane diol

$$\begin{array}{c} CH_{3} \\ H - C - OH \\ H - C - OH \\ H - C_{2}H_{5} \end{array}$$

**Case - 2** When the molecule is unsymmetrical, number of chiral carbon = even number Number of d and I forms  $=2^{(n - 1)}$ Number of meso form  $=2^{(n/2 - 1)}$ 

Total number = addition of the above =  $2^{n} - \frac{1}{2} + 2^{\frac{n}{2}-1}$ 

For eg.: Tartaric acid COOH H—C—OH

Number of d and l forms =  $2^{(n2 - 1)} = 2$ Number of meso form =  $2^{(2/2 - 1)} = 2^{\circ} = 1$ Total optical isomers = 3

**Case- 3.** When the molecule is symmetrical. Number of chiral carbon = add number of d and I form

 $= 2^{(n - 1)} - 2^{(n/2 - \frac{1}{2})}$ Number of meso form  $= 2^{(n/2 - \frac{1}{2})}$ Total number of isomers  $= 2^{n-1}$ 

**R-S system (Absolute configuration)** 

 $R \rightarrow Rectus (Right)$ 

 $S \rightarrow Sinister$  (Left)

R-S nomenclature is assigned as follow :

**Step-I :-** By the set of sequence rule, we give the priority order of atom or group connected through the chiral carbon.



### **Enantiomers :-**

Such configurational isomer which are nor superimpossible on their mirror image, called as entiomers. Such pair is said to be enantiomeric pairs.





Thus identical arrangement have same molecular formula same structural formula same configuration also i.e. if both verticle & horizontal line group are

inverted, then we get same arrangement

(4)Keeping one group as steady, the other groups in the fisher projection can be rotated clockwise or anticlockwise, then such operation will be give same arrangement as the original.



(5) If more than one chiral centre present

(a) molecule have plane of symmetry



(b) Molecule have no plane of symmetry





If the group of whole horizontal line are inverted then such operation will be produces enantiomers of A, (only when molecule have no plane of symmetry).

# **Properties of enantiomers**

- (1) Enantiomers have chiral molecule
- (2) Enantiomers have identical physical properties like bpt, mpt, refrective index, density etc. They rotate ppL in opposite direction but to the equal extent.
- (3) They have identical chemical properties, However their reactivity i.e. rate of reaction will be differ if they combine with other optically active reagent.

### **Optically** active sub

 $R + x \xrightarrow{K_1} P$  $S + x \xrightarrow{\kappa_2} P$ inactive, then  $K_1 = K_2$ 

 $R + y \xrightarrow{K_3} P$ 

 $S + y \xrightarrow{K_4} P$ 

active, then  $K_3 \neq K_4$ 

(4) They have different biological properties i.e. (+) sugar play significant role in animal metabolism while (-) sugar do not.

# Diastereomers

Such configurational isomers which are neither be mirror image nor be superimpossible on each other, called as diastereoisomer.



Cis-trans isomer are configurational isomer but they are not the mirror image thus, they are said to be diastereomer



Diastereomers



# **Characterstic of Diastereomers**

- (1) They are generally optical active, however geometrical isomers are exception.
- (2) They have different physical properties like mpt, bpt, density, solubilities & value of specific rotation.
- (3) They are seperated by fractional distillation, fractional crystallisation & chromatography etc.
- (4) The exhibit similar but not identical chemical behaviour

### **CONFORMATIONAL STEREOISOMERISMS**



### **Conformation of ethane :**



conformation)

Note : In Newman projection of ethane both carbon atoms represented by circle but one behind the other so that only the front carbon is seen. The C-H bond of the front carbon are depicted from the centre of the circle while C-H bonds of back carbon are drawn from the circumference of circle as





- (i) Ethane molecule contains infinite number of conformers.
- (ii) The extreme conformation of ethane molecules are staggered and eclipsed.
- (iii)The energy of staggered conformation is lower than eclipsed conformation by 2.8 kcal/mole (11.7 kJ/mole).
- (iv)Staggered conformation is more stable than the eclipsed conformation.
- (5) The mixture contains 99% staggered conformation and 1% eclipsed conformation.
- (6) Eclipsed and staggered conformations are not isolated from the mixture.

н

 $CH_3$ 

CH<sub>3</sub>

Н  $\Phi = 60^{\circ}$ 

(II)

н

Н

CH<sub>3</sub>

 $F = 120^{\circ}$ 

(III)



If the dihedral angle is less than 60. it is known as skew.

(d)

Here stability of (c) > (b) > (d) > (a).

(c)

Partial eclipsed stability > Fully eclipsed stability.

	SOLVED PROBLEMS								
Ex.1 Sol.	Number having be (A) 7 (i)	of isome nzene rin (B) 6 (ii),	ric forms g will be (C) 5 (iii),	s of C <sub>7</sub> H <sub>9</sub> N - (D) 4 (Ans. C) (iv) (v)		СН <sub>3</sub> СН.СН.СН <sub>3</sub>     СН <sub>3</sub> СН <sub>3</sub> (iii)	CH <sub>3</sub> CH <sub>2</sub> CHCH <sub>2</sub> CH <sub>3</sub> CH <sub>3</sub> (iv)		
Ex.2	<ul> <li>Which of the following is an isomer of diethyl ether -</li> <li>(A) (CH<sub>3</sub>)<sub>3</sub>COH</li> <li>(B) (CH<sub>3</sub>)<sub>2</sub>CHOH</li> <li>(C) C<sub>3</sub>H<sub>7</sub>OH</li> <li>(D) (C<sub>2</sub>H<sub>5</sub>)<sub>2</sub>CHOH</li> <li>(Ans. A)</li> </ul>				$CH_{3} - CH_{3} - CH_{2}CH_{3}$ $CH_{3} - CH_{2}CH_{3}$ $CH_{3}$ $(iv)$				
Sol.	Diethyl ether has 4 carbon atoms, among different alternative alochols only $(CH_3)_3COH$ has 4 carbon atoms.			Ex.6	The maximum n alkene isomers v C <sub>4</sub> H <sub>8</sub> is - (A) 2 (B) 3	umber of unbranched with molecular formula (C) 4 (D) 5			
Ex.3	The possil formula C (A) 2	ble numbe 5 <sub>5</sub> H <sub>8</sub> is - (B) 3	er of alkyı (C) 4 (Ans.	(D) 5 B)	Sol.	$CH_3CH_2CH = CH_2$ cis- butene- 2	(Ans. B) butene - 1 trans- butene-2		
Sol.	CH <sub>3</sub> CH <sub>2</sub> CH	<sub>2</sub> C≡ CH	ι -		Ex.7	CH <sub>3</sub> CHCl <sub>2</sub> and CH	<sup>2</sup> Cl. CH <sub>2</sub> Cl show which		
Ex.4	How man primary a (A) 2	y isomers Icohols - (B) 3	s of C <sub>5</sub> H <sub>1</sub> (C) 4	1 <sup>0</sup> H will be (D) 5 (Ans. C)	Sol.	(A) Functional (C) Position The two isomers ha	(B) Chain (D) Metamerism (Ans. C) ve same functional group,		
Sol.	$CH_3CH_2CH_2$ (i) $HOCH_2 - C$ (iii)	CH <sub>2</sub> CH <sub>2</sub> OH	CH <sub>3</sub> CHCH CH <sub>3</sub> (ii) CH <sub>3</sub> $-CH_3$ CH <sub>3</sub> $-CH_3$ (iv)	H <sub>2</sub> CH <sub>2</sub> OH	Ex.8 Sol.	<ul> <li>but at different positions.</li> <li>Which of the following is an example of position isomerism –</li> <li>(A) Isopentane and neopentane</li> <li>(B) Glucose and fructose</li> <li>(C) Ethanol and dimethyl ether</li> <li>(D) α - Naphthol and β - naphthol(Ans.D)</li> <li>As the name indicates α - naphthol and β-naphthol differ in the position of the alcoholic group.</li> <li>α - naphthol</li> </ul>			
Ex.5	x.5 How many chain isomers can be obtained from the alkane Caller –		Ex.9	Keto-enol tauton	nerism is observed in-				
	(A) 4	(B) 5	(C) 6	(D) 7 (Ans. B)		О ( <b>А)</b> С <sub>6</sub> Н <sub>5</sub> —С—Н	<b>(B)</b> $C_6H_5 - C - CH_3$		
Sol. C	H <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CH	H <sub>2</sub> CH <sub>2</sub> CH <sub>3</sub>	CH₃CH.CH	<sub>2</sub> .CH <sub>2</sub> CH <sub>3</sub>		0			
	(i)		сп <sub>3</sub> (ii)			(C) $C_6H_5 - C - C_6H_5$	H <sub>5</sub>		

(D) 
$$C_6H_5 = C = C = C_6H_5$$
 (Ans.B)

The compound must contain  $\alpha$ -hydrogen Sol. atom for showing keto enol tautomerism.

Ex.10 The enolic form of acetone contains -(A) 9  $\sigma$  bonds, 1 $\pi$  bond and 2 lone pairs (B) 8  $\sigma$  bonds, 2  $\pi$  bonds and 2 lone pairs (C) 10  $\sigma$  bonds, 1  $\pi$  bond and 1 lone pair (D) 9  $\sigma$  bonds, 2  $\pi$  bonds and 1 lone pair (Ans. A)

Sol. 
$$CH_3 - CH_3 \longrightarrow CH_3 - CH_2$$

keto form enolic form No. of  $\sigma$  bonds in enolic form : 3 + 1 + 1 + 1 + 1 + 2 = 9No. of  $\pi$  bonds in enolic form : 1 No. of lone pairs of electrons in enolic form = 2

Ex.11 An alkane can show structural isomerism if it has.....number of minimum carbon atoms – (C) 3 (D) 4

(A) 1 (B) 2

(Ans. D)

- CH<sub>4</sub>, CH<sub>3</sub>.CH<sub>3</sub>, CH<sub>3</sub>.CH<sub>2</sub>.CH<sub>3</sub> exist only in one Sol. structural form, while CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub> can exist in more than one structural form.
- Ex.12 How many structural formulae are possible for C5H11CI -

(A) 6 **(B) 8** (C) 10 (D) 12 (Ans. B)

Sol. CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CI,

$$\begin{array}{ccc} CI & CI \\ L & L \\ CH_3CH_2CH_2CHCH_3, & CH_3CH_2CHCH_2CH_3 \\ (ii) & (iii) \end{array}$$



Ex.13 The compound C<sub>4</sub>H<sub>10</sub>O can show -

- (A) Metamerism
- (B) Functional isomerism
- (C) Positional isomerism

(D) All types (Ans. D)

Sol. The molecular formula C<sub>4</sub>H<sub>10</sub>O reminds us that the compound can be an ether which is isomeric with alcohol. Further ethers can show metamerism while alcohols can show position isomerism.

Ex.14 Which of the following can exhibit cistrans isomerism -

(A) 
$$HC = CH$$
 (B)  $CICH = CHCI$   
(C)  $CH_3$ .CHCI.  $COOH(D) CICH_2 - CH_2CI$   
(Ans. B)

Sol. Remember that cis-tans geometrical isomerism is possible only in alkenes and further only in those alkenes in which the doubly bonded carbon atoms individually have different atoms/groups.

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