STEREOISOMERISM

Contents

Syllabus

Geometrical isomerism; Optical isomerism of compounds containing up to two asymmetric centres, (R, S and E, Z nomenclature excluded). Conformations of ethane and butane (Newman projections)

Name : _____ **Contact No.** _____

STEREOISOMERISM

KEY CONCEPTS

STEREOISOMERISM

- Stereoisomers have the same molecular formula and the same structure but they differ in configuration, i.e. in the arrangement of their atoms in space.

GEOMETRICAL ISOMERISM :

In this type of isomerism the compounds possessing same molecular formula differ in their properties due to the difference in their geometry.

Maleic acid Fumaric acid

➢ CONDITIONS FOR GEOMETRICAL ISOMERISM

1. There should be a double bond ring in the molecule.
2. The two atoms or groups attached to each doubly bonds carbon atom should be different. If one of the two doubly bonded carbon atoms carries two identical groups then the molecule does not exhabit geometrical isomerism.

➢ Examples :

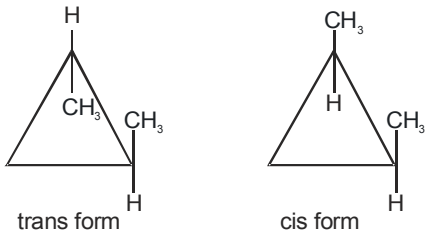
- **Alkenes** $CH_3 - \overset{2}{C}H = \overset{1}{C}H - CH_3$ $C_6H_5 - \overset{2}{C}H = \overset{1}{C}H - COOH$

  In these cases both substitx Vuents on carbon-1 and carbon-2 are different hence they will show geometrical isomerism.

- **Cycloalkanes**

  Geometrical isomerism is possible in cyclic compounds also. There can be no rotation possible above C — C single bonds. In such compounds thus for rotation breakage in the bonds is required resulting to breakage in the ring, **e.g.**

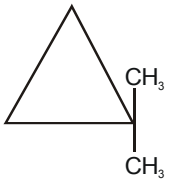
  1, 2-dimethyl cyclopropane exists in two isomeric forms written below :



trans form cis form

1, 2-dimethyl cyclopropane

A requirement for geometrical isomerism in cyclic compounds : There must be at least 2 other groups besides hydorgen on the ring and these must be on different ring C-atom. for example no geometrical isomers are possible for 1, 1-dimethyl cyclopropane.



1, 1-dimethyl cyclopropane (No isomers possible)

- **Oximes and Azo compounds**

The oximes are formed by the reaction of carbonyl compounds (>C=O compounds i.e., aldehydes and ketones) with NH_2OH (hydroxyl amine) as :

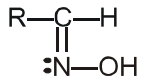
$$>C = O + H_2\ N—OH \rightarrow >C=N—OH + H_2O$$

oxime

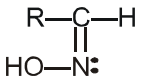
If $-\overset{\overset{O}{\|}}{C}-$ = aldehyde then oxime = aldoxime = $\begin{matrix} R \\ H \end{matrix}\!\!>\!C = N—OH$ or $\begin{matrix} H \\ H \end{matrix}\!\!>\!C = N—OH$

If $-\overset{\overset{O}{\|}}{C}-$ = ketone then oxime = ketoxime = $\begin{matrix} R \\ R \end{matrix}\!\!>\!C = N—OH$

(a) IN ALDOXIMES :



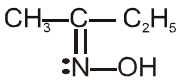
Syn oxime



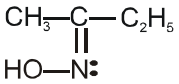
Anti oxime

The first member of aldoximes does not show any geometrical isomer.

(b) IN KETOXIMES :

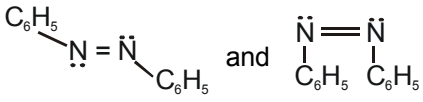


This compound is syn for ethyl group and anti for methyl group or this can be called anti compound.
Similarly,



This compound is anti for ethyl group and syn for methyl group or this can be called syn compound.

(c) IN AZO COMPOUNDS i.e.,



anti form and syn form

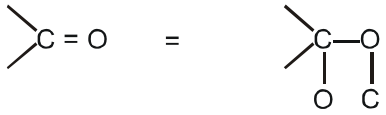
➢ E, Z SYSTEM FOR GEOMETRICAL ISOMERS :

The stereochemistry of highly substituted alkenes cannot be defined as cis or trans. For this purpose a new notation known as **E-Z notation** is used. Following a set of rules (Cahn-Ingold-Prelog rules) the substituents on a double bond are assigned priorities. The double bond is assigned the configuration **E (From entgegen, the German word for opposite)** if the two groups of higher priority are on the opposite sides of the double bond.

On the other hand the double bond is assigned the configuration **Z (from zusammen, the German word for together)** If the two groups of higher priority are on the same side of the double bond.

Cahn-Ingold-Prelog Rules

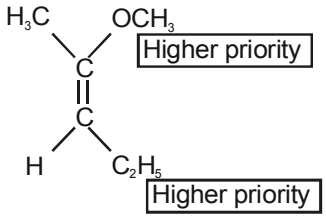
1. The higher the atomic number of the atom bonded directly to the stereocentre, the higher is the priority of the substituent. Among isotopes, the one with higher mass number gets the higher priority.
2. If two identical atoms are attached to the stereocentre, the relative priorityof the two groups is decided by a similar comparison of the next atoms in the group moving away from the stereocentre.
3. A double is counted as two single bonds for both the atoms involved. Thus



Priority Order :- –I, –Br, –Cl, $–SO_3H$, –SH, –F, –OCOR, –OR, –OH, $–NO_2$, $–NR_2$, –NHCOR, NHR, $–CO_2R$, $–CO_2H$, $–CONH_2$, COR, –CHO, $–CH_2OH$,–CN, $–CR_3$, $–C_6H_5$, $–CHR_2$, CH_3 , D, H

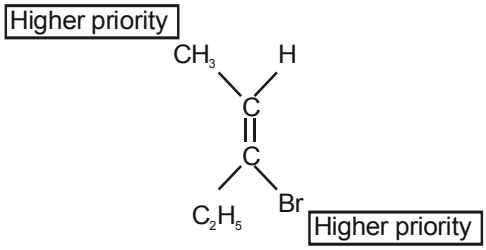
Some examples are being given below :

1.



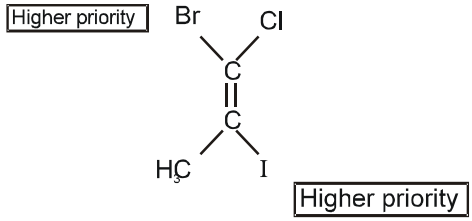
The groups of higher priorities are on opposite sides.
Hence it is (E) - 3-Bromopent-2-ene

2.

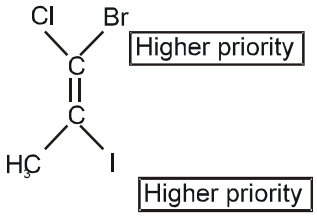


The groups of higher priorities are on same side.
Hence it is (Z) - 2-Methoxypent-2-ene

3.

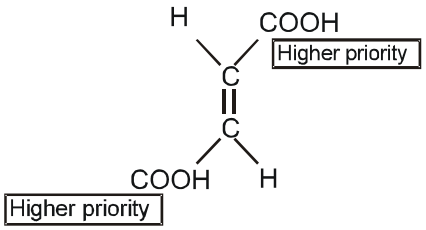


Groups of higher priority
are on opposite sides
(E) -1-bromo-1-chloro-2-Iodo propene

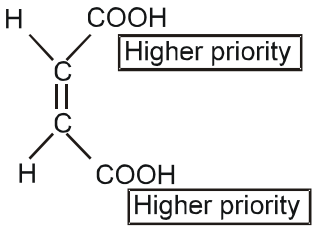


Groups of higher priority
are on same sides
(Z) -1-bromo-1-chloro-2-Iodo propene

4.



(E)-But-2-ene-1, 4-dioic acid
(Fumeric acid)

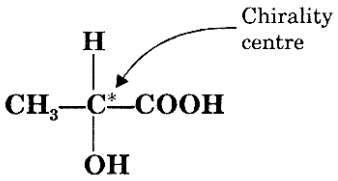


(Z)-But-2-ene-1, 4-dioic acid
(Maleic acid)

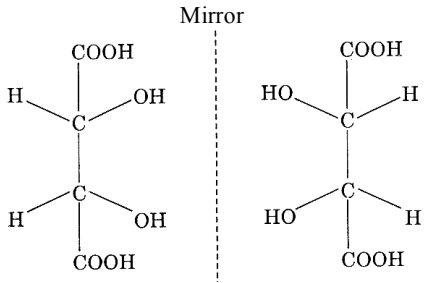
OPTICAL ISOMERISM

➢ **The stereoisomerism which arises due to non-susperimposability of mirror image structure is called enantiomerism or optical isomerism.** The mirror image isomers are called enantiomers.

Dissymmetry or chirality is the necessary and sufficient conditions for the enantiomerism. A carbon atom bonded to four different atom/groups in a molecule is called **chirality**. **A molecule is said to be dissymmetric or chiral if it is not superimposable on its mirror image**. On the other hand, a molecule which is superimopsable on its mirror image is called **non-dissymmetric or a chiral**. Non dissymmetric molecules do not show enantiomerism.



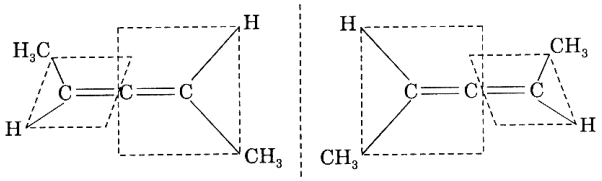
- Generally, the compounds containing an asymmetric carbon in their molecules are dissymmetric and hence show enantiomerism. But there are example where in spite of the presence of asymmetric carbons the compound does not show enantiomerism because its molecules are non-dissymmetric. For example, meso-tartaric acid.



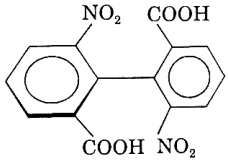
meso-Tartaric acid

Superimposable : does not show enantiomerism

- There are compounds which do not contain any asymmetric carbon atom but still show enantiomerism and optical activity because their molecules are dissymmetric. For example, substituted allenes and substituted biphenyls.



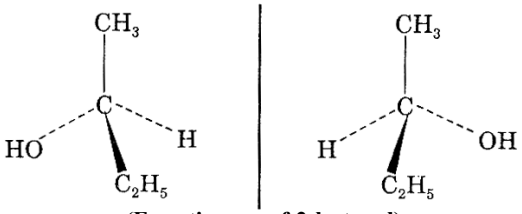
Non-superimposable : shows enantiomerism



DISSYMMETRIC MOLECULE (Shows enantiomerism)

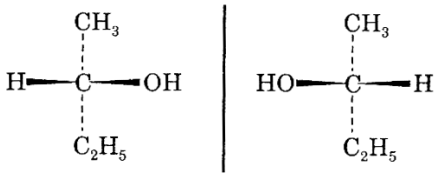
➢ Representation of Enantiomers

1. **Perspective Formula :** In this method a normal line means bonds lying in the plane of paper and broken line means bonds going behind the plane of paper. A solid wedge represents bond projected out towards viewers.



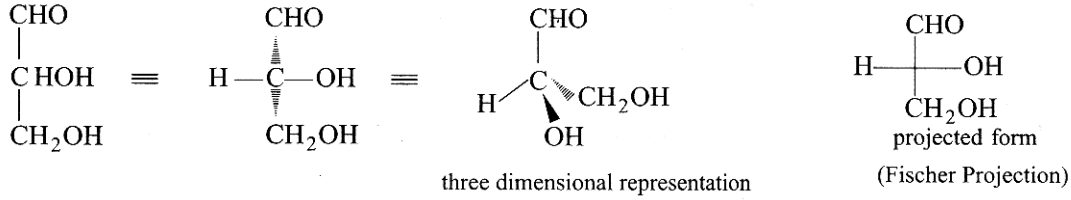
(Enantiomers of 2-butanol)

2. **Projection Formula :** Here the molecule is imagined to be held in such a way that two of the bonds coming towards the viewer are in the horizontal plane and are represented by solid wedges. The other two bonds going behind the plane of paper are in vertical plane which are represented by broken lines. The formula of enantiomers of 2-butanol are



3. **Fischer Projection Formulae :** Envil Fischer devised a most simple and convenient method to represent the three dimensional arrangement of groups bonded to chirality centre. He used the point of intersection of two perpendicular lines to represent the chirality centre. Horizontal lines represent the bonds projected out of the plane of the paper towards viewer. Vertical lines on the other hand, represent the bonds projected back from the plane of the paper away from the viewer.

E.g.



➢ Characteristics of Enantiomers

Some of the important characteristics of enantiomers are as given below :

1. Enantiomers have chiral structures.
2. Enantiomers have identical physical properties such as melting point, boiling point, density, refractive index etc.
3. Enantiomers are optically active substances. They rotate the plane of polarized light in opposite directions but to the equal extent.

	(+)-2-Methyl-1-butanol	(–)-2-Methyl-1-butanol
Specific rotation :	+ 5.90°	– 5.90°
Relative density :	0.8193	0.8193
Boiling point :	128.9°C	128.9°C
Refractive index :	1.4107	1.4107

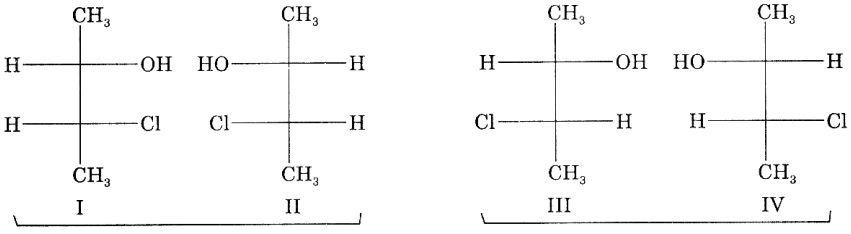
4. Enantiomers have **identical chemical properties**. This means that they form same products as a result of chemical combination. However, their reactivity, i.e. rates of reaction with other optically active substances are different.

➢ Stereoisomers with more than one chirality centres

We have already studied that organic compounds having one chirality centre always possess chiral structures and they exhibit enantiomerism. However, organic molecules having more than one chirality centres may have chiral as well as a chiral structures. The number of possible stereoisomers also increases with the increase in the number of chirality centres, in the molecule. In general, a compound having **n** chiral carbon atoms can have 2^n stereoisomers. In this section we shall study some aspects of organic compounds having two chirality centre.

➢ Diastereomers

The stereoisomers which are non superimposable and do not bear mirror-image relationship are called **diastereomers**. Let us understand it by taking the example of 3-chloro-2-butanol. The molecule has two chirality centre. Thus, the number of possible stereoisomers are 2^2, i.e. 4. The four possible stereoisomers are shownbelow by Fischer projection formulae.



Erythro enantiomers **Threo enantiomers**

- Stereoisomers I and II are non-superimposable mirror images. Hence, they are called **enantiomers.**
- Stereoisomers III and IV are also non-susperimposable mirror images. They are also **enantiomers.**
- I and II also represent enantiomers in which similar groups (H atoms) are present on same side of carbon chain such enantiomers are called **erythro enantiomers**.
- In III and IV similar groups (H atoms) are present on opposite side of carbon chain. Such enantiomers are called **threo enantiomers**.
- Stereoisomers I and III are neither identical nor mirror images. Such stereoisomers are called **diastereomers**.
- In the similar way I and IV; II and III; II and IV also represent diastereoisomeric pairs.
  Thus, diastereomers are configurational isomers which are not enantiomers (It may be noted that cis-trans geometrical isomers which are configurational isomers but not enantiomers can also be called diastereomers).

Characteristics of Diastereomers

(i) The diastereomers have different physical properties such as melting points, boiling points, densities, solubilities and values of specific rotation.

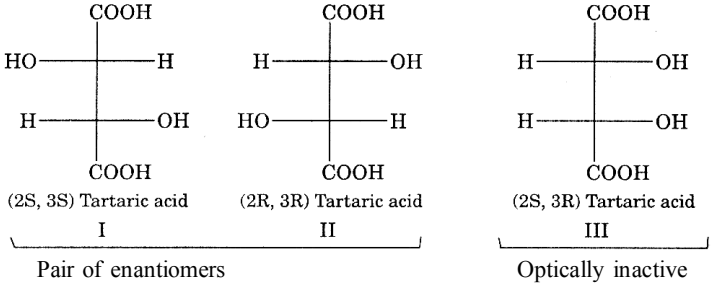
(ii) They can be separated from one another by physical means like fractional distillation, fractional crystallization, chromatography, etc.

(iii) They are generaly optically active. However, geometrical isomers are exceptions.

(iv) They exhibit similar but not identical chemical behavior.

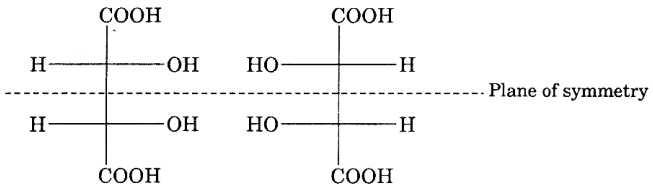
➢ Meso compounds

According to 2^n rule each compound having two chirality centres should have ($2^2 = 4$) four stereoisomers. However, there are some compounds with two chiral carbons which have only three stereoisomers. For example, tartaric acid molecule has two chirality centres but it has only three stereoisomers. For example, tartaric acid molecule has two chirality centres but it has only three stereoisomers as shown below :



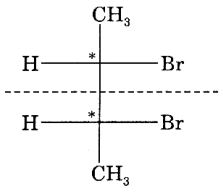
Pair of enantiomers Optically inactive

- Structure I and II are nonidentical mirror images and thus represent pair of enantiomers.
- Structure III is achiral inspite of the presence of two chirality centres. This is because of the presence of plane of symmetry in the molecule. If we draw the mirror image of structure III we shall find that it is superimposable on its mirror image (IV).



(Identical Mirror Images)

- Structure III or IV which are identical are called **meso compounds** (From Greek : meso means middle). Thus, the compounds containing two or more chirality centres but possessing a chiral molecular structure because of having plane of symmetry, are called **meso compound**.



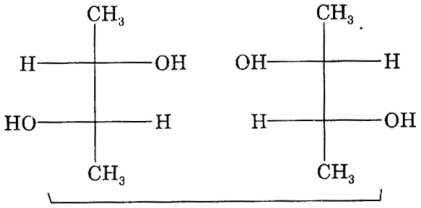
MESO compound

(Plane of symmetry is represented by dotted line .....)

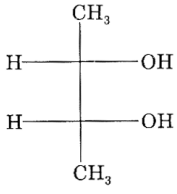
- **Meso compounds are optically inactive**

Meso compounds do not rotate the plane of polarized light in any direction i.e. they are **optically inactive**. This is because of achiral nature of their molecules. Because of the present of plane of symmetry the optical rotation caused by half of the molecule is compensated by the rotation caused by the other half. This cancellation of rotation within the molecule is referred to as internal compensation. In short, the **meso compounds are optically inactive due to internal compensation**.

It may be noted that if a compound with two chirality centres has the same four groups bonded to each of the chiral carbon, than one of its stereoisomer will be a meso compound.



Pair of enantiomers



Meso Compound

➢ RACEMIC MIXTURE

An equimolecular mixture of a pair of enantiomers is **called racemic mixture or racemic modification.** A racemic mixture is optically inactive. This is because of the fact that in equimolecular mixture of enantiomeric pair, that rotation caused by the molecules of one enantiomer is cancelled by the rotation caused the molecule of other enantiomer. This type of compensation of optical rotation in a racemic mixture is referred to as **external compensation**. Thus, **racemic mixture becomes optically inactive because of external compensation.**

Representation of a racemic mixture. The racemic mixture of a particular sample is indicated by using the prefix (dl) or (±). For example, racemic mixture of lactic acid is represented as (±) **lactic acid.**

➢ Calculation of d-, ℓ-forms and meso forms

	For molecules having no plane of symmetry	For molecules having plane of symmetry	
No. of a symmetric carbon atoms = n	n (even or odd)	when n is odd	When is even
No. of d- and ℓ-forms	2^n	2^{n-1}	$2^{n-1} - 2^{(n-1)/2}$
No. of meso forms	0	$2^{(n/2)-1}$	$2^{(n-1)/2}$
Total no. of stereoisomers	2^n	$2^{n-1} + 2^{(n/2)-1}$	2^{n-1}

➢ Absolute Configuration (R, S configuration)

The actual three dimensional arrangement of groups in a molecule containing asymmetric carbon is termed **absolute configuration**.

System which indicates the absolute configurastion was given by three chemists R.S. Cahn, C.K. Ingold and V. Prelog. This system is known as (R) and (S) system or the Cahn–Ingold system. The letter (R) comes from the latin rectus (means right) while (S) comes from the latin sinister (means left).

It is batter system because in manycases configuration to a compound cannot be assigned by D, L method.

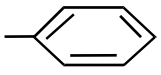
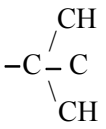
(R) (S) nomenclature is assigned as follows :

1. Each group attached to stereocentre is assigned a priority on the basis of atomic number. The group with the directly attached atom with highest atomic number out of the four groups gets top priority while the group with the atom of least atomic number gets the least priority.

2. If out of the four attached atoms in consideration, two are isotopic (like H and D), then priority goes to higher atomic mass i.e. D.

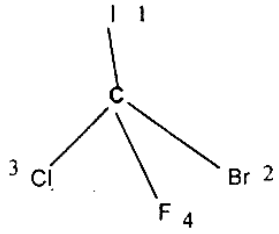
3. If out of the four attached atoms in consideration, two or more are same, then priority is decided on the basis of the atom attached next to it in its group.

4. While deciding the priority, if the atom in consideration is attached is further to an atom through a double bond then it is treated as if it is attached to two such atoms.

- In this way, the phenyl group i.e.,  is treated as if it is is treated as if it is 

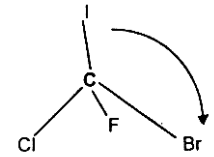
Thus, out of $-CH_2CH_3$ and $-CH=CH_2$, the $-CH=CH_2$ gets priority.

5. After assigning priorties, the lest priority group is written at remotest valency (going away), while the top priority group is written at the top directed valency (towards viewer). Remaining two groups now have two possibilities, giving two configuration. Thus, in the above compound (i.e. Bromochlorofluoriodo methane) we have

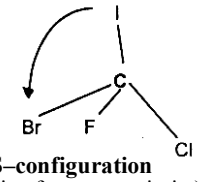


Note that priority order is : I > Br > Cl > F

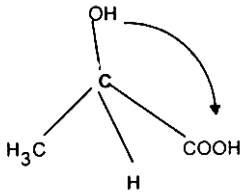
- Now the order from top priority to the one of second priority and then to the one of third priority is determined. If this gives a clockwise direction then it is termed R configuration and if the anticlockwise direction is obtained then it is assigned S configuration. **Eg. :**



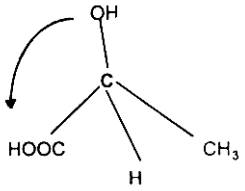
R–configuration
(clockwise from top priority)



S–configuration
(clockwise from top priority)

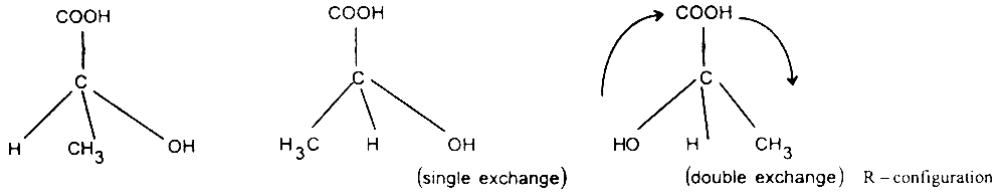


R–configuration
(clockwise from top priority)



S–configuration
(clockwise from top priority)

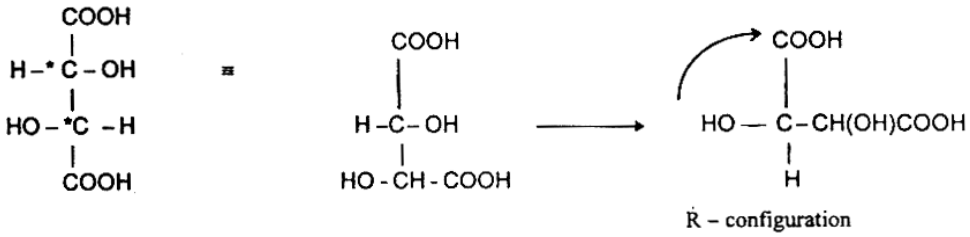
6. If we have to assign the configuration to a given structure and in that the lowest priority group is not on the remotest valency, then we have to first bring this lowest priority group at the valency by exchange rule. One mutual interchanging of the groups lead to reverse configuration and therefore to retain the given configuration the double exchange is to be performed.



Thus, the give structure hs R configuration. Note that the top priority group is not to be necessarily on top valency. We have to simply start the direction form top priority group.

Important : Note that the designation of a compound as R or S has nothing to do with the sign of rotation. the Cahn-Ingold rule can be applied to any three dimensional representation of a chiral compound to determine whether it is R or S only. For example in above case (i.e. lactic acid), R configuration is laevo rotatory is designated as R-(–)-lactic acid. Now the other configuration of it will have opposite sign of rotation i.e. S-(+)-lactic acid.

7. For the compounds containing more than one asymmetric carbon, again the same rules apply. Configuration to each asymmetric carbon is assigned separately. Thus, to assign configuration to first asymmetric carbon in (+)-tartaric acid, we have



CONFORMATIONS

- The different spatial arrangements of atoms which arise due to rotation around carbon-carbon single bond are called **conformations**.

Conformation of Ethane

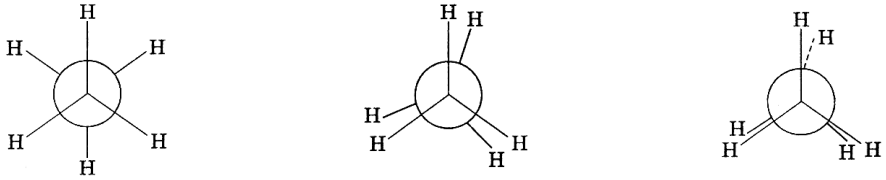
- Out of infinite number of possible conformations of ethane, the two extreme conformations are **staggered** conformation and **eclipsed** conformation. The infinite intermediate conformations are known as **skew** conformations.

- The **Sawhorse projection formula** of the two extreme conformations of ethane are shown in figure.

(a) Staggered form (b) Eclipsed form

Staggered and Eclipsed conformations of ethane

- The **Newman's projection formula** for staggered and eclipsed conformations of ethane are shown in figure.



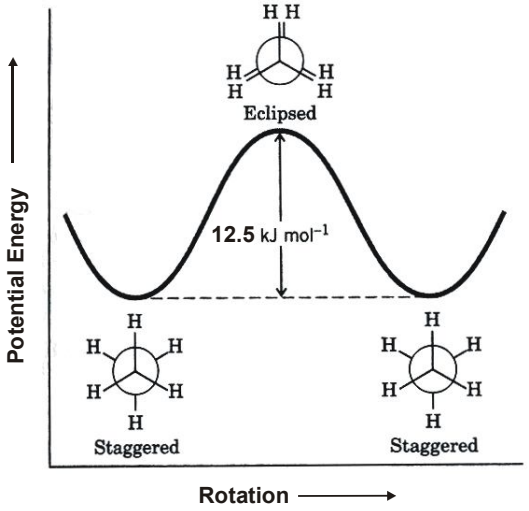
I Staggered form Skew II Eclipsed

Newman's projection formulae of conformations of ethane

Relative Stabilities of the Conformations of Ethane

The conformations of ethane do not have same stability. The **staggered conformations** is relatively more stable than the other conformations. It is because the repulsive interactions between the H-atom attached to the two carbon atoms are minimum due to the maximum distance between them. On the other hand, the **eclipsed conformation** is associated with maximum energy because the repulsive interactions between H-atomson adjacent carbon atoms are maximum due to minimum distance between them. The difference in the energy content of staggered and eclipsed conformations is 12.5 KJ mol^{-1}.

The variation of energy with rotation about the C–C bond in ethane has been shown in figure below :



Changes in energy during rotation about C–C bond in ethane

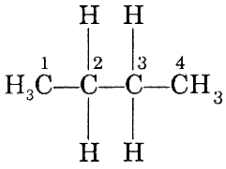
The difference in the energy of various conformers constitutes an energy barrier to rotation. The energy required to rotate the ethane molecule about carbon-carbon single bond is called **torsional energy**. But this energy barrier is not large enough to prevent the rotation. Even at ordinary temperature the molecules possess sufficient thermal and kinetic energy to overcome the energy barrier through molecular collisions. Thus, conformations keep on changing form one form to another very rapidly and cannot be isolated as separate conformers.

- **Torsional energy :-**

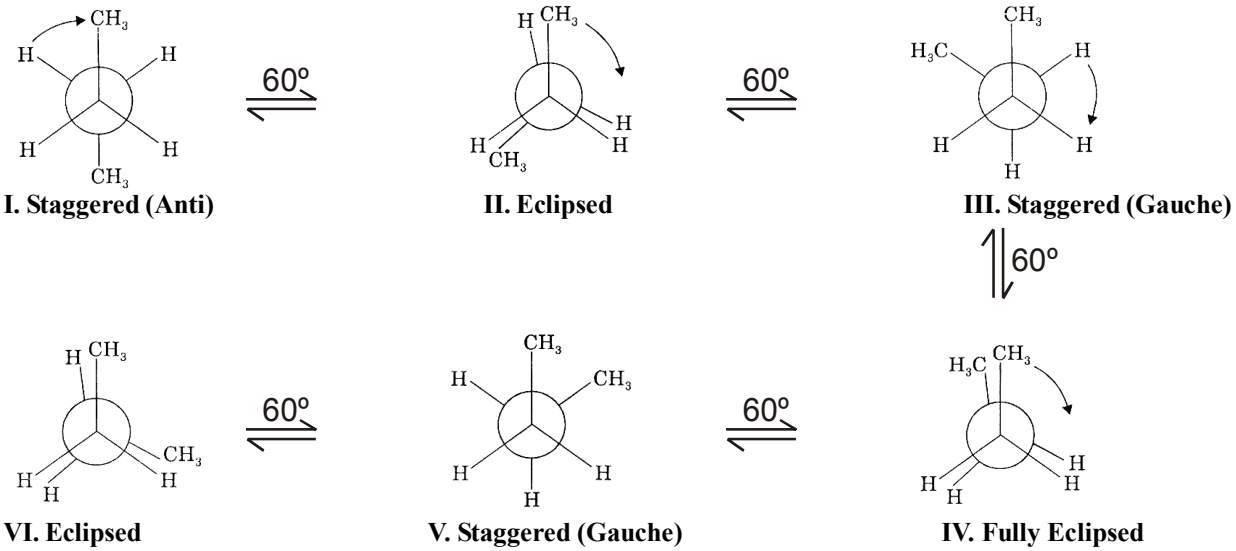
The energy required to rotate the ethane molecule about 'C–C' bond is called torsional energy

Conformations of Butane

Butane molecule can be represented as derivative of ethane as given below :



Considering the rotation around single bond between C-2 and C-3 we get many conformations. Some of them have been given as Newman Projections in figure.



I. Staggered (Anti) **II. Eclipsed** **III. Staggered (Gauche)**

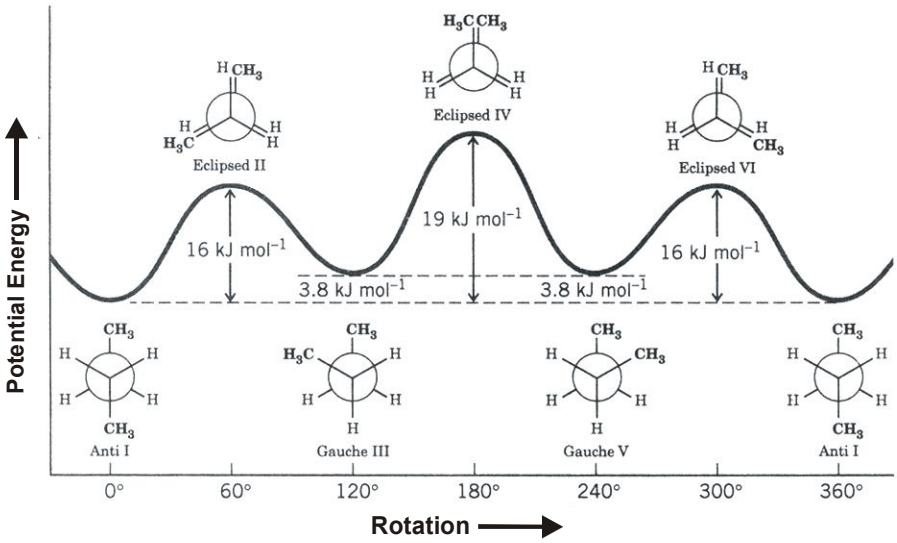
VI. Eclipsed **V. Staggered (Gauche)** **IV. Fully Eclipsed**

Conformations of Butane

Staggered conformations (I), in which methyl groups are as far apart as possible, is most stable due to minimum repulsion between methyl groups. This conformations is also called **anti** conformations. This on rotation through 60º gives eclipsed conformations (II), in which methyl group on one carbon is overlapped by the hydrogen atom on the other carbon.

Further rotation through 60º gives another staggered conformation (III). The conformation is also called **gauche** conformation. Gauche conformation on further rotation through 60° gives **fully elipsed conformation (IV).** (IV) in which methyl groups on two carbons are just opposite each other. In this conformations steric strain is maximum hence this conformations is most unstable. Further rotation through 60º gives again gauche conformations (V) which is mirror image of gauche conformation (III). Conformation (V), on rotation through 60º gives conformation (VI) which is again eclipsed conformation.

The energy profile diagram for the conformation of butane is given below along with the difference of energy between various conformation of butane.



Energy changes that arise from rotation about the C2—C3 bond of butane.

- **Difference between conformation and configuration**

Conformation	Configuration
1. It refers to different arrangement of atoms or groups relative to each other and raised due to free rotation round a sigma bond.	It refers to different arrangement of atoms or groups in space about a central atom.
2. The energy difference between two conformers is lower.	The energy difference between two configuration forms is large.
3. Conformers are not isomers and they can not be separated from each other.	These are optical isomers and can be separated form each other.
4. These are easily inter converted to one another.	These are not easily converted to one another.

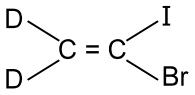
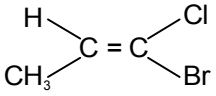
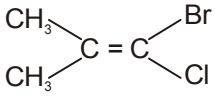
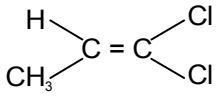
EXERCISE # 1

PART - I : OBJECTIVE QUESTIONS

** Marked Questions are having more than one correct option.*

Section A : Geometrical Isomerism

A-1. Which of the following compounds will exhibit geometrical isomerism -

(A)  (B)  (C)  (D) 

A-2. Stereoisomers have different :

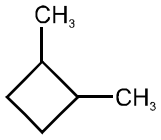
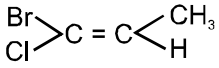
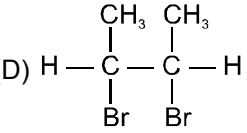
(A) Molecular formula (B) Structural formula (C) Configuration (D) Molecular mass

A-3. Geometrical isomers differ in :

(A) position of functional group (B) spatial arrangement of atoms

(C) position of atoms (D) length of carbon chain

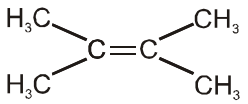
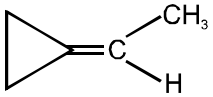
A-4. Which of the following compound does not have restricted rotation ?

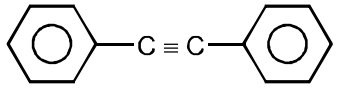
(A)  (B)  (C)  (D) 

A-5. Which of the following isomerism is shown by alkenes but not by alkanes -

(A) Conformational (B) Optical (C) Geometrical (D) Chain

A-6. Which of the following compound has restricted rotation ?

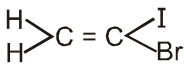
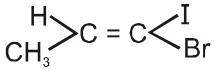
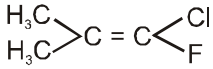
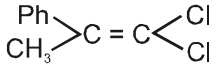
(A)  (B) 

(C)  (D) All of these

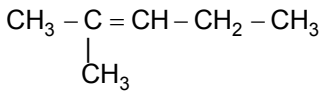
A-7. Which compound can show geometrical isomerism ?

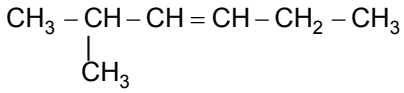
(A) $CH_3CH = C(CH_3)_2$ (B) $CH_3CH = CH_2$ (C) $CH_3CH = CHCH_3$ (D) $(CH_3)_2C = C(CH_3)_2$

A-8. Geometrical isomerism is shown by :

(A)  (B)  (C)  (D) 

A-9. Which of the following will not show cis-trans isomerism ?

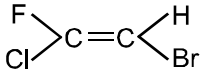
(A) 

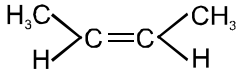
(B) 

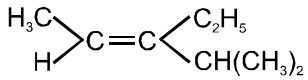
(C) $CH_3 - CH = CH - CH_3$

(D) $CH_3 - CH_2 - CH = CH - CH_2 - CH_3$

A-10. The 'E'-isomer is :

(A) 

(B) 

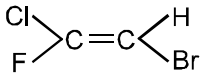
(C) 

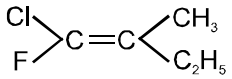
(D) none of the above

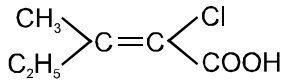
A-11. Geometrical isomerism will be exhibited by -
(A) 1-Pentene (B) 3-Methyl-1-butene (C) 2-Pentene (D) All of these compounds

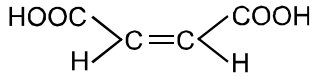
A-12. Which of the following compounds can show geometric isomerism -
(A) Vinyl chloride (B) 1, 1-Dichloroethene (C) 1, 2-Dichloroethene (D) Trichloroethene.

A-13. The 'Z'-isomer is :

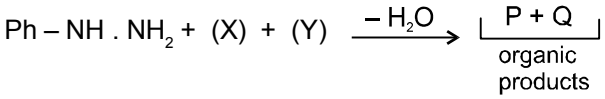
(A) 

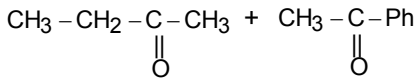
(B) 

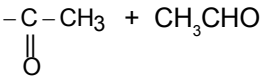
(C) 

(D) 

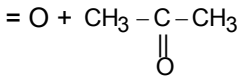
A-14. The compounds X and Y in below reaction can be



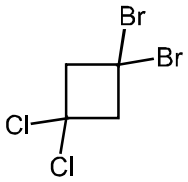
(A) 

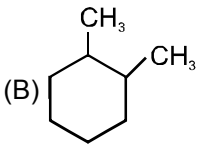
(B) 

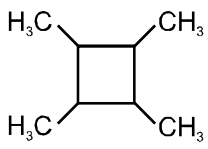
(C) $CH_2 = O + CH_3CHO$

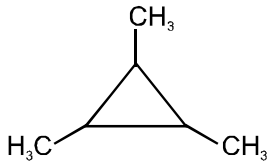
(D) 

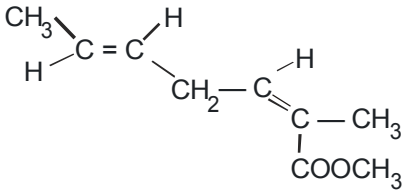
A-15. Which of the following compound can not show geometrical isomerism ?

(A) 

(B) 

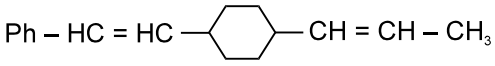
(C) 

(D) 

A-16. The correct stereochemical name of 

(A) Methyl 2-methylhepta (2E, 5E) dienoate (B) Methyl 2-methylhepta (2Z, 5Z) dienoate
(C) Methyl 2-methylhepta (2E, 5Z) dienoate (D) Methyl 2-methylhepta (2Z, 5E) dienoate

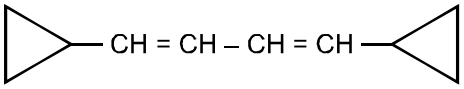
A-17. The total number of geometrical isomers possible in following compound is :



(A) 2 (B) 1 (C) 6 (D) 8

A-18. The number of geometrical isomers in the following compound is :
CH_3–CH = CH – CH = CH – C_2H_5
(A) 4 (B) 3 (C) 2 (D) 5

A-19. The total number of geometrical isomers possible in following compound is :



(A) 4 (B) 6 (C) 3 (D) 2

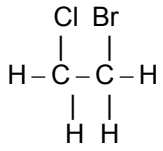
A-20. What characteristic is the best common to both cis-2-butene and trans-2-butene?
(A) B.P. (B) Dipole moment
(C) heat of hydrogenation (D) Product of hydrogenation

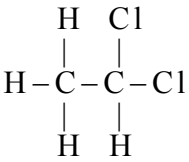
Section : (B) Optical Isomerism

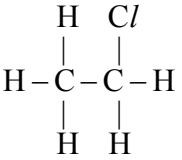
B-1. Optically active isomers but not mirror images are called -

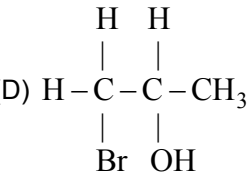
(A) Enantiomers (B) Meso (C) Tautomers (D) Diastereomers

B-2. Which of the following have asymmetric carbon atom?

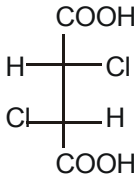
(A) 

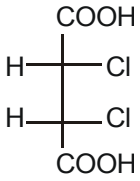
(B) 

(C) 

(D) 

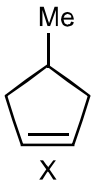
B-3. Two isomer are :

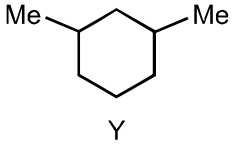


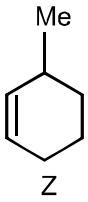


(A) Enantiomers (B) Mesomers (C) Diastereomers (D) Position isomer

B-4. Number of chiral carbon atoms in the compound x, y and z respectively would be :

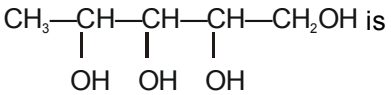






(A) 0, 2, 1 (B) 1, 0, 1 (C) 1, 2, 1 (D) 1, 2, 0

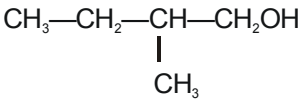
B-5. The number of optically active isomers possible for



(A) 2 (B) 4 (C) 6 (D) 8

B-6. Which of the following compounds can not exist as enantiomers -

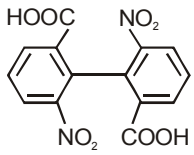
(A) CH_3—CH(OH)COOH

(B) 

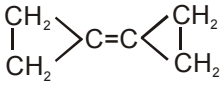
(C) $C_6H_5CH_2$—CH_3

(D) $C_6H_5CHClCH_3$

B-7. Which of the following compounds exhibit optical isomerism ?

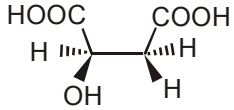
(A) 

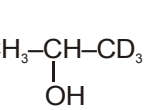
(B) $CH_2=C=CH_2$

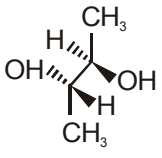
(C) 

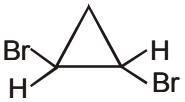
(D) None of these

B-8. Which of the following will not show optical activity ?

(A) 

(B) 

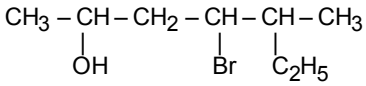
(C) 

(D) 

B.9. Which of the following can exist as enantiomers -
(A) CH_3COOH (B) $CH_3.CH(OH).COOH$ (C) $CH_3.CH_2.COOH$ (D) $HOOC.CH_2.COOH$

B.10. A compound whose molecules are optically inactive even though they contain asymmetric carbon atoms is called :
(A) A threo compound (B) A erythro compound
(C) A dissymmetric compound (D) A meso compound

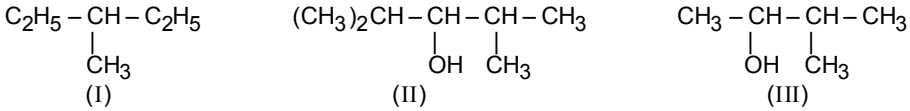
B-11. Number of chiral carbon persent in the following compound :



(A) 2 (B) 3 (C) 4 (D) 5

B-12. The total number of optically active isomer for $CH_2OH(CHOH)_3CHO$ is -
(A) 2 (B) 4 (C) 8 (D) 12

B-13. Observe the following structures I to III



(I) (II) (III)

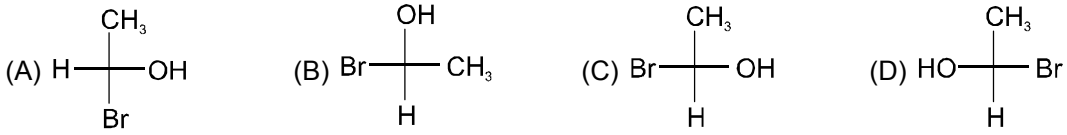
Correct statement is :
(A) All three are chiral compounds (B) I & II are chiral
(C) Only II is chiral (D) Only III is chiral

B-14. Meso-tartaric acid and d-tartaric acid are-
(A) positional isomers (B) enantiomers (C) diastereomers (D) racemic mixture

B-15. Which of the following does not contain any asymmetric carbon but can show enantiomers -
(A) Lactic acid (B) 1, 3-Pentadiene (C) Tartaric acid (D) 2, 3-Pantadiene

B-16. The number of optically active compounds in the isomers of C_4H_9Br is
(A) 1 (B) 2 (C) 3 (D) 4

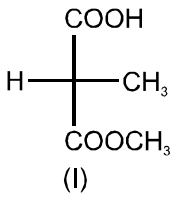
B-17. Which of the following compound has 'S' configuration ?

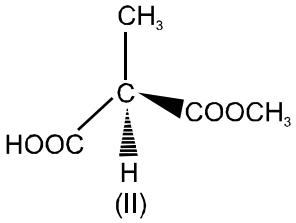


B-18. Which of the following compounds can exist in meso-form-
(A) 1, 2-Dichlorobutane (B) 2, 3-DichloroPentane
(C) 2, 3-Dichlorobutane (D) 1, 2-DichloroPentane

B-19. Which of the following is responsible for the inability of meso compound to show optical activity -
(A) Absence of chirality centre (B) Presence of more than one chirality centres
(C) Dissymmetric nature of its structure (D) Internal compensation.

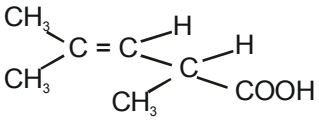
B-20. The correct configuration assigned for compound (I) & (II) respectively are :


(I)


(II)

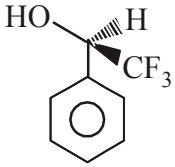
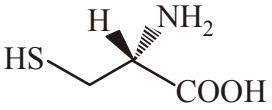
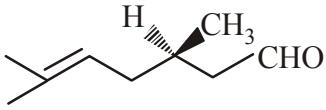
(A) R, R (B) S, S (C) S, R (D) R, S

B-21. The number of optically active isomers observed in 2,3-dichlorobutane is:
(A) 0 (B) 2 (C) 3 (D) 4

B-22. The compound can exhibit 

(A) Geometrical isomerism (B) Geometrical and optical isomerisms
(C) Optical isomerism (D) Tautomerism

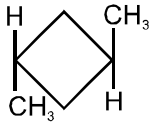
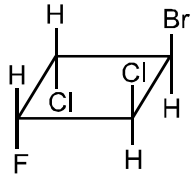
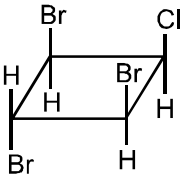
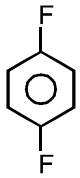
B-23. The R/S configuration of these compounds are respectively.

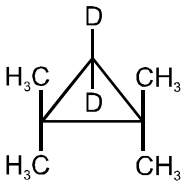
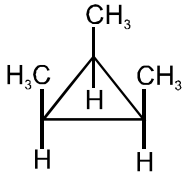
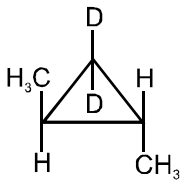
(A) R,R,R (B) R,S,R (C) R,S,S (D) S,S,S

B-24. The instrument which can be used to measure optical activity, i.e., specific rotation:
(A) Refractometer (B) Photometer (C) Voltmeter (D) Polarimeter

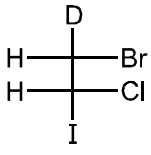
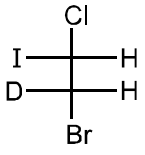
B-25. Which of the following compound has plane of symmetry (POS) but not centre of symmetry (COS) ?

(A) 
(B) 
(C) 
(D) 

B-26. Which of the following compound does not possess a C_2 axis of symmertry ?

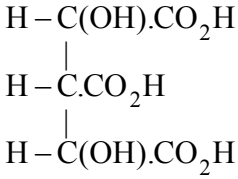
(A) 
(B) 
(C) 
(D) 

B-27. The two compounds given below are :

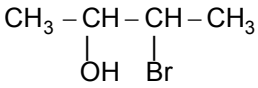
(A) Enantiomer (B) Identical (C) Meso compound (D) Diastereomers

B-28. How many stereoisomers can exist for the following acid



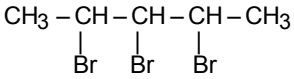
(A) Two (B) Four (C) Eight (D) Sixteen

B-29. Total number of stereoisomers of compound is :



(A) 2 (B) 4 (C) 6 (D) 8

B-30.

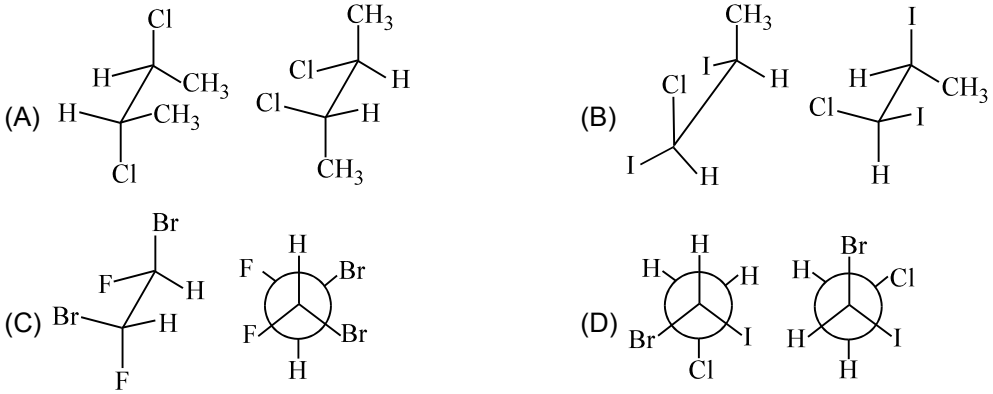


Total number of stereoisomers in above compound :

(A) 6 (B) 4 (C) 8 (D) 16

Section (C) Conformational Isomerism

C-1. Which of the following pairs of compound is/are identical ?



C-2. The eclipsed and staggered conformation of ethane is due to -

(A) Free rotation about C–C single bond (B) Restricted rotation about C–C single bond

(C) Absence of rotation about C–C bond (D) None of the above

C-3. Increasing order of stability among the three main conformation (i.e. eclipse, anti, gauche) of ethylene glycol is:

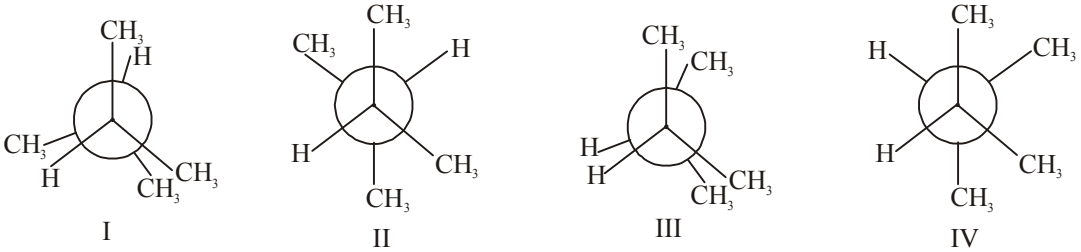
(A) Eclipse, gauche, anti (B) Gauche, eclipse, anti

(C) Eclipse, anti, gauche (D) Anti, gauche, eclipse

C-4. Which of the following conformations of n-butane is the least stable -

(A) Gauche (B) Anti (C) Eclipsed (D) Fully eclipsed

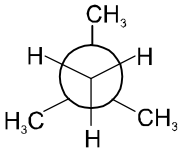
C-5. In which of the following has minimum torsional strain and minimum Vander waal strain.

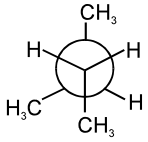


(A) I (B) II (C) III (D) IV

C-6. The energy difference between staggered and eclipsed conformations of ethane is about -
(A) 25 kJ/mole (B) 30 kJ/mole (C) 100 kJ/mole (D) 12.5 kJ/mole

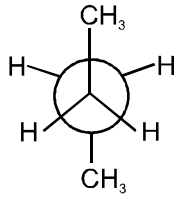
C-7. The two structures I & II represents :

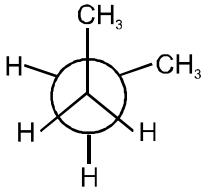

(I)

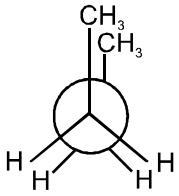

(II)

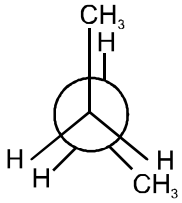
(A) Conformational isomers (B) Stereoisomers
(C) Constitutional isomers (D) Identical

C-8. Which of the following is represent the staggered conformation with dihedral angle $\phi = 60$?

(A) 

(B) 

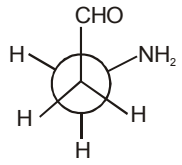
(C) 

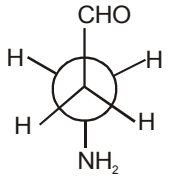
(D) 

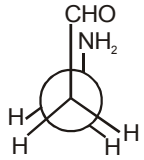
C-9. In the Newman projection formula of the least stable staggered form of n–butane, Which of the following reasons is the causes of its unstability ?
(A) Vander–Waal's strain (B) Torsional strain
(C) Combination of both. (D) None of these

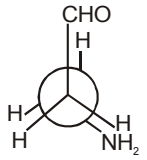
C-10. The dihedral angle between two methyl groups in partially eclipsed conformation of n-butane is
(A) 180° (B) 120° (C) 90° (D) 109° 28'

C-11. Which of the following is most stable ?

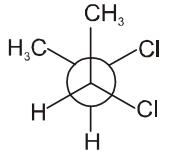
(A) 

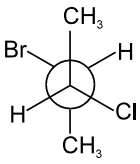
(B) 

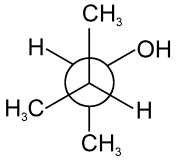
(C) 

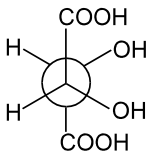
(D) 

C-12. Which of the following is an achiral molecule ?

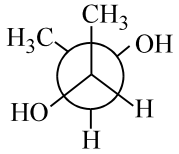
(A) 

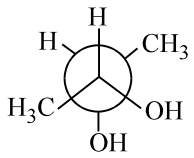
(B) 

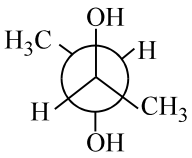
(C) 

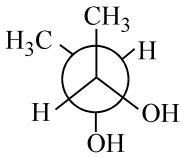
(D) 

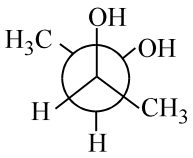
C-13*. Which of the following molecules is/are identical with that represented by



(A) 

(B) 

(C) 

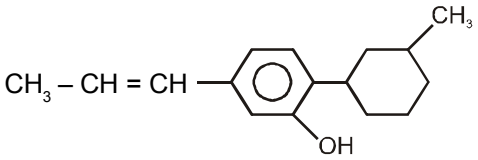
(D) 

PART - II : MISCELLANEOUS QUESTIONS

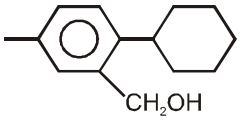
Comprehensions Type :

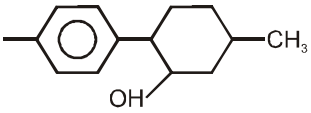
Comprehension # 1

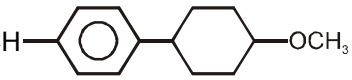
Observe the following compound and answer the question 1 to 3

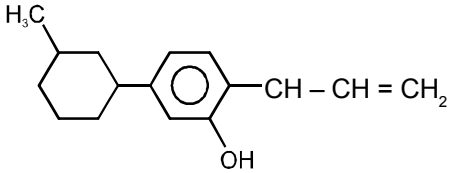


1. Which of the following cannot be its functional isomer,

(A) 

(B) 

(C) 

(D) 

2. The total number of its geometrical isomers is :

(A) 2 (B) 4 (C) 8 (D) 16

3. The number of chiral (asymmetric) carbon atom it has,

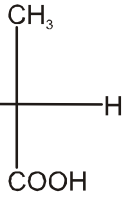
(A) 3 (B) 2 (C) 1 (D) 4

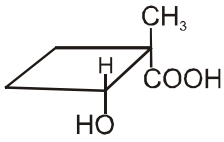
Comprehension # 2

The simple axis of symmetry is defined as n fold axis of symmetry denoted as C_n. It is an axis such that if one rotates the molecule about the axis by 360/n , the new position of model is superimposable with original one.

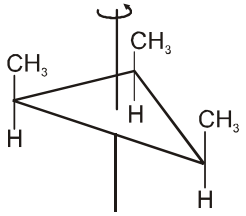
It is clear that if molecule is turned by 360° (n = 1) along any axis new position is superimposable. Thus C_1 symmetry is universaly present in all compounds.

4 Which of them contains C_1 axis of symmetry

(A) 

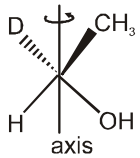
(B) 

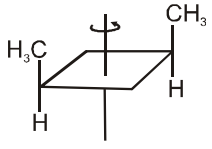
(C) CH_4 (D) All

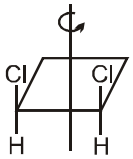
5. In the molecule  which axis of symmtry exists along the given axis.

(A) C_2 (B) C_3 (C) C_4 (D) All of the above

6. In which C_2 axis is present along the given axis

(A) 

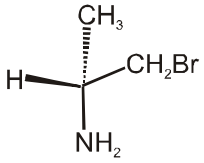
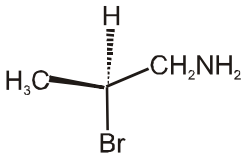
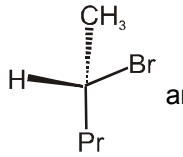
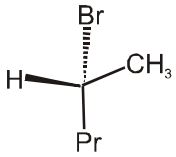
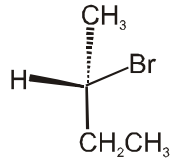
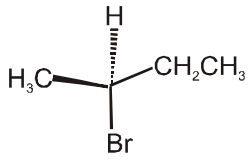
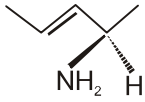
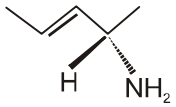
(B) 

(C) 

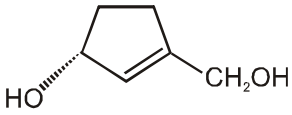
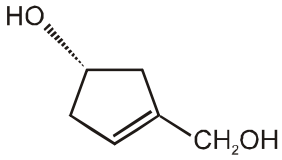
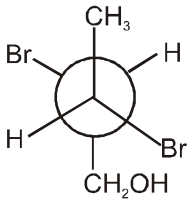
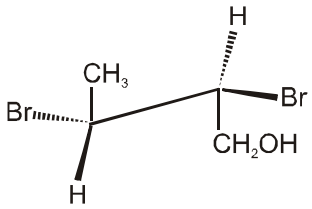
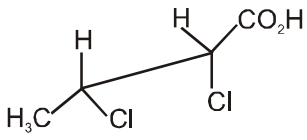
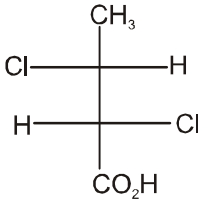
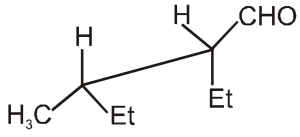
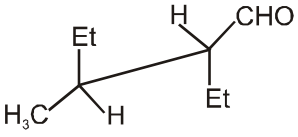
(D) None of these

Match the column Type

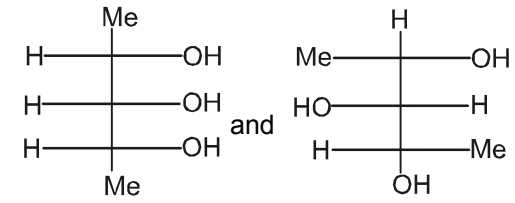
7.

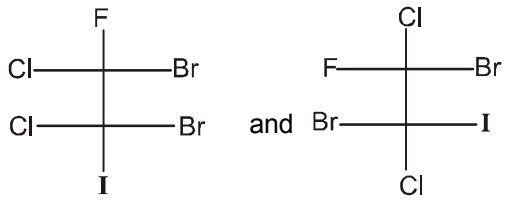
	Column – I		**Column – II**
(A)	 and 		(p) Enantiomer
(B)	 and 		(q) Diastereomer
(C)	 and 		(r) Structural Isomer
(D)	 and 		(s) Identical

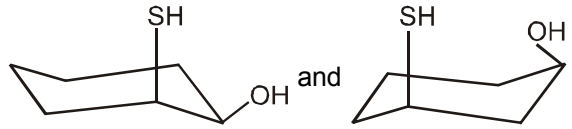
8.

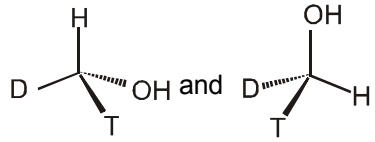
	Column – I		**Column – II**
(A)	 and 		(p) Diastereomer
(B)	 and 		(q) Identical
(C)	 and 		(r) Enantiomer
(D)	 and 		(s) Structural Isomer

9. **Column – I** **Column – II**

(A)  (p) Identical

(B)  (q) Enantiomer

(C)  (r) Diastereomer

(D)  (s) Position isomer

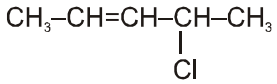
Assertion / Reasoning Type

DIRECTIONS :

Each question has 5 choices (A), (B), (C), (D) and (E) out of which ONLY ONE is correct.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.
(C) Statement-1 is True, Statement-2 is False.
(D) Statement-1 is False, Statement-2 is True.
(E) Statement-1 and Statement-2 both are False.

10. **Statement-1 :** For the given compound the two isomers of configurations trans (R) and trans (S) are enantiomers.



Statement-2 : The two isomers in statement-1 are mirror image stereoisomers.

11. **Statement-1 :** In $CH_3–CH_3$ the conformations at all energy minima are degenerate. (degenerate = of same energy)
Statement-2 : At energy minima the torsional strain is minimum.

12. **Statement-1 :** An achiral molecule always has plane of symmetry as well as centre of symmetry.
Statement-2 : Molecular symmetry arises only when plane of symmetry & centre of symmetry both are present.

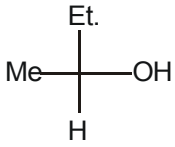
13. **Statement-1 :** All the hydrogen atoms in $CH_2=C=CH_2$ lie in one plane.
Statement-2 : All the carbon atoms in it are sp^2-hybridised

14. **Statement-1 :** Benzaldehyde forms two oximes on reacting with NH_2OH.
Statement-2 : The two oximes arise due to geometrical isomerism.

EXERCISE # 2

PART - I : MIXED OBJECTIVE

* ***Marked Questions are having more than one correct option.***

1.  it has chiral centre (). It is -

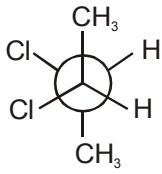
(A) R (B) S (C) Both (D) None

2. How many conformations does ethane have :

(A) 1 (B) 2 (C) 3 (D) Infinite

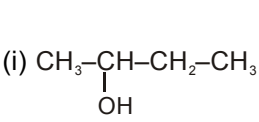
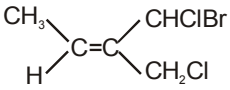
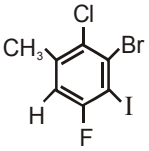
3. Isomers which can be inter converted through rotation around a single bond are -

(A) Conformers (B) Diastereomers (C) Enantiomers (D) Position isomers

4. Compound  contains how many chiral centres

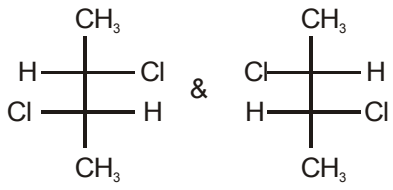
(A) 1 (B) 2 (C) 3 (D) None of these

5. Which of the following compounds can be optically active

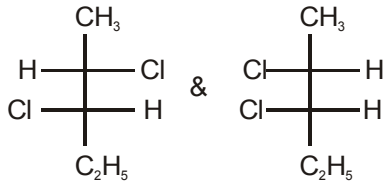
(i)  (ii)  (iii) $CH_3–C\equiv C–CH=CH–CH_3$ (iv) 

(A) All (B) (i), (ii) (C) (i), (ii), (iii) (D) (i), (iii)

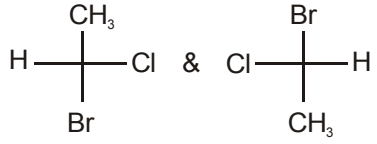
6. Optically inactive is

(A) 

equimolar mixture

(B) 

equimolar mixture

(C) 

equimolar mixture

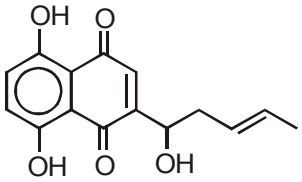
(D) None of these

7. Two optically active acyclic compounds X and Y (molecular formula C_5H_9Br) give following reactions

$X \xrightarrow{H_2(1\,mol)} W$ (achiral); $Y \xrightarrow{H_2(1\,mol)} S$ (chiral), X is

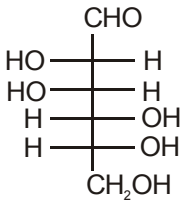
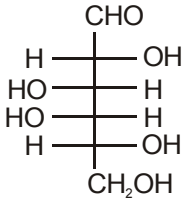
(A) 3-bromo-pent-1-ene (B) 4-bromopent-2-ene

(C) 3-bromo-cyclopent-2-ene (D) None of these

8. 

For the above molecule how many chiral centres are possible

(A) 1 (B) 2 (C) 3 (D) None of these

9. D-mannose and D-galactose are  D-Mannose  D-Galactose

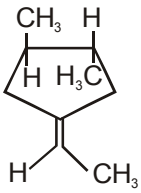
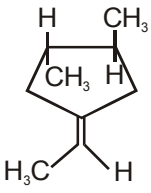
(A) enantiomers (B) diastereomers (C) epimers (D) not stereoisomers

10. How many chiral centers are present in D-glucose ?

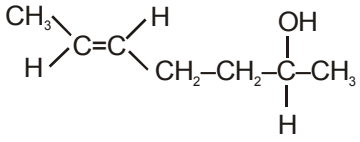
(A) 0 (B) 1 (C) 4 (D) 6

11. The total number of optically active stereoisomers for the glucose molecule are

(A) 0 (B) 4 (C) 8 (D) 16

12.  &  are

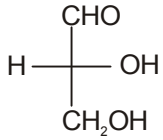
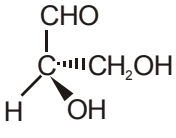
(A) enantiomers (B) diastereomers (C) geometrical isomers (D) same structure

13. The compound, whose stereo-chemical formula is written below, exhibits x-geometrical isomers and y-optical isomers 

The values of x and y are

(A) 4 and 4 (B) 2 and 2 (C) 2 and 4 (D) 4 and 2

14. By Fischer projections glyceryl aldehyde is represented as

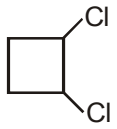
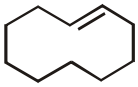
(A)  (B)  (C) Both true (D) None of these

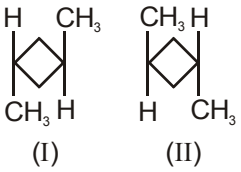
15. Type of isomerism shown by the product of the reaction between benzaldehyde and hydroxyl amine is

(A) syn and anti geometrical (B) cis and trans geometrical

(C) E and Z geometrical (D) None of these

16. Which will form geometrical isomers ?

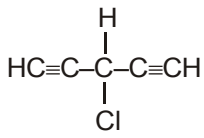
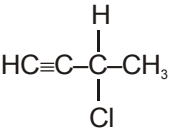
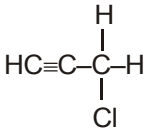
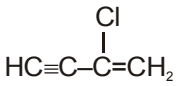
(A)  (B) $CH_3CH=NOH$ (C)  (D) All

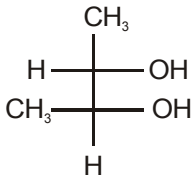
17.  I and II are

(I) (II)

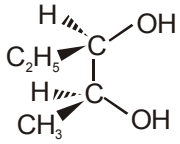
(A) chiral-identical mirror images (B) chiral-enantiomers
(C) geometrical isomer (each separately) (D) racemic mixture

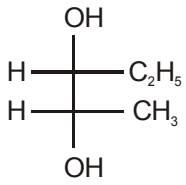
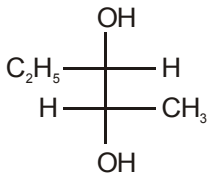
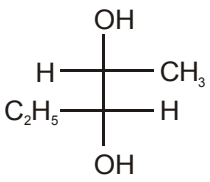
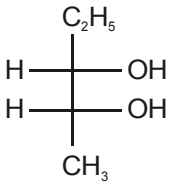
18. Which of the following is most likely to show optical isomerism ?

(A)  (B)  (C)  (D) 

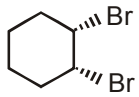
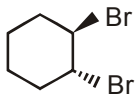
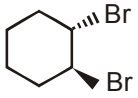
19. Correct configuration of the compound  is

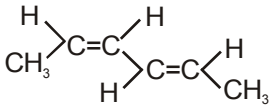
(A) 1S, 2S (B) 1S, 2R (C) 1R, 2S (D) 1R, 2R

20. Fischer projection formula of compound  can be represented as :

(A)  (B)  (C)  (D) 

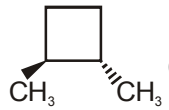
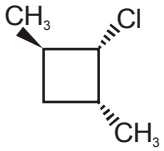
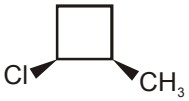
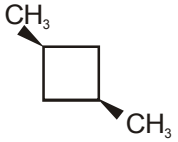
21. Select 'cis' isomer among the following :

(A)  (B)  (C)  (D) None of these

22. The correct name of the structure 

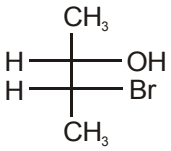
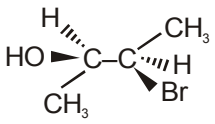
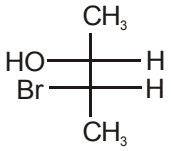
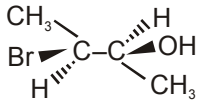
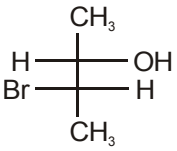
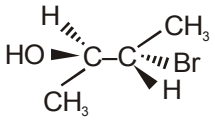
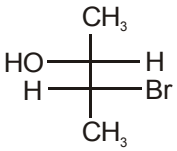
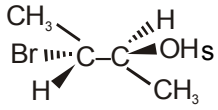
(A) (E), (E)-2,4-hexadiene (B) (Z), (Z)-2,4-hexadiene
(C) (E), (Z)-3,5-hexadiene (D) (Z), (E)-2,4-hexadiene

23. Which of the following is/are chiral ?

(i)  (ii)  (iii)  (iv) 

(A) (i), (ii), (iii) (B) (i), (ii), (iv) (C) (ii), (iii), (iv) (D) (i), (iii), (iv)

24. Match List I, List II, List III and select the correct answer from the given codes

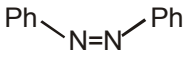
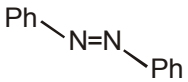
List I (Fischer Projection)	**List II (Perspective formulas)**	**List III (Name of the Compounds)**
(a) 	(1) 	(i) (2R, 3R) -3-bromo-2-butanol
(b) 	(2) 	(ii) (2S, 3S) -3-bromo-2-butanol
(c) 	(3) 	(iii) (2S, 3R) -3-bromo-2-butanol
(d) 	(4) 	(iv) (2R, 3S) -3-bromo-2-butanol

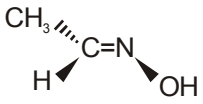
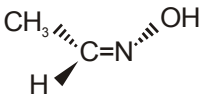
Codes :

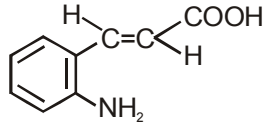
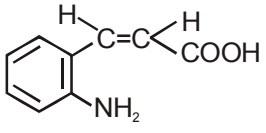
(A) (A–1–i); (B–2–ii); (C–3–iii); (D–4–iv) (B) (A–4–iii); (B–3–iv); (C–2–ii); (D–1–i)

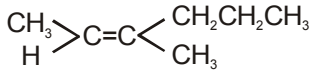
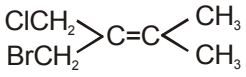
(C) (A–4–iv); (B–3–iii); (C–2–ii); (D–1–i) (D) (A–3–iii); (B–4–ii); (C–2–i); (D–1–iv)

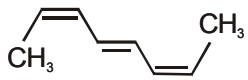
25. For which of the following pairs of compounds are the incorrect notations given ?

(A)  syn-azobenzene and  anti-azobenzene

(B)  syn-acetaldoxime and  Anti-acetaldoxime

(C)  Trans-o-aminocinnamic acid and  Cis-o-aminocinnamic acid

(D)  Z-isomer and  E-isomer

26. The IUPAC name of the compound 

(A) (2E, 4E, 6Z)-octa-2,4,6-triene
(B) (2E, 4E, 6E)-octa-2,4,6-triene
(C) (2Z, 4E, 6Z)-octa-2,4,6-triene
(D) (2Z, 4Z, 6Z)-octa-2,4,6-triene

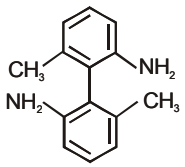
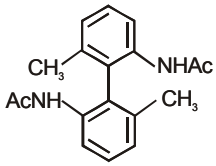
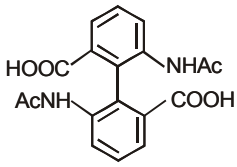
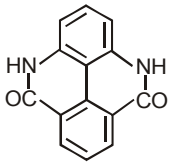
27. Match List I with List II and select the correct answer from the given codes :

List I (Compound)	**List II (Number of optical isomers)**
(A) A symmetrical compound with 'n' chiral carbon	(i) 2^{n-1}
(B) Symmetrical molecule with 'n' chiral carbon when n is even	(ii) $2^{n-1}+2^{\frac{n-1}{2}}$
(C) Symmetrical molecule with 'n' chiral carbon when n is odd	(iii) 2^n

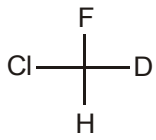
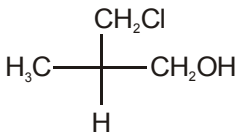
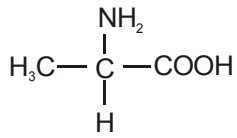
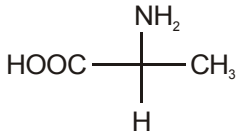
Codes :

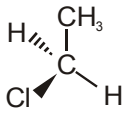
	A	**B**	**C**
(A)	1	2	3
(B)	3	2	1
(C)	3	1	2
(D)	2	3	1

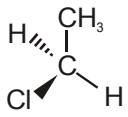
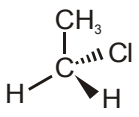
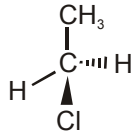
28. Select the optically inactive compound among the following :

(A) 
(B) 
(C) 
(D) 

29. Identify, which of the following molecule does not have 'R' configuration ?

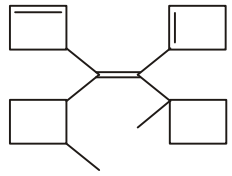
(A) 
(B) 
(C) 
(D) 

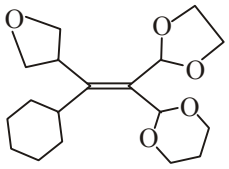
30. Which of the following is the enantiomer of the structure 

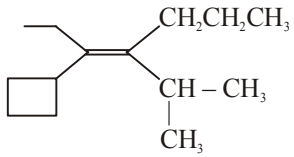
(A) 
(B) 
(C) 
(D) It does not have an enantiomer

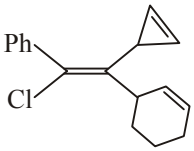
PART - II : SUBJECTIVE QUESTIONS

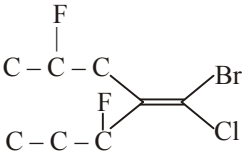
1. Assign E & Z configuration?

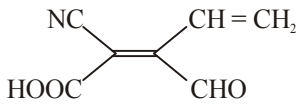
(I) 

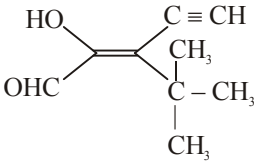
(II) 

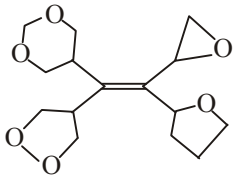
(III) 

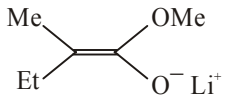
(IV) 

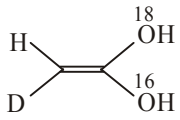
(V) 

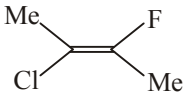
(VI) 

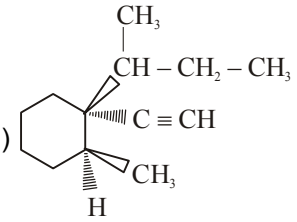
(VII) 

(VIII) 

(IX) 

(X) 

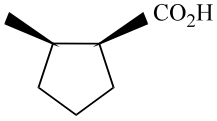
(XI) 

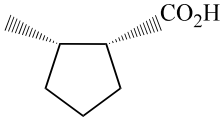
(XII) 

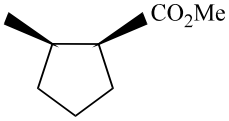
2. Write the structure of:

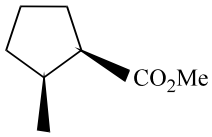
(i) (E) penta-1,3-diene
(ii) (2Z, 4E)hexa-2,4-diene
(iii) (2E, 4E)-3-ethylhexa-2,4-diene
(iv) (R)-2-Bromopentane
(v) (S)-3-bromo-3-chlorohexane
(vi) (2S, 3R)-2,3-dibromobutane

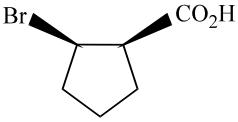
3. What are the relationships between the following pairs of isomers?

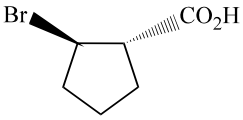
(a) 

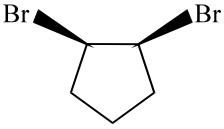
and 

(b) 

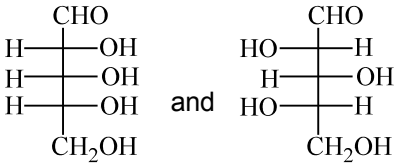
and 

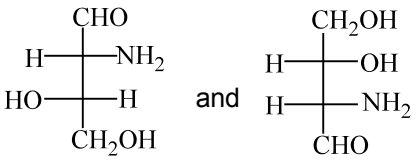
(c) 

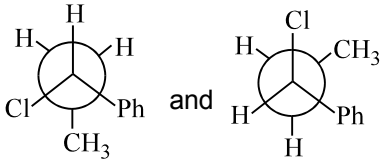
and 

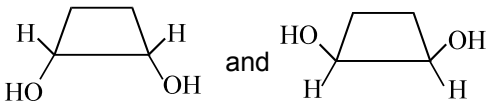
(d) 

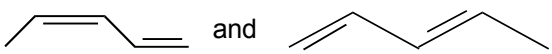
and 

(e) 

(f) 

(g) 

(h) 

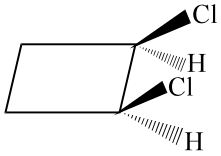
(i) 

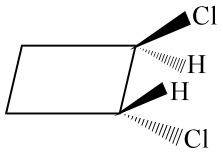
4. Mention the specific type of isomerism exhibited by each of the following pairs:
(a) 1,2-dichloro ethane and 1,1-dichloro ethane
(b) Propanoic acid and methyl acetate
(c) Methyl acetate and ethyl formate
(d) o-Nitrophenol and P-nitrophenol
(e) Anisole and o-cresol
(f) Phenol and Cyclohexa-2,4-dien-1-one

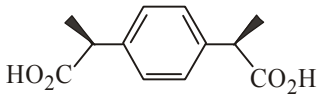
5. Find out the total number of cyclic isomers of C_6H_{12} which are optically active?

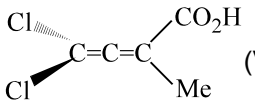
6. How many cyclopentane structures (including stereo) are possible for C_7H_{14}.

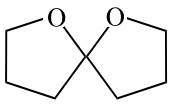
7. With reasons, state whether each of the following compounds I to IX is chiral.

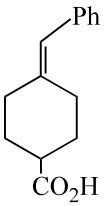
(I) 

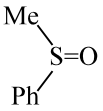
(II) 

(III) 

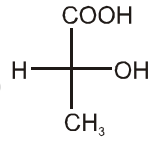
(IV) 

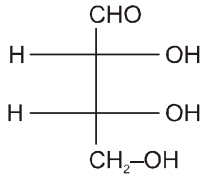
(V) 

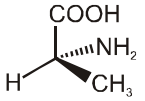
(VI) 

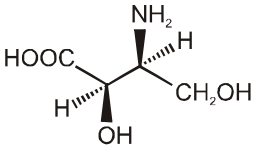
(VII) 

8. Find D/L configuration in the following molecules.

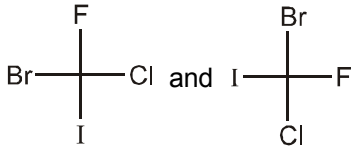
(I) 

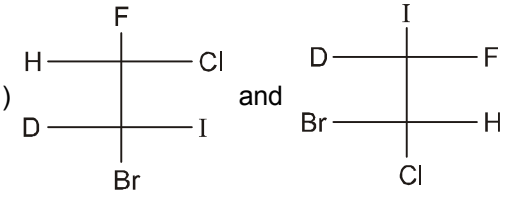
(II) 

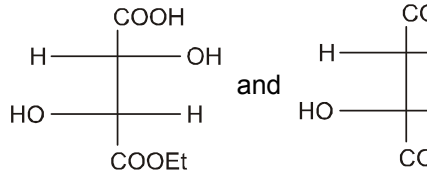
(III) 

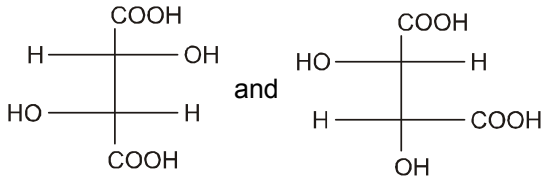
(IV) 

9. Find relationship between the given pairs.

(I) 

(II) 

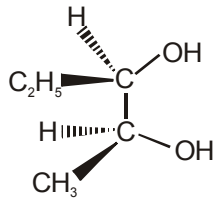
(III) 

(IV) 

10. For the given compound $CH_3 - \underset{\underset{OH}{|}}{CH} - CH = CH - CH_3$.

(I) Find total number of stereoisomers.
(II) Number of optically active stereoisomers.
(III) Total number of fractions on fractional distillation of all stereoisomers.

11.



Fischer projection formula of this compound can be represented as :

12. What does D/L & d/ℓ represent.

13. Optical purity or enantiomeric excess is given as

$$\text{optical purity} = \frac{\text{excess of one enantiomer over other}}{\text{entire mixture}} \times 100$$

If optical purity of a d–ℓ mixture is 72% and it is known that d isomer is in excess then what is the percentage of this excess isomer

14. (+)-Mandelic acid has a specific rotation of + 158 unit. What would be the observed specific rotation of each of the following mixture ?
(a) 25% (–)-mandelic acid and 75% (+)-mandelic acid
(b) 50% (–)-mandelic acid and 50% (+)-mandelic acid
(c) 75% (–)-mandelic acid and 25% (+)-mandelic acid.

15. Write the newman projection formula along C_1–C_2 bonds in staggered form of following compounds.

(I) $\overset{1}{C}H_3–\overset{2}{C}H_2–CH_3$

(II) $\overset{1}{C}H_3–\overset{2}{C}H(CH_3)–CH_3$

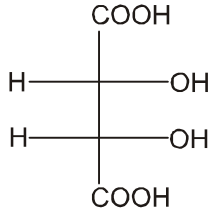
(III) $\overset{1}{C}H_3–\overset{2}{C}H(CH_3)–CH_3$ (with CH_3 on C2)

(IV) $CH_3–\overset{1}{C}H(CH_3)–\overset{2}{C}H–CH_3$ (with CH_3 on C1 and C2)

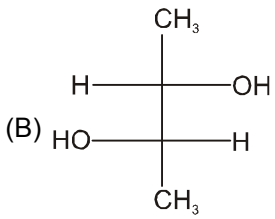
16. Write the newman projection formula of the following compounds
(I) $Cl–CH_2–CH_2–CH_3$ in its most polar form.
(II) $Cl–CH_2–CH_2–Cl$ in its most stable form.
(III) $HO–CH_2–CH_2–OH$ in its most stable form.
(IV) $HOOC–CH_2–CH_2–COOH$ in its least stable staggered form.

17. Convert the following Fischer projection into Newmann & Sawhorse projection

(A)



(B)



EXERCISE # 3

PART - I : IIT-JEE PROBLEMS (PREVIOUS YEARS)

** Marked Questions are having more than one correct option.*

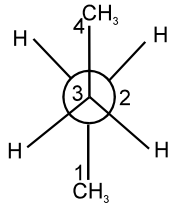
1. Which of the following compounds exhibits stereoisomerism ? **[JEE-2002(S), 3/90]**
(A) 2-methylbutene-1 (B) 3-methylbutyne-1
(C) 3-methylbutanoic acid (D) 2-methylbutanoic acid

2. An enantiomerically pure acid is treated with racemic mixture of an alcohol having one chiral carbon. The ester formed will be : **[JEE-2003(S), 2/84]**
(A) Optically active mixture (B) Pure enantiomer
(C) Meso compound (D) Racemic mixture

3. A recemic mixture of (±) 2-phenylpropanoic acid on esterification with (+) 2-butanol gives two ester. Mention the stereochemistry of the two esters produced. **[JEE-2003(M), 2/60]**

4. Give the Newman projection formula of the least stable staggered form of n–butane. Which of the following reasons is the causes of its unstability ? **[JEE-2004, 2/60]**
(i) Vander–Waal's strain (ii) Torsional strain (iii) Combination of both.

5. Newman projection of Butane is given,C-2 is rotated by 120º along C-2 & C-3 bond in anticlockwise direction the conformation formed is : **[JEE-2004, (S) 2/84]**



(A) staggered (B) fully eclipsed (C) gauche (D) partially eclipsed

6. It is given that for conformational isomers, the net dipole moment is **[JEE-2005, 6/60]**

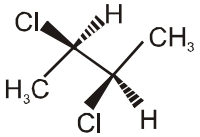
$\mu_{obs} = \Sigma \mu_i x_i$

where μ_{obs} = obsereved dipole moment of the compound
μ_i = dipole moment of the stable conformational isomers
x_i = mole fraction of stable conformers

for the compound $Z - CH_2 - CH_2 - Z$ draw the Newman projection formula of all the stable conformational isomers, if μ_{obs} = 1D, and x_{anti} = 0.82, and find μ_{gauche}. Now draw the Newman projection formula of the most stable conformation of meso Y – CHD – CHD – Y
(a) If Y is CH_3 (rotation about $C_2 - C_3$ bond)
(b) If Y is OH (rotation about $C_1 - C_2$ bond)

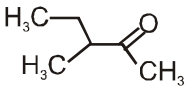
7. **Statement-1 :** Molecules that are not superimposable on their mirror images are chiral. because
Statement-2 : All chiral molecules have chiral centres. **[JEE-2007, 3/162]**
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.
(C) Statement-1 is True, Statement-2 is False.
(D) Statement-1 is False, Statement-2 is True.

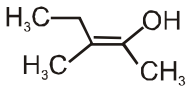
8.* The correct statement(s) about the compound given below is (are) **[JEE-2008, 4/163]**

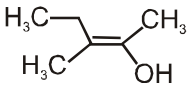


(A) The compound is optically active
(B) The compound possesses centre of symmetry
(C) The compound possesses plane of symmetry
(D) The compound possesses axis of symmetry

9.* The correct statements(s) concerning the structures E,F and G is (are) : **[JEE-08, 4/163]**


(E)


(F)


(G)

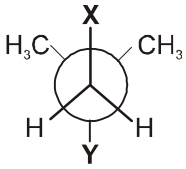
(A) E,F, and G are resonating structures (B) E,F and E, G are tautomers
(C) F and G are geometrical isomers (D) F and G are diastereomers

10.* The correct statement(s) about the compound $H_3C(HO)HC–CH=CH–CH(OH)CH_3$ **(X)** is(are) : **[JEE-2009, 4/160]**

(A) The total number of stereoisomers possible for X is 6.
(B) The total number of diastereomers possible for X is 3.
(C) If the stereochemistry about the double bond in X is trans, the number of enantiomers possible for X is 4.
(D) If the stereochemistry about the double bond in X is cis, the number of enantiomers possible for X is 2.

11. The total number of cyclic structural as well as stereo isomers possible for a compound with the molecular formula C_5H_{10} is **[JEE-2009, 4/160]**

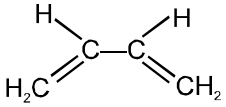
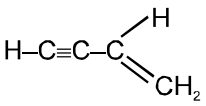
12*. In the Newman projection for 2, 2-Dimethylbutane **[JEE-2010, 3/163]**



X and **Y** can respectively be :
(A) H and H (B) H and C_2H_5 (C) C_2H_5 and H (D) CH_3 and CH_3

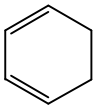
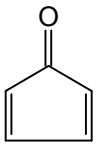
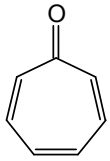
13. The total number of cyclic isomers possible for a hydrocarbon with the molecular formula C_4H_6 is / are : **[JEE-2010, 3/163]**

14*. Amongst the given options, the compound(s) in which all the atoms are in one plane in all the possible conformations (if any) is (are) : **[JEE-2011, 4/240]**

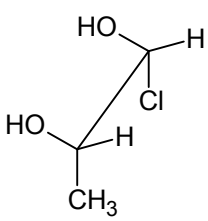
(A)  (B)  (C) $H_2C=C=O$ (D) $H_2C=C=CH_2$

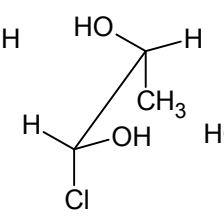
15. In allene (C_3H_4), the type(s) of hybridisation of the carbon atoms is (are) **[JEE-2012, 3/136]**
(A) sp and sp^3 (B) sp and sp^2 (C) only sp^2 (D) sp^2 and sp^3

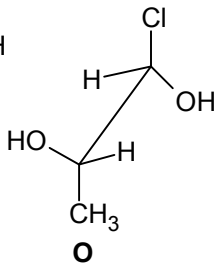
16*. Which of the following molecules, in pure form, is (are) unstable at room temperature ? **[JEE-2012, 4/136]**

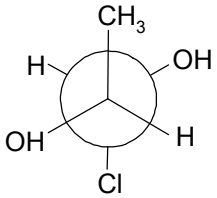
(A)  (B)  (C)  (D) 

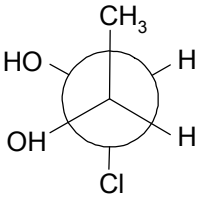
17*. Which of the given statement(s) about N, O, P and Q with respect to M is (are) correct ? **[JEE-2012, 4/136]**


M


N


O


P


Q

(A) M and N are non-mirror image stereoisomers (B) M and O are identical
(C) M and P are enantiomers (D) M and Q are identical

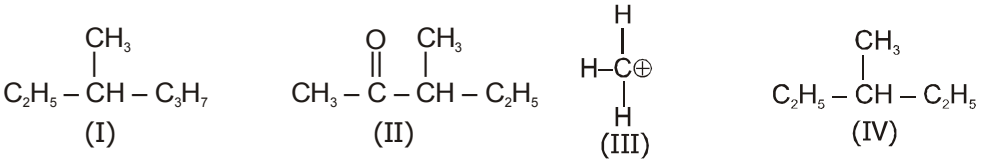
PART - II : AIEEE PROBLEMS (PREVIOUS YEARS)

1. Racemic mixture is formed by mixing two **[AIEEE 2002]**
(1) Isomeric compounds (2) Chiral compounds
(3) Meso compounds (4) Optical isomers

2. Which of the following does not show geometrical isomerism ? **[AIEEE 2002]**
(1) 1,2-Dichloro-1-pentene (2) 1,3-Dichloro-2-pentene
(3) 1,1-Dichloro-1-pentene (4) 1,4-Dichloro-2-pentene

3. The general formula $C_nH_{2n}O_2$ could be for open chain **[AIEEE 2003]**
(1) Diketones (2) Carboxylic acids (3) Diols (4) Dialdehydes

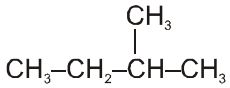
4. Among the following four structures I to IV. **[AIEEE 2003]**

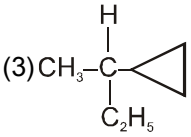


(I) (II) (III) (IV)

it is true that
(1) All four are chiral compounds (2) Only I and II are chiral compounds
(3) Only III is a chiral compound (4) Only II and IV are chiral compounds

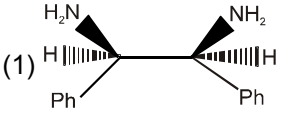
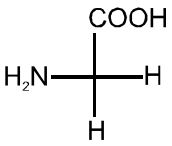
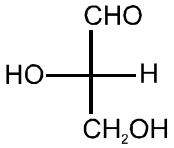
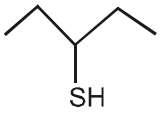
5. Amongst the following compounds, the optically acitve alkane having lowest molecular mass is **[AIEEE 2004]**

(1) $CH_3–CH_2–CH_2–CH_3$ (2) 

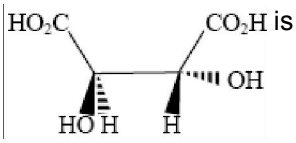
(3)  (4) $CH_3–CH_2–C\equiv CH$

6. Which of the following compounds is not chiral ? **[AIEEE 2004]**
(1) 1–Chloropentane (2) 2-Chloropentane
(3) 1-Chloro-2-methylpentane (4) 3-Chloro-2-methylpentane

7. Which of the following molecules is expected to rotate the plane of polarized light? **[AIEEE 2007, 3/120]**

(1)  (2)  (3)  (4) 

8. The correct decreasing order of priority for the functional groups of organic compounds in the IUPAC system of nomenclature is **[AIEEE 2008, 3/105]**
(1) $–SO_3H$, –COOH, $–CONH_2$, –CHO (2) –CHO, –COOH, $–SO_3H$, $–CONH_2$
(3) $–CONH_2$, –CHO, $–SO_3H$, –COOH (4) –COOH, $–SO_3H$, $–CONH_2$, –CHO

9. The absolute configuration of  is **[AIEEE 2008, 3/105]**

(1) R, R (2) R, S (3) S, R (4) S, S

10. The alkene that exhibits geometrical isomerism is : **[AIEEE 2009, 4/144]**
(1) 2-methyl propene (2) 2-butene (3) 2-methyl-2-butene (4) propene

11. The number of stereoisomers possible for a compound of the molecular formula CH_3–CH=CH–CH(OH)–Me is: **[AIEEE 2009, 4/144]**
(1) 2 (2) 4 (3) 6 (4) 3

12. Out of the following, the alkene that exhibits optical isomerism is. **[AIEEE 2010, 4/144]**
(1) 3-methyl-2pentene (2) 4-methyl-1-pentene (3) 3-methyl-1-pentene (4) 2-methyl-2-pentene

13. Identify the compound that exhibits tautomerism. **[AIEEE 2011, 4/120]**
(1) 2-Butene (2) Lactic acid (3) 2-Pentanone (4) Phenol

14. Which one of the following statements is correct ? **[AIEEE 2012, 4/120]**
(1) All amino acids except lysine are optically active
(2) All amino acids are optically active.
(3) All amino acids except glycine are optically active
(4) All amino acids except glutamic acid are optically active

15. How many chiral compounds are possible on monochlorination of 2 - methyl butane ? **[AIEEE 2012, 4/120]**
(1) 8 (2) 2 (3) 4 (4) 6

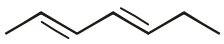
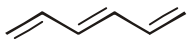
16*. Which branched chain isomer of the hydrocarbon with molecular mass 72u gives only one isomer of mono substituted alkyl halide ? **[AIEEE 2012, 4/120]**
(1) Tertiary butyl chloride (2) Neopentate
(3) Isohexane (4) Neohexane

EXERCISE # 4

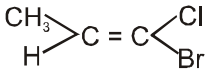
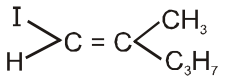
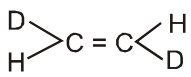
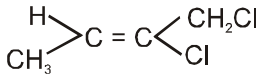
NCERT QUESTIONS

1. How many acyclic structural isomers of C_5H_{10} can show geometrical isomerism ?

2. How many cyclic structural isomers of C_5H_{10} can show geometrical isomerism.

3. Find the total number of geometrical isomers of following compounds.
(I)  (II) 

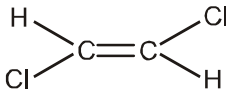
4. Write all carbonyl compounds with molecular formula C_3H_6O and then react with excess of NH_2OH and find out how many total isomeric oximes are formed.

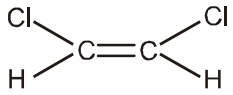
5. Indicate whether each of the following compound is 'E' or 'Z'.
(i)  (ii) 
(iii)  (iv) 

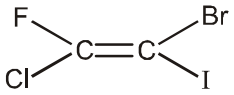
6. Carbonyl compounds react with NH_2OH forming oximes which represents geometrical isomersm. Which smallest carbonyl compounds forms oxime but does not show geometrical isomerism ?

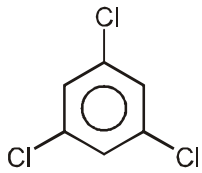
7. Calculate total number of possible geometrical isomers of Ph – CH = CH – CH = CH – COOH.

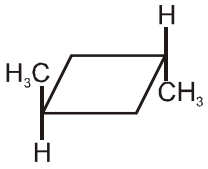
8. Find plane of symmetry and centre of symmetry (if possible) in the following compounds.

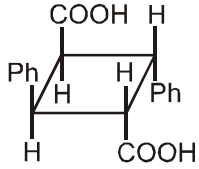
(I) 

(II) 

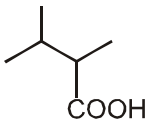
(III) 

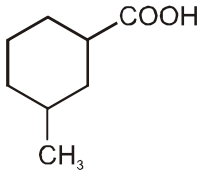
(IV) 

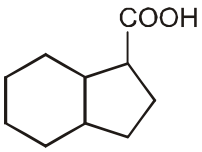
(V) 

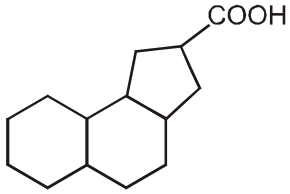
(VI) 

9. Find total number of chiral carbon atoms in the following compounds :

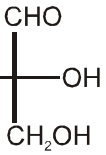
(I) 

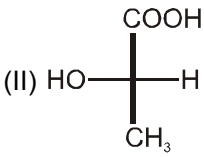
(II) 

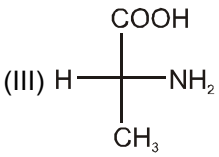
(III) 

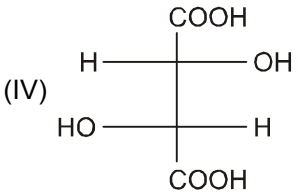
(IV) 

10. Find R/S configuration of following compounds.

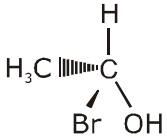
(I) 

(II) 

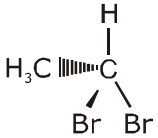
(III) 

(IV) 

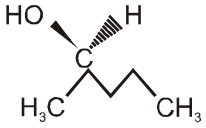
11. Identify chiral and achiral molecules in each of the following pairs of compounds :

(a) 

(i)

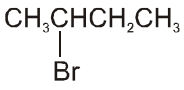


(ii)

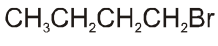
(b) 

(i)

(ii)

(c) 

(i)



(ii)

ANSWERS

Exercise # 1

PART - I

A-1.	(B)	**A-2.**	(C)	**A-3.**	(B)	**A-4.**	(D)	**A-5.**	(C)	**A-6.**	(D)	**A-7.**	(C)
A-8.	(B)	**A-9.**	(A)	**A-10.**	(C)	**A-11.**	(C)	**A-12.**	(C)	**A-13.**	(D)	**A-14.**	(D)
A-15.	(A)	**A-16.**	(D)	**A-17.**	(D)	**A-18.**	(A)	**A-19.**	(C)	**A-20.**	(D)	**B-1.**	(D)
B-2.	(D)	**B-3.**	(C)	**B-4.**	(A)	**B-5.**	(D)	**B-6.**	(C)	**B-7.**	(A)	**B-8.**	(C)
B.9.	(B)	**B.10.**	(D)	**B-11.**	(B)	**B-12.**	(C)	**B-13.**	(D)	**B-14.**	(C)	**B-15.**	(D)
B-16.	(B)												
B-17.	(C)	**B-18.**	(C)	**B-19.**	(D)	**B-20.**	(C)	**B-21.**	(B)	**B-22.**	(C)	**B-23.**	(A)
B-24.	(D)	**B-25.**	(C)	**B-26.**	(C)	**B-27.**	(A)	**B-28.**	(B)	**B-29.**	(B)	**B-30.**	(B)
C-1.	(A)	**C-2.**	(A)	**C-3.**	(C)	**C-4.**	(D)	**C-5.**	(D)	**C-6.**	(D)	**C-7.**	(C)
C-8.	(B)	**C-9.**	(A)	**C-10.**	(B)	**C-11.**	(A)	**C-12.**	(A)	**C-13*.**	(AD)		

PART - II

1.	(D)	**2.**	(B)	**3.**	(B)	**4**	(D)	**5.**	(B)	**6.**	(B)
7.	(A) r, (B) p, (C) s, (D) p			**8.**	(A) s, (B) r, (C) q, (D) p			**9.**	(A) p, (B) r, (C) s, (D) q		
10.	(A)	**11.**	(B)	**12.**	(E)	**13.**	**(C)**	**14.**	**(A)**		

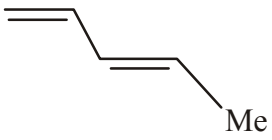
Exercise # 2

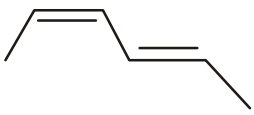
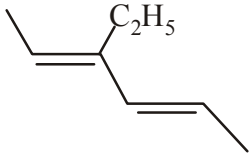
PART - I

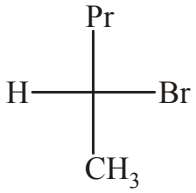
1.	(B)	**2.**	(D)	**3.**	(A)	**4.**	(B)	**5.**	(B)	**6.**	(A)	**7.**	(A)
8.	(A)	**9.**	(B)	**10.**	(C)	**11.**	(D)	**12.**	(A)	**13.**	(B)	**14.**	(A)
15.	(A)	**16.**	(D)	**17.**	(C)	**18.**	(B)	**19.**	(A)	**20.**	(A)	**21.**	(A)
22.	(D)	**23.**	(A)	**24.**	(B)	**25.**	(D)	**26.**	(C)	**27.**	(C)	**28.**	(D)
29.	(D)	**30.**	(D)										

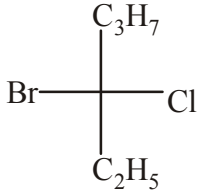
PART - II

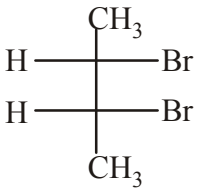
1. Z – I, II, III, VI, VII ; E – IV, V, VIII, IX, X, XI, XII

2. (i) 

(ii) 
(iii) 

(iv) 

(v) 

(vi) 

3. (a) Enantiomers, (b) Enantiomers, (c) Geometrical isomers & Diastereomers, (d) Positional, (e) Optical (Diastereomers), (f) Diastereomers, (g) Enantiomers, (h) Identical, (i) Geometrical isomers (Diastereomers)

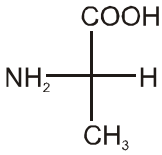
4. (a) Positional (b) Functional (c) Metamerism (d) Positional (e) Functional (f) Tautomerim

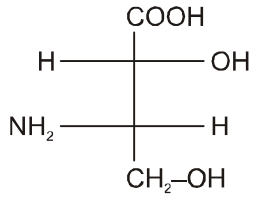
5. 8

6. **8**

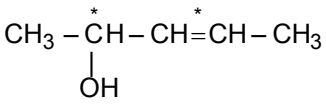
7. achiral : I, III, IV ; chiral : II,V, VI, VII

8. (I) D (II) (2D, 3D)

(III) Equivalent fischer projection is  and configuration L.

(IV) Equivalent fischer projection is  and configuration (2D, 3L).

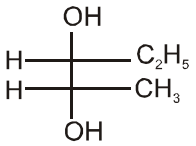
9. (I) Enantiomers (II) Positional isomers (III) Identical (IV) Diastereomers

10. (I) 

Number of stereocentres = 2 so total number of stereoisomers = $2^2 = 4$

(II) All 4 isomers are optically active.

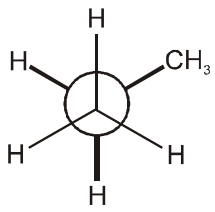
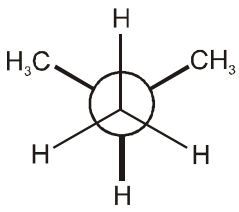
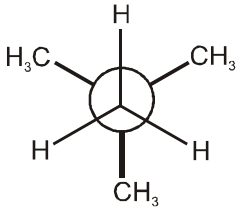
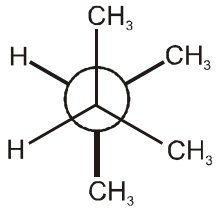
(III) Total enantiomeric pairs are 2, hence number of fraction will be 2.

11. 

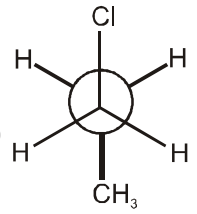
12. D/L represent nomenclature (relative configuration) while d/ℓ represents direction of optical rotation.

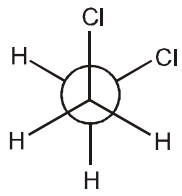
13. 86%

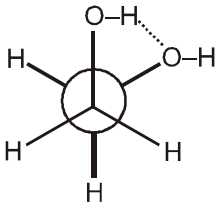
14. (a) 79 unit
(b) 0
(c) – 79 unit

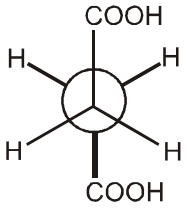
15. (I)  (II)  (III)  (IV) 

16. 86%

17. (I) 

(II) 

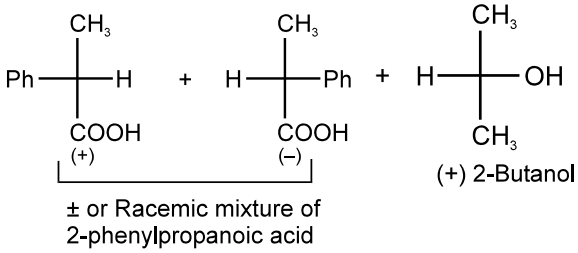
(III) 

(IV) 

Exercise # 3

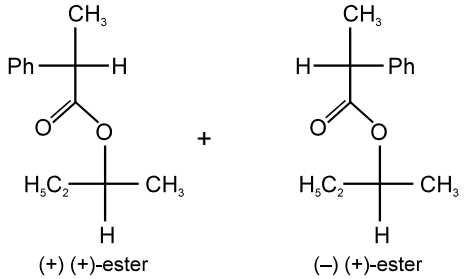
PART - I

1. (D) **2.** (A)

3. 

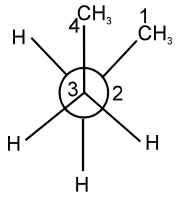
± or Racemic mixture of 2-phenylpropanoic acid

(+) 2-Butanol



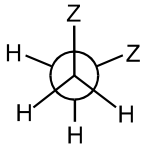
(+) (+)-ester (–) (+)-ester

4. Least stable staggered form of n–butane is



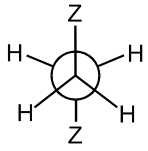
This is due to Vander Waal's strain developed between the methyl groups at C_2 & C_3. There is no torsional strain in the staggered form at torsional angle 60° .

5. (C)

6. 

Gauche form

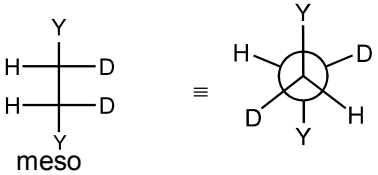
μ_{obs} = 1D



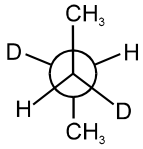
Anti form

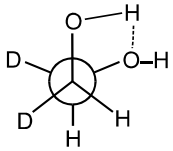
x_{gauche} = 0.18

$\Rightarrow \quad \mu_{obs} = \Sigma \mu_i x_i \quad \Rightarrow \quad 1 = \mu_{gauche} \times 0.18 + 0.82 \times 0 \quad \Rightarrow \quad \mu_{gauche} = \dfrac{1}{0.18} = 5.55\ D$



meso

(a) If Y is CH_3 , the Newman projection is 

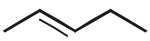
(b) If Y is OH, the Newman projection is 

7.	(C)	**8.***	(AD)	**9.***	(BCD)	**10.***	(AD)	**11.**	**7**	**12*.**	(BD)	**13.**	**5**
14*.	(BC)	**15.**	(B)	**16*.**	(BC)	**17*.**	(A*BC)						

PART - II

1.	(4)	**2.**	(3)	**3.**	(2)	**4.**	(2)	**5.**	(3)	**6.**	(1)	**7.**	(3)
8.	(4)	**9.**	(1)	**10.**	(2)	**11.**	(2)	**12.**	(3)	**13.**	(3)	**14.**	(3)
15.	(3)	**16*.**	(23)										

Exercise # 4

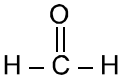
1. Only one which is  .

2. Only one which is  .

3. (I) 4 (II) 2

4. **3**

5. (i) = E (ii) = E (iii) = E (iv) = Z

6. 

7. 4

8.
(I)	Plane of symmetry and Centre of symmetry.	(II)	Plane of symmetry.
(III)	Plane of symmetry.	(IV)	Plane of symmetry.
(V)	Plane of symmetry and Centre of symmetry.	(VI)	Centre of symmetry.

9. (I) 1 (II) 2 (III) 3 (IV) 5

10. (I) R (II) S (III) R (IV) (R, R)

11. (a) In structure (i), the central carbon is bonded to four different substituents (H, OH, Br and CH_3) and hence (i) is chiral.
Structure (ii) has two identical Br atoms attached to central carbon atom and hence it is achiral molecule.
(b) (i) is chiral and (ii) is achiral.
(c) (i) is chiral and (ii) is achiral