STEREOISOMERISM

CONTENTS

JEE (Advanced) Syllabus

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

JEE(MAIN) SYLLABUS

Isomerism : Structure and stereo isomerism

Conformations : Sawhorse and Newman projections (of ethane and butane).
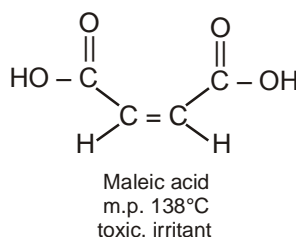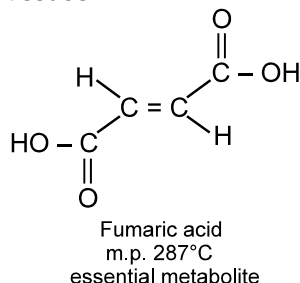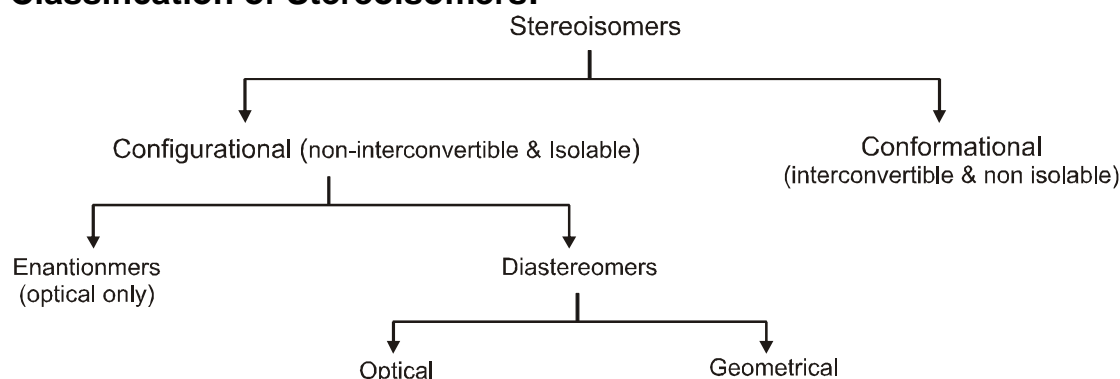
Stereoisomerism

Introduction:

The particular kind of isomers that are different from each other only in the way the atoms are oriented in space are called stereoisomers. These isomers have same **connectivity** of atoms and groups. Stereoisomers have remarkably different physical, chemical and biological properties.

Ex. The two stereoisomers of butenedioic acid are maleic acid and fumaric acid. Fumaric acid is an essential metabolic intermediate in both plants and animals, but maleic acid is toxic and irritating to tissues.

Fumaric acid
m.p. 287°C
essential metabolite

Maleic acid
m.p. 138°C
toxic, irritant

Classification of Stereoisomers:

Stereoisomers

Configurational (non-interconvertible & Isolable)

Conformational (interconvertible & non isolable)

Enantionmers (optical only)

Diastereomers

Optical

Geometrical

1. Configurational isomers:

(I) Those isomers differ in the configuration (The spatial arrangement of atoms that characterises a particular stereoisomer is called its configuration).

(II) Configurational isomerism arises due to non-interconvertibility at room temperature. Since these are non interconvertible, therefore can be separated by physical or chemical methods.
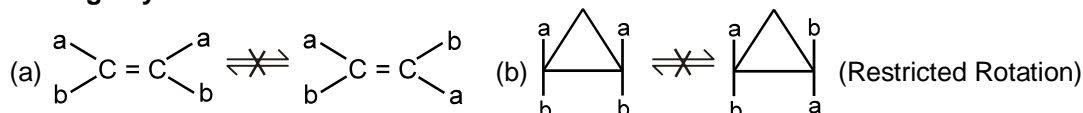
Section (A): Geometrical isomerism

1.1 Geometrical isomerism:

D-1 Isomers which possess the same **molecular and structural** **f**ormula but differ in the arrangement of atoms or groups in space due to **restricted rotation** are known as geometrical isomers and the phenomenon is known as geometrical isomerism.
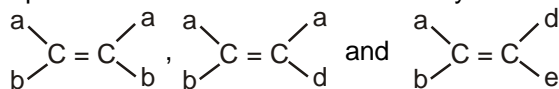
Conditions of geometrical isomerism:

(I) Geometrical isomerism arises due to the presence of a double bond or a ring structure (i.e. $\overset{\displaystyle >}{}C = C\overset{\displaystyle <}{}$, $\overset{\displaystyle >}{}C = N -$, $-N=N-$ or ring structure)

Due to the rigidity of double bond or the ring structure the molecules exist in two or more orientations. This **rigidity to rotation** is described as restricted rotation / hindered rotation / no rotation.
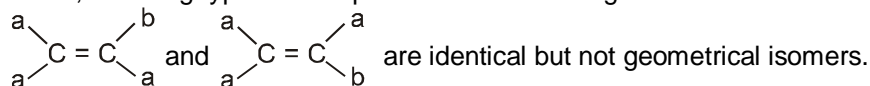
(a) $\overset{a}{\underset{b}{}}C = C\overset{a}{\underset{b}{}}$ $\rightleftharpoons\!\!\!\!/$ $\overset{a}{\underset{b}{}}C = C\overset{b}{\underset{a}{}}$ (b) (Restricted Rotation)

(II) Different groups should be attached at each doubly bonded atom.

$$\underset{b}{\overset{a}{\diagdown}}C=C\underset{b}{\overset{a}{\diagup}} \quad , \quad \underset{b}{\overset{a}{\diagdown}}C=C\underset{d}{\overset{a}{\diagup}} \quad \text{and} \quad \underset{b}{\overset{a}{\diagdown}}C=C\underset{e}{\overset{d}{\diagup}}$$

On the other hand, following types of compounds cannot show geometrical isomerism:

$$\underset{a}{\overset{a}{\diagdown}}C=C\underset{a}{\overset{b}{\diagup}} \quad \text{and} \quad \underset{a}{\overset{a}{\diagdown}}C=C\underset{b}{\overset{a}{\diagup}} \quad \text{are identical but not geometrical isomers.}$$
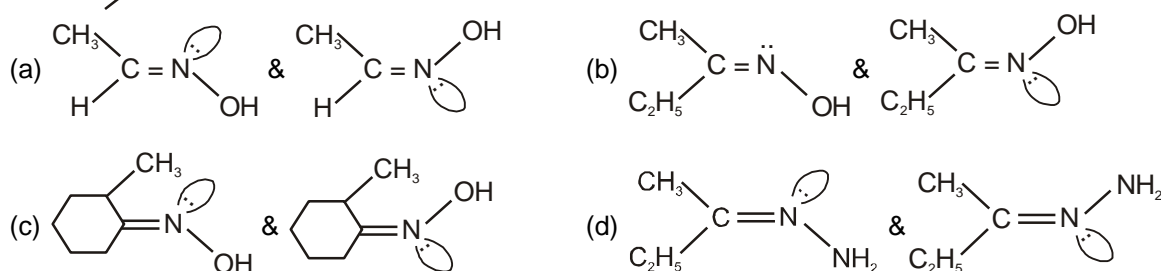
(III) Groups responsible to show geometrical isomerism must be nearly in the same plane.
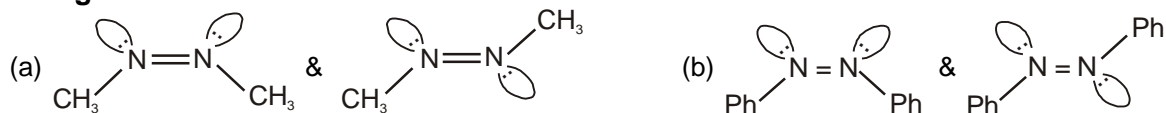
Examples of geometrical isomers:

(I) Along $\diagdown C=C \diagup$ bond

(a)
$$\underset{H}{\overset{CH_3}{\diagdown}}C=C\underset{H}{\overset{Br}{\diagup}} \quad \& \quad \underset{H}{\overset{CH_3}{\diagdown}}C=C\underset{Br}{\overset{H}{\diagup}}$$

(b)

(II) Along $\diagdown C=N-$ bond

(a)
$$\underset{H}{\overset{CH_3}{\diagdown}}C=N\overset{\cdot\cdot}{\diagup_{OH}} \quad \& \quad \underset{H}{\overset{CH_3}{\diagdown}}C=N\overset{OH}{\diagdown_{\cdot\cdot}}$$

(b)
$$\underset{C_2H_5}{\overset{CH_3}{\diagdown}}C=\ddot{N}\diagdown_{OH} \quad \& \quad \underset{C_2H_5}{\overset{CH_3}{\diagdown}}C=N\overset{OH}{\diagdown_{\cdot\cdot}}$$

(c)

(d)
$$\underset{C_2H_5}{\overset{CH_3}{\diagdown}}C=N\diagdown_{NH_2} \quad \& \quad \underset{C_2H_5}{\overset{CH_3}{\diagdown}}C=N\overset{NH_2}{\diagdown_{\cdot\cdot}}$$

(III) Along –N=N– bond

(a)
$$\underset{CH_3}{\overset{\cdot\cdot}{\diagdown}}N=N\underset{CH_3}{\overset{\cdot\cdot}{\diagup}} \quad \& \quad \underset{CH_3}{\overset{\cdot\cdot}{\diagdown}}N=N\underset{\cdot\cdot}{\overset{CH_3}{\diagup}}$$

(b)
$$\underset{Ph}{\overset{\cdot\cdot}{\diagdown}}N=N\underset{Ph}{\overset{\cdot\cdot}{\diagup}} \quad \& \quad \underset{Ph}{\overset{\cdot\cdot}{\diagdown}}N=N\underset{\cdot\cdot}{\overset{Ph}{\diagup}}$$
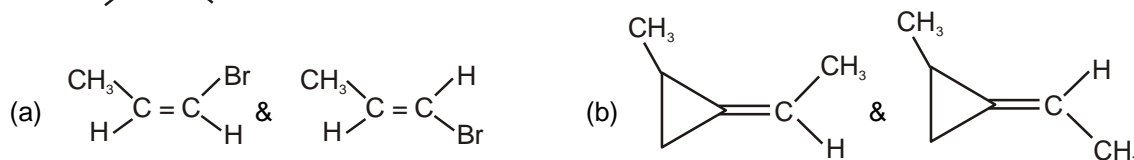
(IV) Along σ bond of cycloalkane

(a)

(b)

(V) Along $\diagdown C=C \diagup$ in ring structures:

Usually in cycloalkenes double bond has cis configuration. Their trans isomers do not exist due to large angle strain. But if the ring is large enough then the trans stereoisomer is also possible. The **smallest trans cycloalkene** that is stable enough to be isolated & stored is **trans-cyclooctene.**

(a)

trans-cyclohexene
highly unstable (not exist)

(b)

trans-cyclooctene
(less stable than cis)
(isolable at – 90°C)
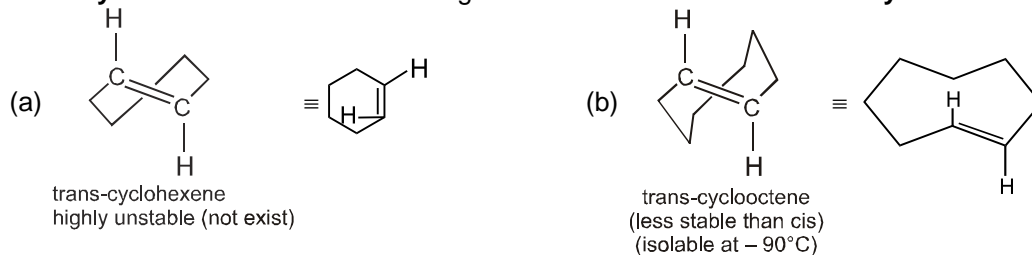
Configurational nomenclature in geometrical isomerism:

Configuration	Criteria	Remarks
cis / trans	Similarity of groups	If the two similar groups are on same side of restricted bond the configuration is cis otherwise trans.
E/Z	Seniority of groups	If the two senior groups are on same side of restricted bond the configuration is Z (Z = zusammen = together) otherwise E (E = entgegen = opposite).

Section (B): CIP rules (E/Z naming) & Physical properties of G.I.
Sequence rules (Cahn-Ingold-Prelog sequence rules):

For deciding the seniority of groups following (CIP) rules are applied:

Rule-I: The group with the first atom having higher atomic number is senior. According to this rule the seniority of atoms is:

$$I > Br > Cl > S > F > O > N > C > H$$
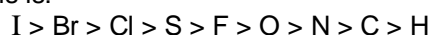
Rule-II: The higher mass isotope is senior.

Thus   (a) $-T > -D > -H$.   (b) $-C^{14}H_3 > -C^{12}H_3$

Rule-III: If the first atom of group is identical then second atom is observed for seniority.

$$-CH_2Cl > -CH_2OH > -CH_2NH_2 > -CH_2CH_3 > -CH_3$$
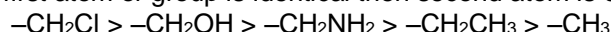
Rule-IV: Groups containing double or triple bonds are assigned seniority as if both atoms were duplicated or triplicated that

>C=Y is written hypothetical as $\begin{array}{c} > C-Y \\ \; | \quad | \\ (Y)\;(C) \end{array}$ & –C≡Y is written hypothetical as $\begin{array}{c} (Y)\;(C) \\ \; | \quad | \\ -C-Y \\ \; | \quad | \\ (Y)\;(C) \end{array}$

–C=O is written hypothetical as $\begin{array}{c} H \\ | \\ -C-O \\ \; | \quad | \\ (O)\;(C) \end{array}$ & –C≡N is written hypothetical as $\begin{array}{c} (N)\;(C) \\ \; | \quad | \\ -C-N \\ \; | \quad | \\ (N)\;(C) \end{array}$
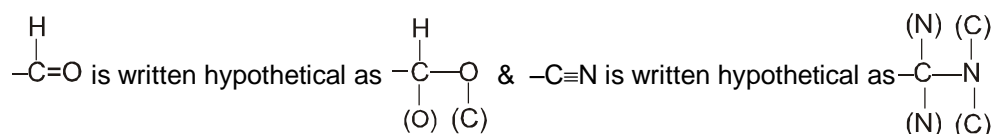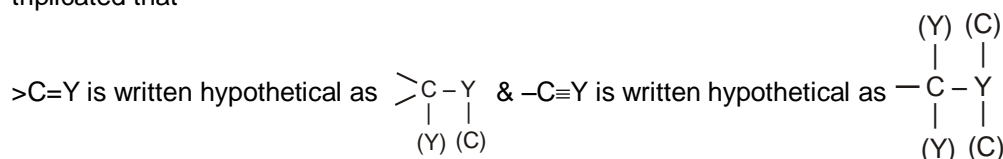
Ex. To decide seniority of multiple bonded groups (–C≡CH, –CH=CH$_2$) their hypothetical equivalents are compared.

$$\begin{array}{c} C \quad C \\ | \quad | \\ -C-C-H \\ | \quad | \\ C \quad C \end{array} \quad > \quad \begin{array}{c} C \quad C \\ | \quad | \\ -C-C-H \\ | \quad | \\ H \quad H \end{array}$$

$\text{(for } -C \equiv C-H) \quad \text{(for } -CH = CH_2)$
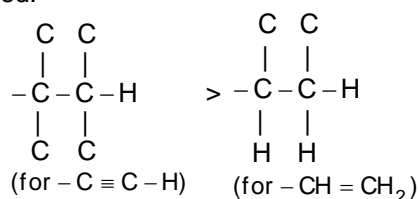
Rule V : Bond pair is senior to lone pair.

Que. In which compound, Cis-Trans nomenclature cannot be used?

(A) $CH_3-CH=CH-CH_3$ (B) $CH_3-CH=CH-COOH$

(C) $\begin{array}{c} Cl \quad\quad\quad CH_3 \\ \searrow \quad\quad\quad \nearrow \\ C = C \\ \nearrow \quad\quad\quad \searrow \\ Br \quad\quad\quad C_2H_5 \end{array}$ (D) $C_6H_5-CH=CH-CHO$

Ans. C

Que. Which of the following structures will show geometrical isomerism?

(A) $CH_3CH=CCl_2$ (B) $CH_3-CCl=CBr-CH_3$ (C) $CH_3CH=CHBr$ (D) $Ph-CH=N-OH$
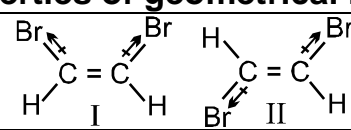
Ans. (B, C, D)

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Sol. (A)

Both are identical

(B)

Non – identical (Geometrical Isomer)

(C)

Non–identical (Geometrical Isomer)

(D)

Non–identical (Geometrical Isomer)

Que. Identify E and Z form of stilbene?

(A)

(B)

Ans. (A) E   (B) Z

Physical properties of geometrical isomers:

Physical properties		Remarks
Dipole moment	I > II	cis-isomer has resultant of dipoles while in trans isomer dipole moments cancel out
Boiling point	I > II	Molecules having higher dipole moment have higher boiling point due to larger intermoleculer force of attraction
Solubility (in H_2O)	I > II	More polar molecules are more soluble in H_2O.
Melting point	II > I	More symmetric isomers have higher melting points due to better packing in crystalline lattice & trans isomers are more symmetric than cis.
Stability	II > I	The molecule having more vander waal strain are less stable. In cis isomer the bulky groups are closer they have larger vander waals strain.

Section (C): Chiral carbon and projection formula
1.2 Optical isomers:

Plane polarised light: Ordinary light is an electromagnetic wave, which has oscillation in all the directions perpendicular to the path of propagation. When ordinary light is passed through Nicol prism it has all its oscillations in the same plane and is called plane-polarised light.

D-2. **Optical Activity:** Certain compounds rotate the plane of polarised light in a characteristic way when it is passed through their solutions. These compounds are referred to as **optically active compounds**. The angle of rotation can be measured by an instrument called polarimeter.

Dextrorotatory compounds: If the substance rotates plane-polarised light to the right (i.e. in clockwise direction) then it is called dextrorotatory & indicated by **'d'** or **(+)**.

Laevorotatory compounds: If light is rotated towards left (i.e. in anticlockwise direction) then substance is said to be laevorotatory and indicated by **'l '** or **(–)**.

Polarimeter
Used to measure the optical rotation of molecules in solution

The polarimeter Tube contains an optically active substance (such as an Amino acid) in a solution which causes the plane of polarizes light to rotate.

Polarimeter Tube (10 cm long)

Analyzar, A rotatable Polarizer - This lens is rotated until nolight goes through the second lens. The angle is then measured to determined the optical rotation of the Amino acid solution.

Fixed Polarizer cannot Rotate

Notice that the plane of the vibrating light has changed after going through the Polarimeter Tube.

Light Source

Cause of optical activity:

The foundation of modern theory of stereochemistry was laid by Louis Pasteur when he observed two different kind of crystals, which were mirror images of each other. Aqueous solution of both types of crystals showed optical rotation that was equal in magnitude but opposite in direction. Pasteur believed that this difference in optical activity was associated with the three dimensional arrangement of atoms in the two types of crystals.

Later Van't Hoff and LeBel proposed that all the four valencies of carbon are directed towards the four corners of regular tetrahedron, and if all the four substituent attached to such a carbon are different the resulting molecule lack symmetry and such a molecule is referred to as asymmetric molecule and **asymmetry** of the molecule is responsible for optical activity in such organic compounds.

D3.   Chirality:

A compound which is non-superimposable to its mirror image is called **chiral** while a compound which is superimposable to its mirror image is called **achiral**.

D4.   Chiral center:

A compound in which a carbon is attached with four different groups lacks symmetry and is called chiral carbon or asymmetric carbon. It is represented by **C***.

Asymmetric and dissymmetric compounds:

A molecule which does not possess any element of symmetry (there are all 23 elements of symmetry) is called asymmetric. A molecule which does not possess plane of symmetry, centre of symmetry and alternating axis of symmetry is called dissymmetric.

Condition for optical activity:

The minimum condition for a compound to show optical activity is molecular dissymmetry i.e. absence of plane of symmetry, centre of symmetry and alternating axis of symmetry.
For Examples:

(a) $CH_3 - CH - CH_3$ (2-chloropropane):
$\qquad\qquad\quad |$
$\qquad\qquad\; Cl$
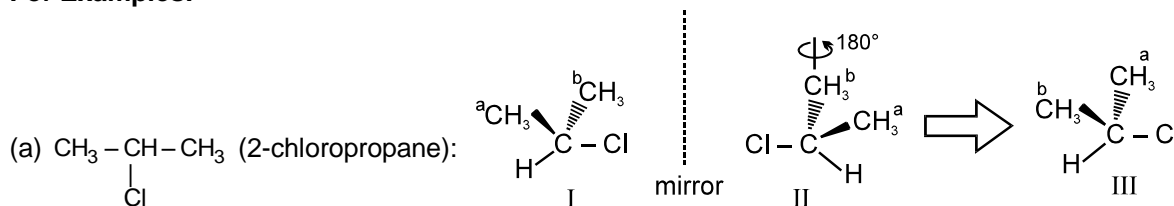
I has no chiral centre since two groups (a & b) are identical. It is superimposable on its mirror image II ($\equiv$III).

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(b) $CH_3 - \overset{*}{C}H - C_2H_5$ (2-chlorobutane):
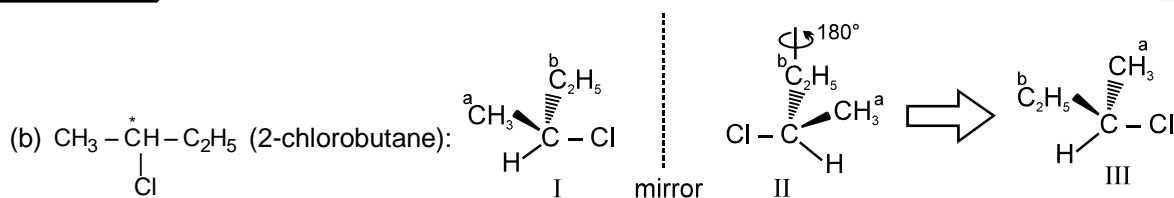
I has one chiral centre it is asymmetric & it is not superimposable to its mirror image II (≡ III).

The necessary condition for chirality is not just the presence of asymmetric carbon atoms but the dissymmetry of the molecule as a whole.

Projection formulas in optical isomerism:

(I) Wedge-dash projection formula:

It is a convenient way of depicting three dimensional structure in two dimension. In this projection four bonds of a tetrahedral molecule is shown by two lines (in the plane), one wedge (up the plane) and one dash line (down the plane)
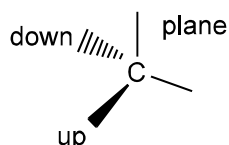
(II) Fischer projection formula:

It is also a convenient way of depicting three dimensional structure in two dimension.

Rules for writing Fischer projection formula:

(i) The molecule is drawn in the form of cross (+) with the chiral carbon at the intersection of horizontal & vertical lines.

(ii) On vertical line, main chain is taken with first carbon at the top.

(iii) The horizontal lines represent the bonds directed towards the viewer and vertical lines represent away from the viewer

Ex. (a) Glyceraldehyde $CH_2 - \overset{*}{C}H - CHO$ can be represented in two different Fischer projection as

$\qquad\qquad\qquad\qquad$ OH $\quad$ OH
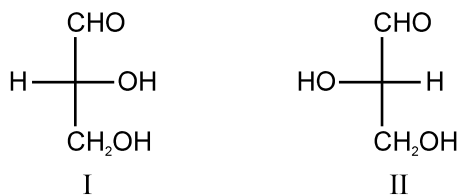
(b) Alanine $CH_3 - \overset{*}{C}H - COOH$ can be represented in two different Fisher projections as

$\qquad\qquad\qquad\qquad\qquad$ NH$_3$
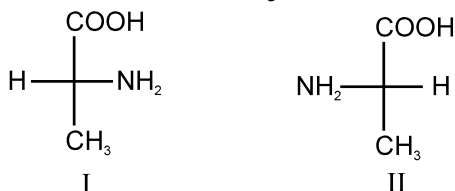
(III) Saw horse projection formula:

The molecule is viewed slightly from above, from the right and projected on the paper. The bond between the carbon atoms is drawn diagonally. The lower left hand carbon is considered to be towards front and upper right hand side carbon towards back.

(IV) Newman projection Formula:

(i) These projection formulae are obtained by viewing the molecule along the bond joining the two carbon atoms.

(ii) The carbon atoms near the eye is represented by a point and three other atoms/groups attached to it by 3 equally spaced lines.

(iii) The carbon atom further from the eye is represented by a circle and three atoms / groups attached to it by 3 equally spaced lines.

Ex.

Staggered (Saw horse)   Staggered (Newman)

Eclipsed (Saw horse)   Eclipsed (Newman)
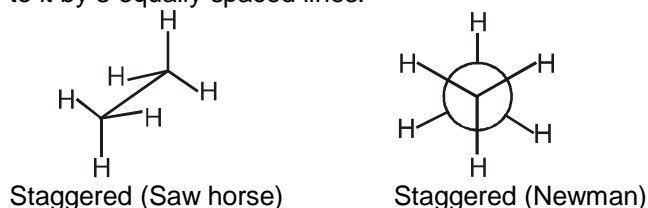
Ex. 2,3-Dimethylebutane can be represented by the following projections as follows.
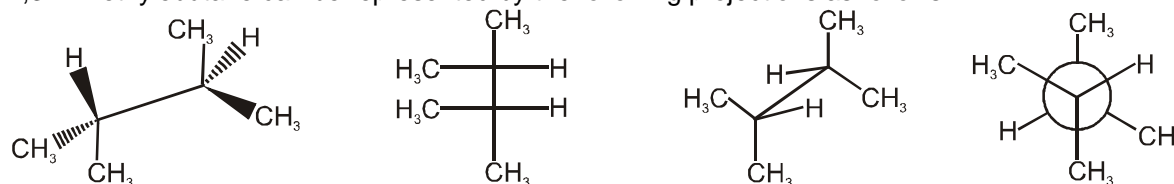
Ex. 2-Bromo-3-chlorobutane can be represented by the following projections as follows.
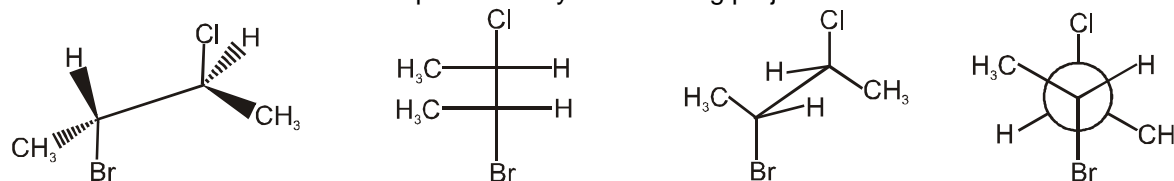
All the presentations have identical configurations

Section (D): R/S & D/L Naming.

Configurational nomenclature in optical isomers:

(I) D-L System (Relative configuration):

This method is used to relate the configuration of sugars and amino acids by the help of enantiomers of glyceraldehyde. The configuration of (+)-glyceraldehyde has been assigned as D and the compounds with the same relative configuration are also assigned as D & those with (-) glyceraldehyde are assigned as L.

D-(+)-glyceraldehyde
– OH group on right side

Mirror

L-(–)-glyceraldehyde
– OH group on left side

Ex.

$$\begin{array}{c} COOH \\ | \\ H_2N —\!\!—\!\!— H \\ | \\ CH_3 \end{array}$$
L-Alanine

$$\begin{array}{c} COOH \\ | \\ H —\!\!—\!\!— NH_2 \\ | \\ CH_2OH \end{array}$$
D(+)-serine

$$\begin{array}{c} COOH \\ | \\ NH_2 —\!\!—\!\!— H \\ | \\ CH_2CH_2COOH \end{array}$$
L-(+)-Glutamic acid
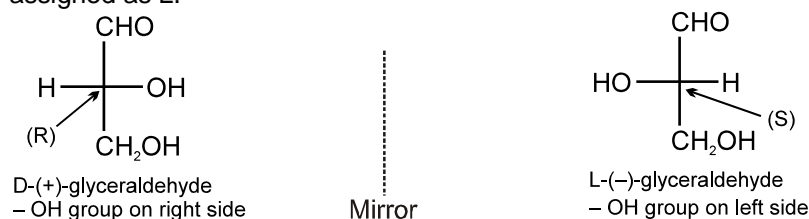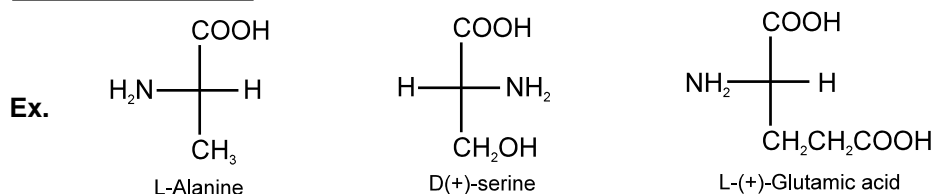
Sugars have several asymmetric carbons. A sugar whose highest numbered chiral centre (the penultimate carbon) has the same configuration as D-(+)-glyceraldehyde (–OH group on right side) is designated as a D-sugar, one whose highest numbered chiral centre has the same configuration as L-glyceraldehyde is designated as an L-sugar.

Ex.

$$\begin{array}{c} CHO \\ | \\ H —\!\!— OH \\ | \\ HO —\!\!— H \\ | \\ H —\!\!— OH \\ | \\ \boxed{H —\!\!— OH} \\ | \\ CH_2OH \end{array}$$
D-(+)-Glucose

$$\begin{array}{c} CHO \\ | \\ HO —\!\!— H \\ | \\ \boxed{H —\!\!— OH} \\ | \\ CH_2OH \end{array}$$
D-Threose

$$\begin{array}{c} CHO \\ | \\ HO —\!\!— H \\ | \\ \boxed{OH —\!\!— H} \\ | \\ CH_2OH \end{array}$$
L-Erythrose

$$\begin{array}{c} CH_2OH \\ | \\ C = O \\ | \\ HO —\!\!— H \\ | \\ H —\!\!— OH \\ | \\ \boxed{H —\!\!— OH} \\ | \\ CH_2OH \end{array}$$
D-Fructose

$$\begin{array}{c} CHO \\ | \\ HO —\!\!— H \\ | \\ HO —\!\!— H \\ | \\ H —\!\!— OH \\ | \\ \boxed{H —\!\!— OH} \\ | \\ CH_2OH \end{array}$$
D-Mannose
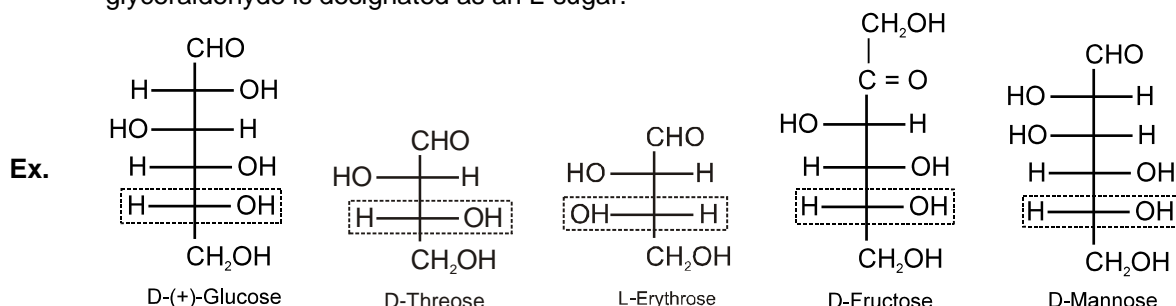
(II) R and S configurations in Fischer projection: (Absolute configuration)

Step-I: The priorities of groups which are attached with the asymmetric C-atom are assigned by CIP rule.

Step-II: The lowest priority group is brought to the bottom of Fischer projection by two or even simultaneous exchanges.

Step-III: Then an arrow is drawn from first priority group to second priority group to third priority group. If the arrow is clockwise the configuration assigned to the projection is **R** & If it is anticlockwise the configuration assigned is **S**.

Ex.

(a)
$$\begin{array}{c} (1) \\ F \\ (3) \; D —\!\!\bigoplus\!\!— CH_3 \; (2) \\ R \\ H \\ (4) \end{array}$$

(b)
$$\begin{array}{c} (3) \\ CH_2OH \\ S \\ (1) \; Br —\!\!\bigoplus\!\!— Cl \; (2) \\ CH_3 \\ (4) \end{array}$$

(c)
$$\begin{array}{c} (2) \\ COOH \\ (1) \; NH_2 —\!\!—\!\!— H \; (4) \\ CH_3 \; (3) \end{array} \equiv \begin{array}{c} NH_2 \\ HOOC —\!\!\bigoplus\!\!— CH_3 \\ S \\ H \end{array}$$

(d)
$$\begin{array}{c} (2) \\ CHO \\ (4) \; H —\!\!—\!\!— OH \; (1) \\ CH_2OH \; (3) \end{array} \equiv \begin{array}{c} (1) \\ OH \\ R \\ (3) \; HOH_2C —\!\!\bigoplus\!\!— CHO \; (2) \\ H \end{array}$$

(e)
$$\begin{array}{c} (4) \\ H \\ (1) \; NH_2 —\!\!—\!\!— CHO \; (2) \\ CH_2CH_3 \; (3) \end{array} \equiv \begin{array}{c} (3) \\ CH_2CH_3 \\ (2) \; CHO —\!\!\bigoplus\!\!— NH_2 \; (1) \\ R \\ H \end{array}$$
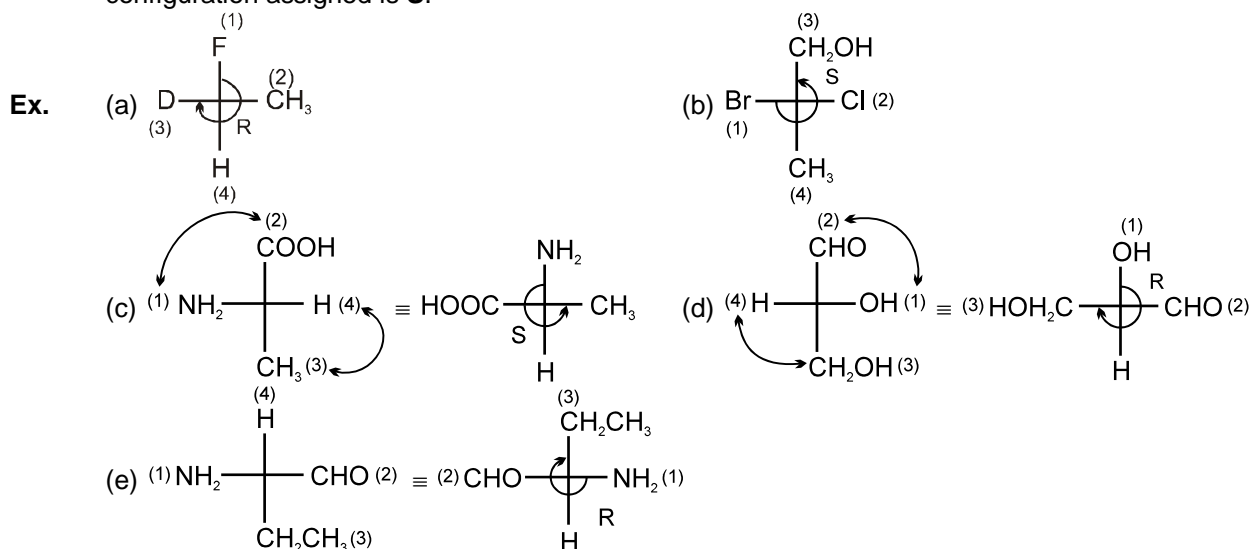
(III) R and S configurations in wedge-dash formula: (Absolute configuration)

Step-1 : Decide the priority of groups by sequence rule.

Step-2 : Bring the lowest prior group to dash by even simultaneous exchanges.

Step-3 : Draw an arrow from first prior group to second prior group till third prior group.

Step-4 : If the direction of arrow is clockwise the configuration is R and if anticlockwise it is S.

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Converting a wedge-dash formula into Fischer projection formula:

Draw the Fischer projection formula having equivalent configuration to the wedge-dash formula.

Ex. (a)
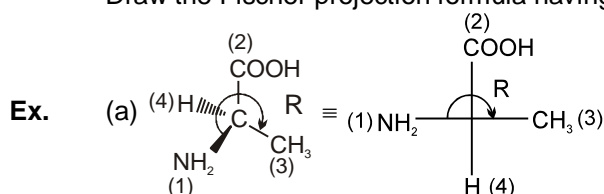
Here the lowest prior group is already on dash, there is no need for exchanges.

(b)

(c)

(d)
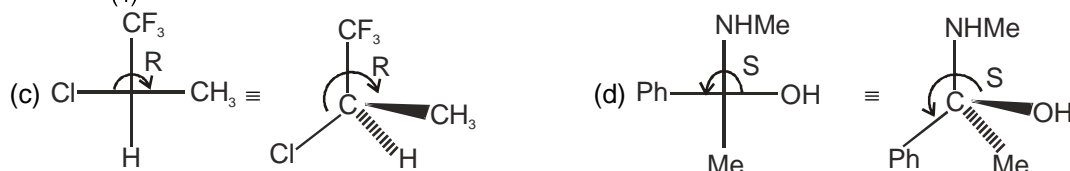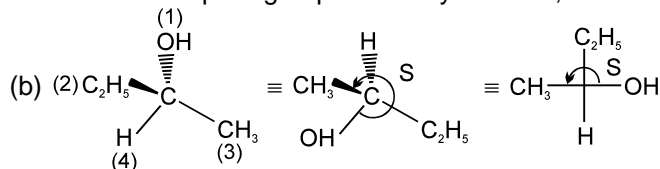
Section (E): Element of Symmetries (POS, COS, AOS)
Element of symmetry and concept of molecular dissymmetry/asymmetry and chirality.

D5. **Plane of symmetry (σ):**

It is an imaginary plane which bisects the molecule in two equal halves in such a way that each half of the molecule is the mirror image of the other half.

Plane of symmetry   Plane of symmetry   Plane of symmetry
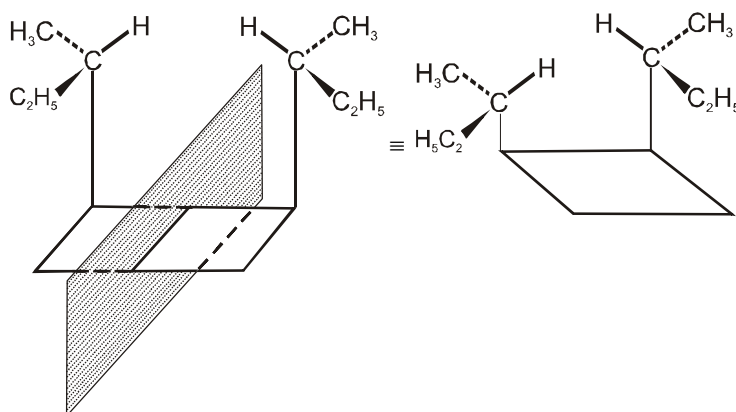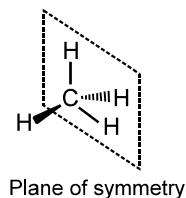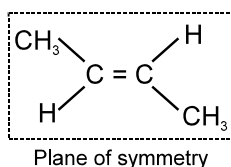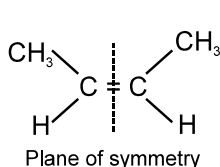
Cis-(1R, 2S)-Disec-butylcyclobutane

D6. **Centre of symmetry (i):**

A centre of symmetry is a point from which lines, when drawn on one side and produced an equal distance on the other side, will meet identical points in the molecule.

centre
of symmetry   centre
of symmetry absent
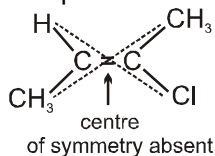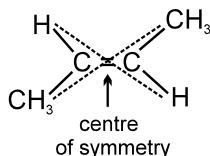
D7. Axis of symmetry (C_n):

Axis of symmetry is an line about which the molecule can be rotated by $360^0/n$ and thereby produce a molecule indistinguishable from the original molecule.

C_3 axis of symmetry C_2 axis of symmetry
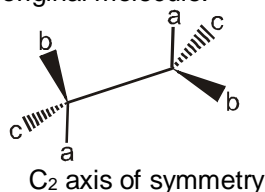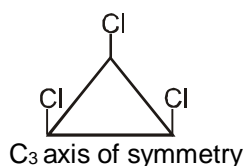
D8. Alternating axis of symmetry (S_n):

A molecule possess an n-fold alternating axis of symmetry if when rotated through an angle of $360^0/n$ about this axis and then followed by reflection in plane perpendicular to the axis; the molecule is indistinguishable from the original molecule. It is also called **improper axis of symmetry**

S_2 S_4
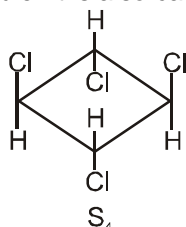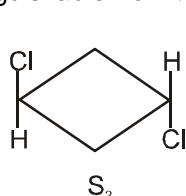
Section (F): Definition and Properties of Enantiomers, Diastereomers, Meso compounds

D9. Enantiomers:

Stereoisomers which are non-superimposable mirror images of each other are called enantiomers.

Ex.   (a) 2-Chlorobutane: (b) Glucose:
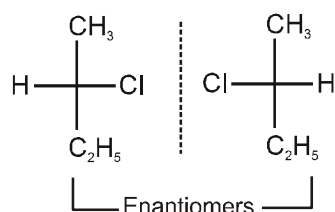
                        D-(+)- Glucose   L-(−)-Glucose
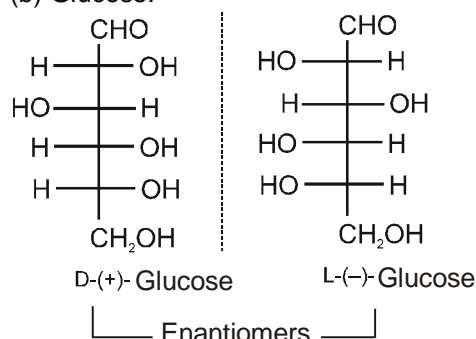
Racemic mixture:

D10. **A mixture of equal amounts of enantiomers is called a racemic mixture or racemic modification.** A racemic modification is always **optically inactive** when enantiomers are mixed together, the rotation caused by a molecule of one enantiomer is exactly cancelled by an equal and opposite rotation caused by a molecule of its enantiomer.

The prefix (±) is used to specify the racemic nature of the particular sample.

e.g. (±) Lactic acid, or (d + ℓ) Lactic acid.

Optical diastereomers:

D11. **The optical isomers which are neither mirror image nor superimposable to each other are called diastereomers.** Diastereomers have different physical and chemical properties and they can be easily separated by physical methods.

Ex.   Let us consider the stereoisomers of 3-chlorobutan-2-ol

    I   II   III   IV

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There are 4 stereoisomers of 3-chlorobutan-2-ol. In which (I & II) & (III & IV) are enantiomeric pairs. (I & III) or (I & IV) or (II & III) or (II & IV) all the isomers in each pair are neither mirror image nor superimposable to each other. Therefore these pairs are optical diastereomers.
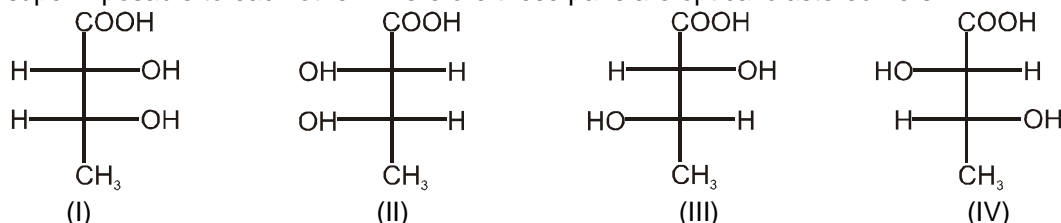
(I)   (II)   (III)   (IV)

There are 4 stereoisomers of 2,3-Dihydroxybutanoic acid In which (I & II) & (III & IV) are enantiomeric pairs. (I & III) or (I & IV) or (II & III) or (II & IV) all the isomers in each pair are neither mirror image nor superimposable to each other. Therefore these pairs are optical diastereomers.

Properties of Enantiomers & Diastereomers:

	Properties	Enantiomers	Diastereomers
(1)	Molecular formula	Same	Same
(2)	Structural formula	Same	Same
(3)	Stereo chemical formula (structure formula with orientation)	Different	Different
(4)	Dipole moment	Same	Different
(5)	Physical properties (m.p., b.p., density, solubility, refractive index etc.)	Same	Different
(6)	Specific rotation	Different sign but same magnitude	Different
(7)	Chemical properties		
	(a) with optically inactive compound	Same	Different
	(b) with optically active compound	Different	Different

D12 ## Meso compound:

An optical inactive molecule whose at least one diastereomer is optically active.

* Mirror image of meso compound is superimposable over each other & non resolvable.

* Molecule contains chiral centers & symmetry but optically inactive.

Ex. Let us consider the stereoisomers of 2, 3-Butanediol

I   II   III   IV

Plane of symmetry   Plane of symmetry
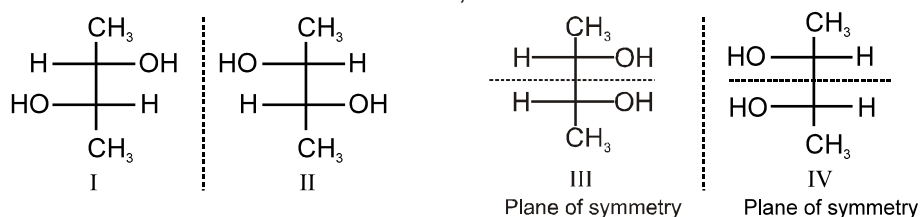
In all the possible isomers I & II are enantiomers but III & IV are not enantiomers since they have plane of symmetry and are superimposable to each other

Note : All symmetrical compounds are superimposable to their mirror images.

Thus III & IV are identical & meso compounds.

Thus total stereoisomers of 2, 3-butanediol is 3. Two enantiomers and one meso isomer.

Ex.

(Meso)   (Meso)   (Meso)   (Meso)
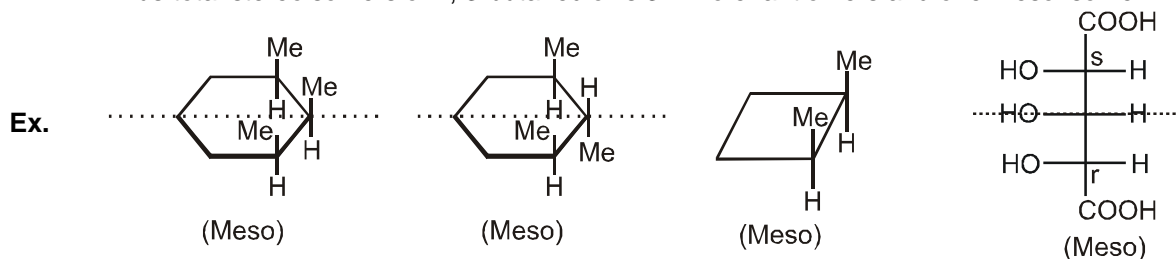
Section (G): Specific rotation, optical purity, enantiomeric excess and Optical Resolution

D13. **Specific rotation (α):** Specific rotation is the number of degrees of rotation observed if a 1-dm (10-cm) tube is used and the compound has concentration 1 g/ml. Thus specific rotation [α] is

$$[\alpha]_t^\lambda = \frac{\theta}{\ell \times C}$$

[α] = Specific rotation ; θ = observed angle of rotation (degree)
ℓ = Path length (dm) ; C = concentration (g/ml)
λ = wavelength (nm) ; t = temperature (25°C)

Note : (i) Specific rotation of a compound is **independent** of the length of tube and concentration of the solution.

(ii) Since optical rotatory power is a property of molecules, if two substances have unequal molecular weights but are alike with respect to the power of rotating the plane of polarized light, the substance of smaller molecular weight has the larger specific rotation, simply because it has more molecules per unit weight.

Optical purity:

Sometimes we deal with mixture that is neither optically pure nor racemic mixture. In these cases we specify the optical purity of the mixture. It is defined as the ratio of its rotation to the rotation of pure enantiomer.

Optical purity = $\dfrac{\text{observed optical rotation}}{\text{optical rotation of pure enantiomer}} \times 100$

Ex. If we have some 2-butanol with observed rotation of +9.72, we compare this rotation with +13.5 rotation of the pure (+) enantiomer.

Optical purity = $\dfrac{9.72}{13.5} \times 100 = 72\%$.

That means 72% is pure (+) 2-Butanol and 28% is racemic (± mixture)
Total (+) isomer = 72 + 14 = 86%, (–) isomer = 14%

Enantiomeric excess:

To compute the enantiomeric excess of a mixture we calculate the excess of predominant enantiomer as a percentage of the entire mixture. The calculation of enantiomeric excess gives the same result as the calculation of optical purity.

$\therefore$ Optical purity = Enantiomeric excess = $\dfrac{|d - \ell|}{d + \ell} \times 100 = \dfrac{\text{excess of one enantiomer over other}}{\text{entire mixture}} \times 100$

Thus for above example optical purity = enantiomeric excess = $d - \ell = 72\%$ & $d + \ell = 100\%$

So, $2d = 172 \implies d = 86\%$ & $\ell = 14\%$ (composition of mixture)

Ex. Cholesterol, when isolated from natural sources, is obtained as a single enantiomer. The observed rotation α of a 0.3 g sample of cholesterol in 15 mL of chloroform solution contained in a 10 cm polarimeter tube is –0.78º. Calculate the specific rotation of cholesterol. A sample of synthetic cholesterol was prepared consisting entirely of (+)-cholesterol. This synthetic (+)-cholesterol was mixed with some natural (–)-cholesterol. The mixture had a specific rotation $[\alpha]_D^{20}$ of –13º. What fraction of the mixture was (+)-cholesterol?

Sol. Specific rotation = $[\alpha]_t^\lambda = \dfrac{\theta}{\ell \times C} = -\dfrac{0.78}{1 \times \dfrac{0.3}{15}} - 39^0$

Enantiomeric excess = $\dfrac{\text{observed optical rotation}}{\text{optical rotation of pure enantiomer}} \times 100 = \dfrac{-13°}{-39°} \times 100 = 33.3\%$.

Therefore (+)-cholesterol is of 33.3 % and (–)-cholesterol is of 66.6 % in the mixture.

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Reaction of chiral molecules with optically active reagent (optical resolution):

Resolution refers to the method of separating a racemic mixture into its enantiomeric constituents.

Method: A racemic mixture is allowed to react with another optically pure compound. This changes a racemic mixture into a mixture of diastereomers which have different melting and boiling point and solubility. These can be separated from one another by conventional method of separation of compounds. The separated diastereomers is then broken down to give pure enantiomers.

Suppose a racemic mixture (±) A is to be separated. It is reacted with an optically pure compound (+) B. Thus the schematic diagram for resolution will be.

$$(\pm)\,A \quad + \quad (+)\,B$$

$$\downarrow$$

$$[(+)\,A\,(+)\,B] \quad + \quad [(-)\,A\,(+)\,B] \quad \binom{\text{Diastereomers}}{\text{separable}}$$

$$[(+)\,A\,(+)\,B] \qquad\qquad\qquad [(-)\,A\,(+)\,B]$$

$$(+)A \qquad (+)B \qquad\qquad (-)A \qquad (+)B$$
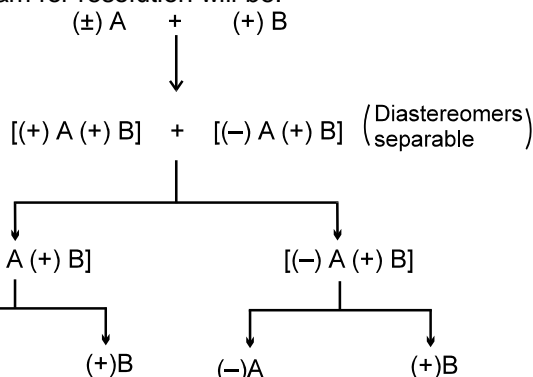
Ex.   **Separation of racemic mixture of 2-Chloropropanoic acid.**

Diastereomers (Separable)

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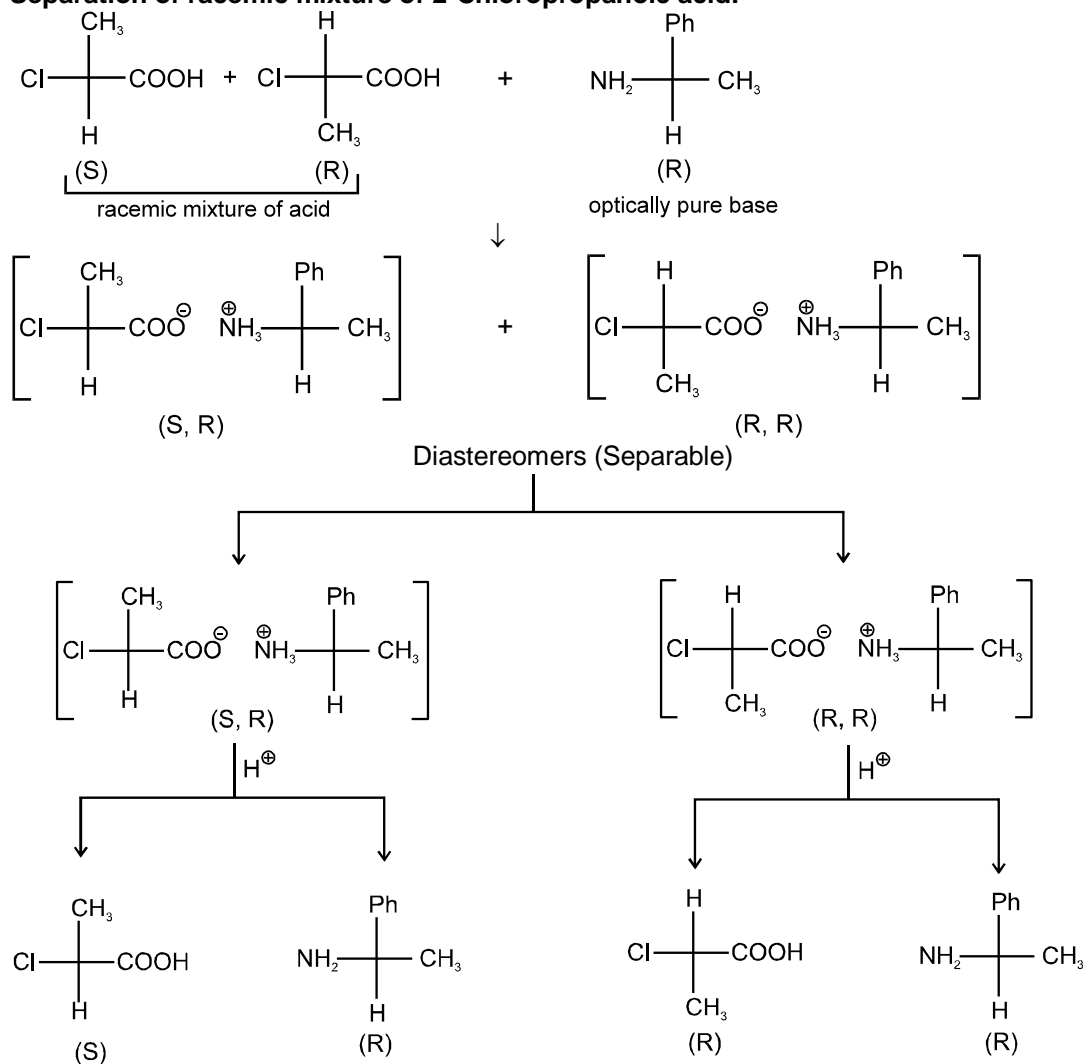
Section (H): Optical active compounds without chiral carbon and Amine inversion

(I) Case of allene:

(a) Allenes with even π bonds:
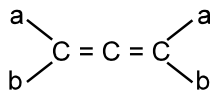
The orbital diagram of this structure will be
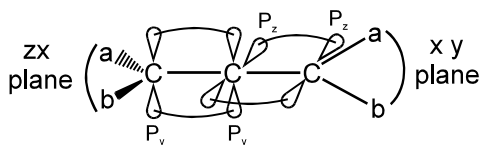
Since the groups at the end of allene are in perpendicular plane, it will not show geometrical isomerism. The molecule lacks centre of symmetry as well as plane of symmetry. Overall the structure has molecular dissymmetry which is the sufficient condition for optical activity. The molecule will exist in two enantiomeric forms.

Enantiomers
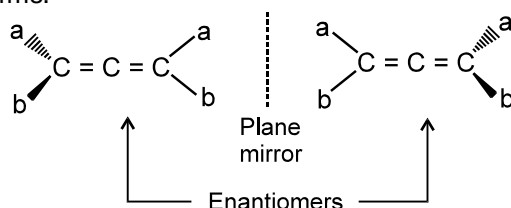
(b) Cummulene with odd π bonds:
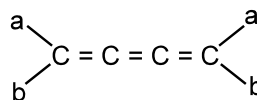
The orbital diagram of this structure will be
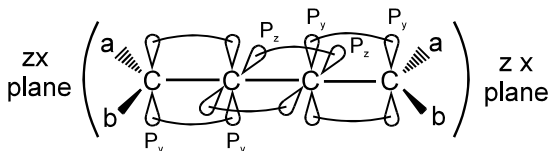
The groups at the end of allene structure lie in same plane (ZX plane). Therefore it will have a plane of symmetry (ZX plane). The molecules lacks molecular dissymmetry & it will not show optical activity and optical isomerism. But the compound will exist in two geometrical diastereomeric forms.

Geometrical Diastereomers
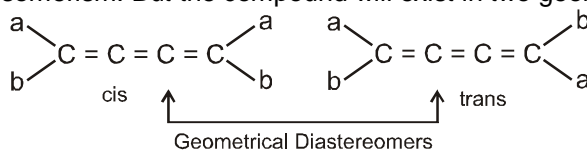
(II) Case of spiranes:

A similar case like allene is observed in spiranes. The spiranes with even rings and different groups at terminal carbons show optical activity & optical isomerism, while the spiranes with odd rings shows geometrical isomerism.

(a) spiranes with even rings:

 Shows optical isomerism.

(b) Spiranes with odd rings:

 Shows geometrical isomerism.
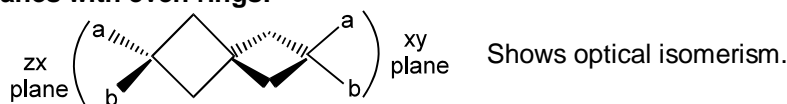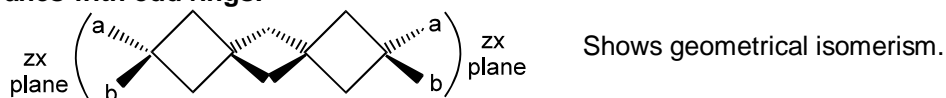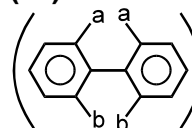
(III) Case of cycloalkylidene:

Enantiomeric pairs
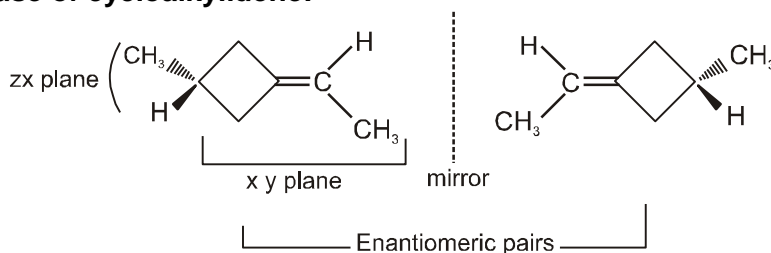
(IV) Case of ortho-ortho-tetrasubstituted biphenyls:

 Becomes non-planar at room temperature in order to have minimum electronic repulsion among the substituents. In this orientation (phenyl planes perpendicular to each other) the free rotation of C–C single bond is restricted and molecule shows optical activity due to molecular dissymmetry.

Enantiomers
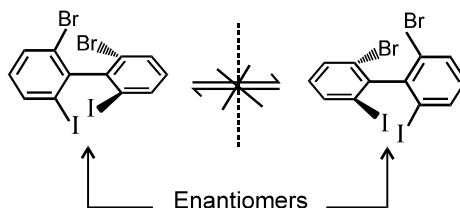
Compounds having chiral centers other than carbon:

The tetrahedral atom with four different groups attached to it is a stereo center (chiral center). Thus when atom like nitrogen, phosphorous, sulphur, silicon, germanium has four different groups attached with them they are chiral and show optical activity & hence optical isomerism possible.
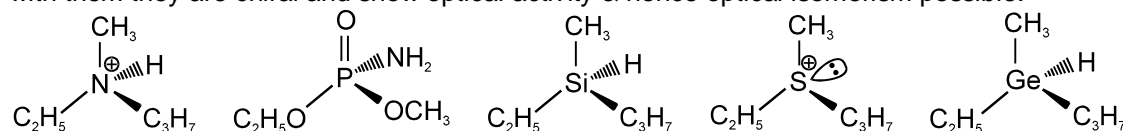
Asymmetric nitrogen: Amine inversion

Amine with all different groups attached to N-atom have chiral centre ($R_1R_2R_3N$) as nitrogen atom. Since the geometry of the molecule is tetrahedral it has molecular dissymmetry. It will exist as two enantiomers but the two enantiomers of amines cannot be separated because they rapidly interconvert into each other. Therefore they always exist as racemic mixture hence optically inactive.

Ex. Ethylmethyl amines. $CH_3\overset{..}{N}HC_2H_5$

 (Inter convertible & non-resolvable)

Mirror plane
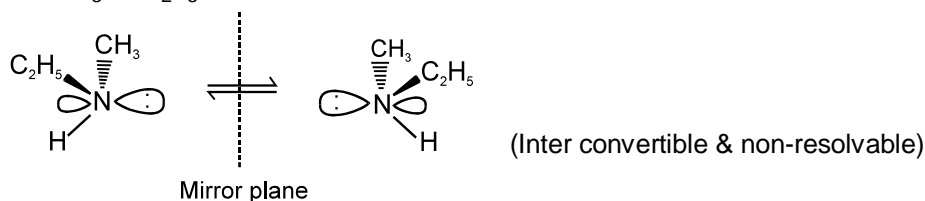
Inter convertible enantiomers are also known as **invertomers** (non resolvable)

Note: Nitrogen salts and cyclic amines will not undergo amine inversion.

Ex. (a)

 (non Inter convertible & resolvable)

(+) form   (−) form

(b)   (non Inter convertible & resolvable)

       (+) form   (−) form

(c)   (non Inter convertible & resolvable)

       (+) form   (−) form
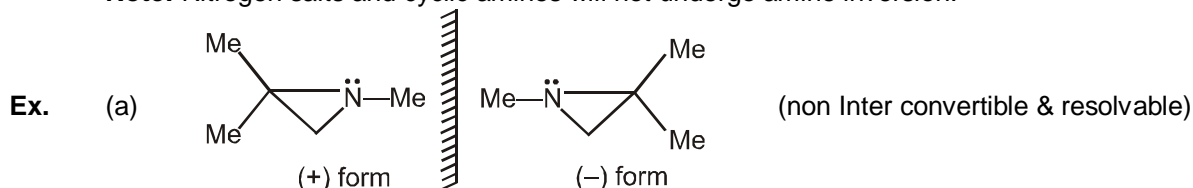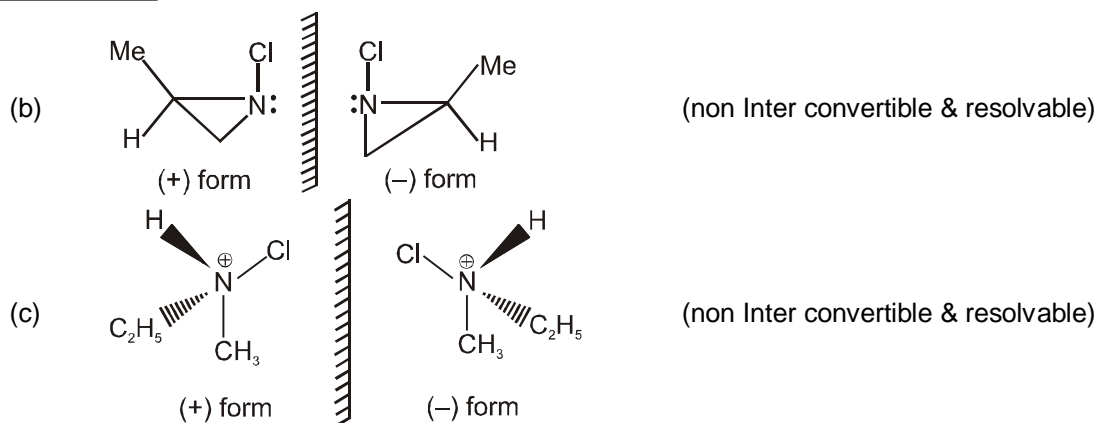
Section (I): Calculation of no. of stereoisomers

D14   **Stereo center:** Stereo center is defined as an atom or bond bearing groups of such nature that an interchange of any two group will produce a stereoisomer.

Note: **Pseudo Chiral center** is an atom which is attached to two constitutionally like chiral groups and two other distinct atoms/ groups.
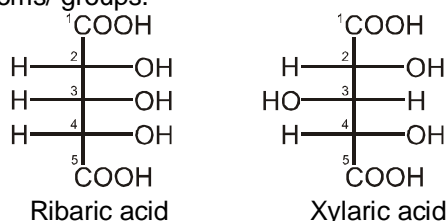
Ribaric acid   Xylaric acid   (C-3 is Pseudo chiral center)

Number of stereoisomers:

Number of Stereoisomers (either geometrical or optical or both) can be found by calculating the number of **stereo centers** in the compound.

	Nature of compound	No. of Stereoisomers (n=no. of stereo centers)
(I)	Compound with dissimilar ends	2^n
(II)	Compound with similar ends and even stereo centers	$2^{n-1} + 2^{\frac{n-1}{2}}$
(III)	(III) Compound with similar ends and odd stereo centers (a) If only Geometrical stereo centers are present in the molecule (b) If only optical stereo centers are present in the molecule	$2^{n-1} + 2^{\frac{n-1}{2}}$ 2^{n-1} only

Note : **(i) Compounds having similar ends with even chiral centers then:**

enantiomers = 2^{n-1} & meso compounds =$2^{\frac{n-1}{2}}$.

(ii) Compounds having similar ends with odd chiral centers then:

enantiomers = 2^{n-1} – $2^{\frac{n-1}{2}}$ & meso compounds = $2^{\frac{n-1}{2}}$.

Ex.   **(a)** $CH_3 - CH = CH - CH = CH - C_2H_5$ (Molecule with dissimilar ends).

Here n = 2, So Number of G.I = 4 [(cis, cis),(trans, trans),(cis, trans), (trans, cis)]

(b) $CH_3 - CH = CH - CH = CH - CH_3$ (Molecule with similar ends)

Here n = 2, So Number of G.I =3 [(cis, cis),(trans, cis),(cis, trans) = (trans, cis)]

(c) $CH_3 - CH = CH - CH = CH - CH = CH - CH_3$ (Molecule with similar ends)

Here n = 3, So Number of G.I = 6

[(cis, cis, trans) = (trans, cis, cis) (cis, trans, trans) = (trans, trans, cis), (cis, cis, cis)

(trans, trans, tans), (cis, trans, cis, (trans, cis, trans)]

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(d) Let us draw the total stereoisomers of $CH_3 - \overset{*}{C}H - \overset{*}{C}H - \overset{*}{C}H - CH_3$ with OH, OH, OH substituents

Sol. n = 3 (odd chiral centers with similar ends.) so,

Total stereoisomers = $2^{3-1} = 2^2 = 4$ **(enantiomers = $2^{n-1} - 2^{\frac{n-1}{2}}$ & meso compounds = $2^{\frac{n-1}{2}}$)**

I   II
⌊——— Enantiomers ———⌋

III
(meso₁)

IV
(meso₂)
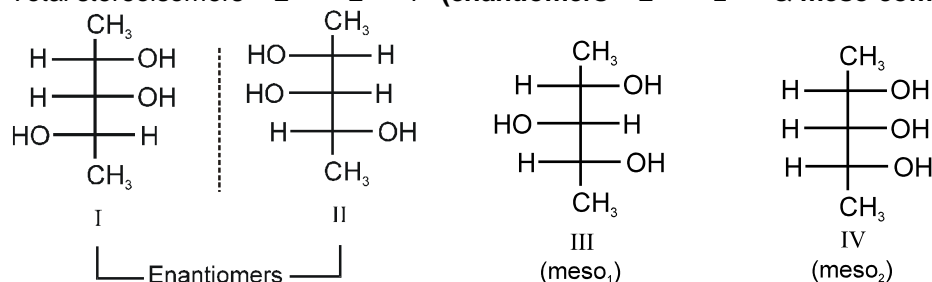
(e) Let us draw the total stereoisomers of $CH_3 - \overset{*}{C}H - \overset{*}{C}H - CH_3$ with OH, OH substituents

Sol. n = 2 (even chiral centers with similar ends.)

So, total isomers = $2^{n-1} + 2^{\frac{n}{2}-1}$ (enantiomers = 2^{n-1} & meso compounds = $2^{\frac{n}{2}-1}$)

I   II
⌊——— Enantiomers ——⌋

Meso
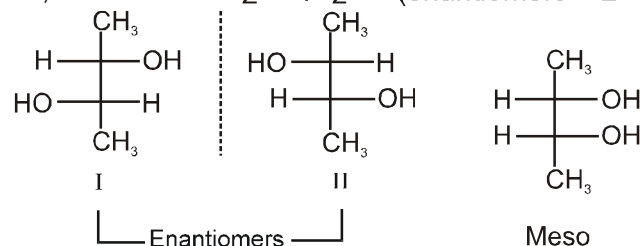
(f) Let us draw the total stereoisomers of CH₃–CH(OH) –CH₂–CH=CH–Cl
Sol. Total stereo centers (n) = 1 + 1 = 2 (Molecule with dissimilar ends)
So, total stereoisomers = $2^2 = 4$ [(R, cis); (R, trans); (S, cis); (S, trans)]

Note : **If the starting materials of a reaction are achiral and the products are chiral, then they will be formed as a racemic mixture of two enantiomers.**

Section (J): Conformational Isomerism
2. Conformations:
Free rotation: For defining free rotation let us consider the bonding in ethane.

Ethane molecule
carbon-carbon σ-bond
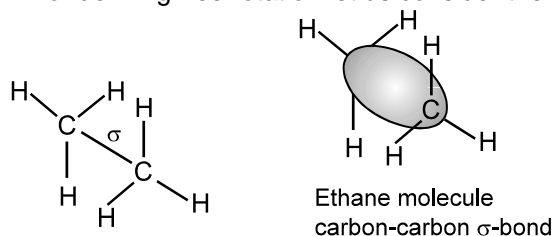
We find that the σ-bond joining the carbon atoms is cylindrically symmetrical about the line joining the two carbon nuclei; if the energy does not differ much in different arrangements the molecule can rotate about this   carbon-carbon σ bond, we describe this freedom to change by saying that there is free rotation about the carbon-carbon single bond.

D15 **Conformations:**
Different arrangements of atoms that can be converted into one another by rotation about single bonds are called conformations.

D16   Conformers:

There are infinite arrangement (conformations) which arise due to free rotation around carbon-carbon σ bond, **out of them different conformations corresponding to energy minima are called conformers.** The conformational isomerism arises due to free rotation along a bond.

Note: **(i)** Conformers are also called as **rotational isomers or conformational isomers.**

(ii) It may be remembered that in all the conformations, the bond angles and the bond lengths remain the same.

D17   Conformational Energy:

The rotational energy barrier is known as conformational energy. It is the potential energy difference between most stable conformation and least stable conformation. As size of group increases conformational energy increases. Conformational energy for ethane is 12.5 kJ/mol, for propane 14.5 kJ/mol and for butane 19 kJ/mol.

Configuration v/s Conformation:

Configuration is the spatial arrangement of molecule without considering the internal forces acting on the molecule whereas conformation is the spatial arrangement of the molecule when all the internal forces are taken into account. In this more restricted sense, the term conformation is used to designate different spatial arrangements arising by twisting or rotation of bonds of a given configuration.

Newman projection:

For conformational analysis, a special type of structural formula is convenient to use which is called Newman projection formula and another type is a sawhorse formula.

Newman projection
formula

sawhorse formula
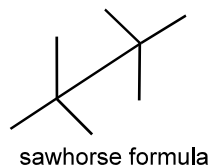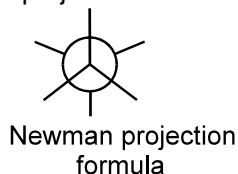
To write Newman projection formula we imagine ourselves taking a view from one carbon atom directly along the selected bond axis to the next atom. The front carbon and its other bonds are represented as

 and those of the back carbon as
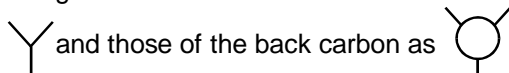
Dihedral angle:

The angle between C–X and C–Y in X–C–C–Y when it is visualised along C–C bond.
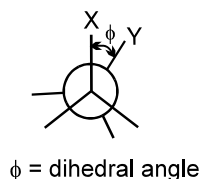
ϕ = dihedral angle

Staggered, eclipsed and skew conformations:

(I) The **staggered conformation** of a molecule is that conformation where the dihedral angle between the bonds at each atom of carbon-carbon bond is 60°, 180°, 300°.

(II) In the **eclipsed conformation** the atoms bonded to carbons at each end of carbon-carbon bond are directly opposite to one another. The dihedral angle between them is 0°, 120°, 240°.

staggered conformation
of ethane

Eclipsed conformation
of ethane
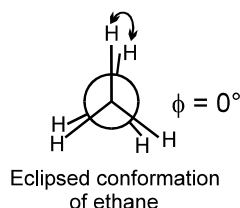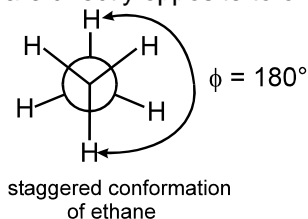
(III) Skew conformation: All conformations other than staggered or eclipsed are skew conformations.

Factors affecting stability of conformations:

(I) Angle strain: Any deviation from "normal" bond angles are accompanied by angle strain. It is normally present in the cyclic structures but absent in the acyclic structures.

(II) Torsional strain: Any pair of tetrahedral carbons attached to each other tend to have their bonds staggered for minimum repulsion between their bonds. Any deviation from the staggered conformation are accompanied by torsional strain. It is also known as **Pitzer strain** or **Eclipsing strain. Torsional strain** is maximum in eclipsed and minimum in staggered.

(III) van der Waals strain: Non-bonded atoms or groups that just touch each other i.e. they are about as far apart as the sum of their van der Waals radii, if brought any closer together they repel each other. Such crowding together is accompanied by van der Waals strain.

Conformational analysis of ethane:

Ethane molecule contains a carbon-carbon σ bond and each carbon is further attached to 3 H-atoms. It exists in two extreme conformations i.e.
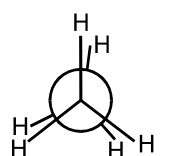
(i) Eclipsed conformation   **(ii) Staggered conformation**
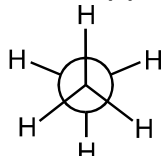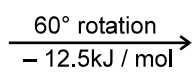
The potential energy barrier between the two conformations of ethane is about 12.5 kJ/mol.

The potential energy of ethane molecule is at a minimum for the staggered conformation, increase with rotation and reaches a maximum at the eclipsed conformation. Most ethane molecules naturally exist in the most stable staggered conformation. **There are only three energy minima that is ethane has only three conformers (conformational isomers).** Since they are indistinguishable and degenerate.

Energy profile of eclipsed and staggered forms of ethane
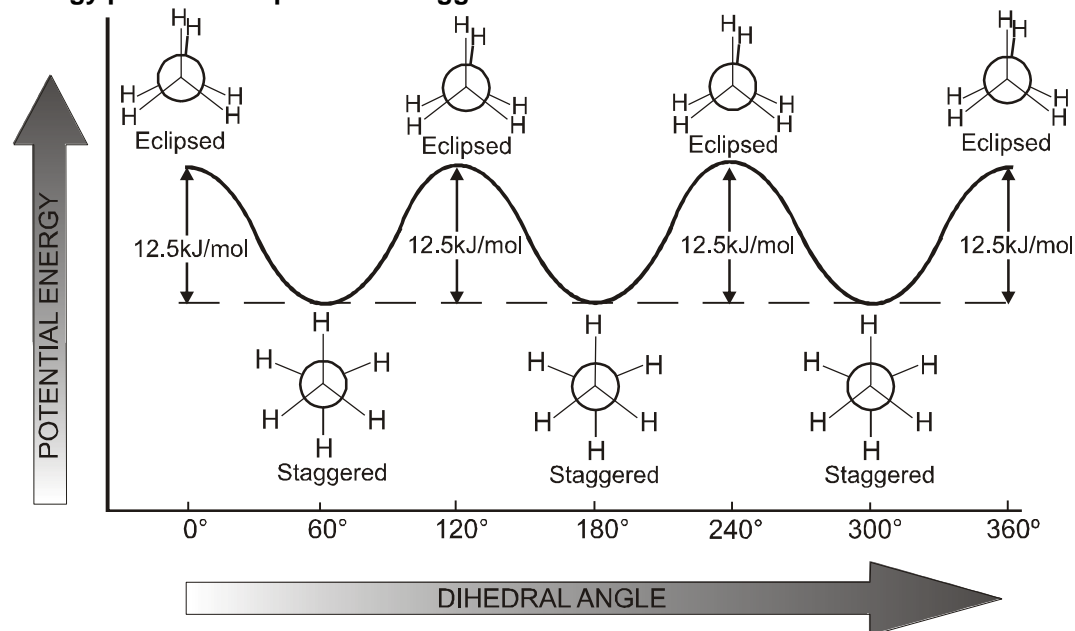
Stability order: Staggered > Eclipsed.

Conformational analysis of butane:

If we consider rotation about the C_2–C_3 bond of butane, we find that there are six important conformations shown as I - VI below:

I
Eclipsed
conformation

II
Gauche
conformation

III
partially
eclipsed conformation

IV
Anti conformation

V
Partially eclipsed
conformation

VI
gauche
conformation
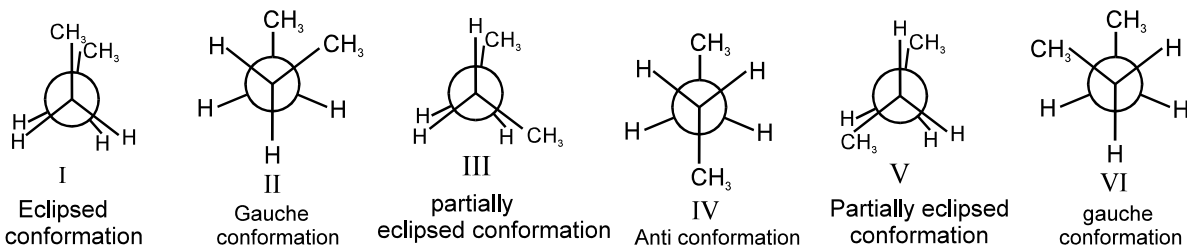
Energy profile of conformations of butane:
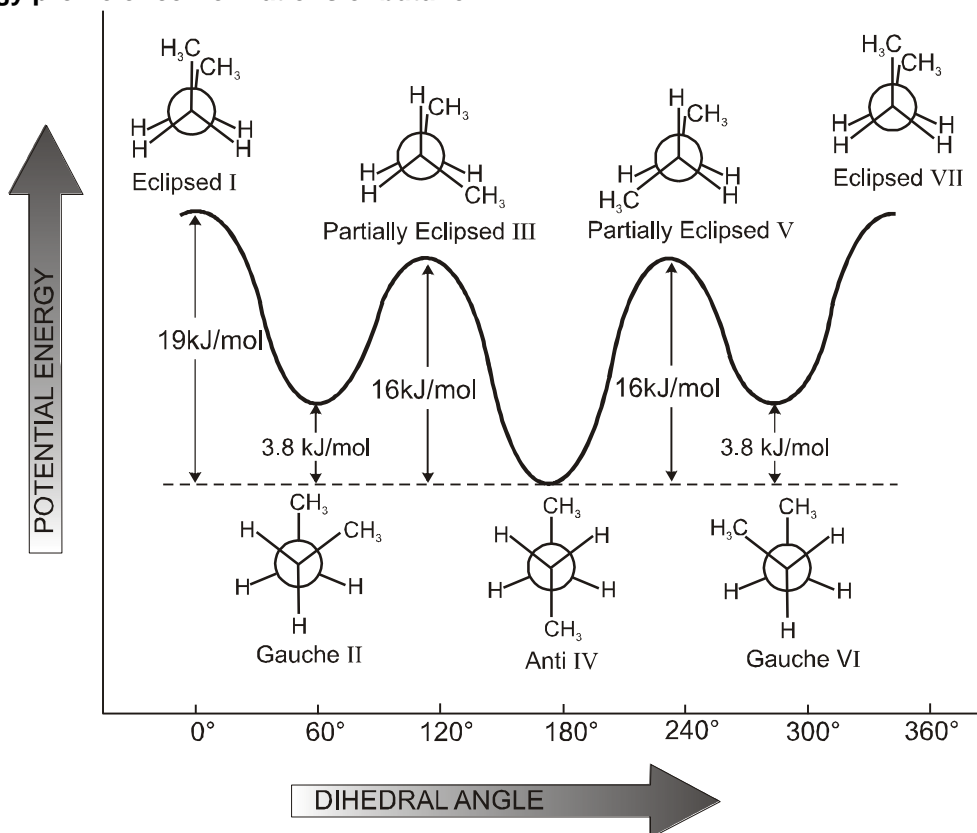
Strains and stability in n-butane

Conformation of n-butane	dihedral angle (ϕ)	Torsional strain	Vander Waal strain	Stability
Anti	180°	Absent	Absent	Maximum
Partially eclipsed	120°	Maximum	Present (between $-CH_3$ & $-H$ grps)	Intermediate-1
Gauche	60°	Absent	Present (between two $-CH_3$ grps)	Intermediate-2 (> Intermediate1)
Fully eclipsed	0°	Maximum	Maximum (between two $-CH_3$ grps)	Minimum

Gauche form of butane is chiral but butane is optically inactive.

The stability order will be: Anti > Gauche > partially eclipsed > fully eclipsed.

n-Butane exists as **three conformers** one anti (IV) and two gauche (II & VI). The gauche conformers II and VI are mirror images of each other and hence are **conformational enantiomers**. Gauche conformations (II & VI) and anti conformation (IV) are not mirror images of each other and hence are **conformational diastereomers.**

n-Butane spends the greater part of its time as the anti conformer, and divides the smaller part equally between the two gauche conformers. As a result of the rapid inter-conversion these conformers **can't be separated**.

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ADVSIM - 20

Case of intra molecular hydrogen bonding:

In case of G–CH_2–CH_2 –OH, where G = –OH, –NH_2, –F, –NR_2, –NO_2,–COOH, –CHO the Gauche form is more stable than the anti-form due to intra molecular hydrogen bonding

Ex. 2-Flouroethanol (i) Gauche form (ii) Anti form
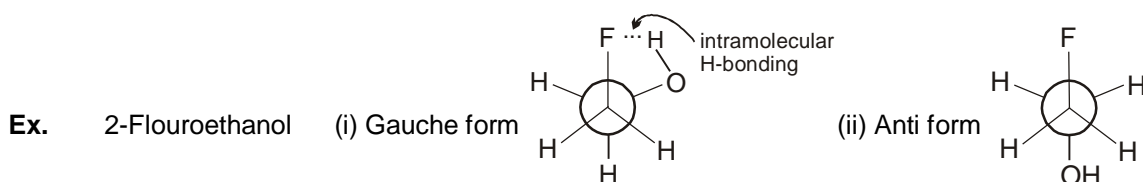
Stability order: Gauche form > Anti form > partially eclipsed > fully eclipsed.

Que. Which is the most stable & optically active conformer among the following?

(A)   (B)   (C)   (D)
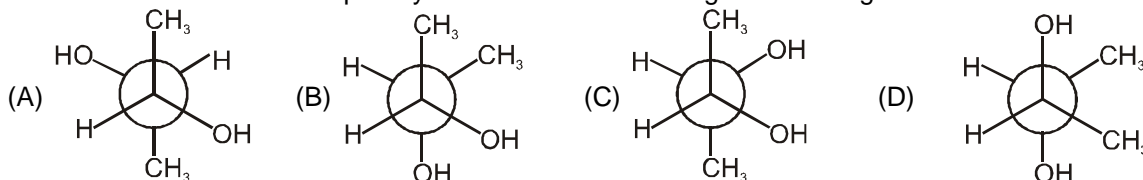
Sol. Structure (C) is optically active & most stable due to hydrogen bonding.

Que. In which of the following molecules gauche form is more stable than their anti form?
(A) 2-Aminoethanol   (B) 2-Nitroethanol
(C) 3-Hydroxypropanoic acid   (D) 3-Hydroxypropanal
Ans. (ABCD)

Sol. (A)   (B)   (C)   (D)
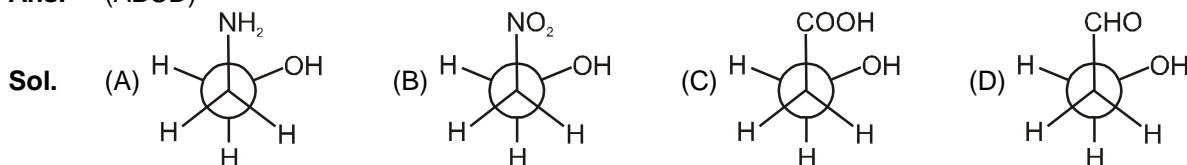
Section (K): Cyclohexane
3.   Conformational analysis of cyclohexane:

(I) Chair form: The most stable conformation of cyclohexane ring is the chair conformation. It is the staggered form of cyclohexane. In this non-planar structure the C–C bonds angles are close to 109.5º. This conformation is free from all the strains (like angle strain and torsional strain.)

chair conformation

chair form (all staggered bonds)
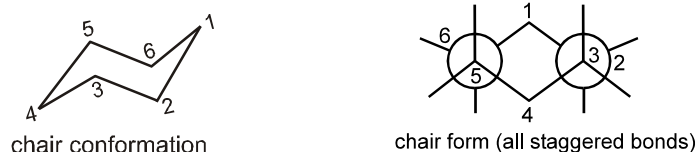
Axial and equatorial bonds in chair form of cyclohexane:

Axial C – H bonds

Equatorial C – H bonds

Axial & equatorial
bonds together
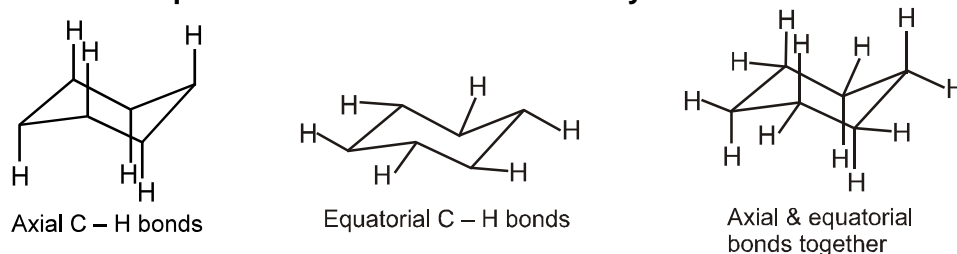
The 12 hydrogen atoms of chair conformation of cyclohexane can be divided into two groups. Six of the hydrogen's called axial hydrogen, hence their bonds parallel to a vertical axis that passes through the rings centre. These axial bonds are directed up & down on adjacent carbons. The second set of six hydrogen's called equatorial hydrogen which are located approximately along the equator of the molecule.

(II) Boat form: Another conformation which is known as boat conformation has exactly eclipsed conformations. Boat form is the transition state of two chair form.

Boat conformation

Boat conformation
(all eclipsed bonds)

Flagpole hydrogens
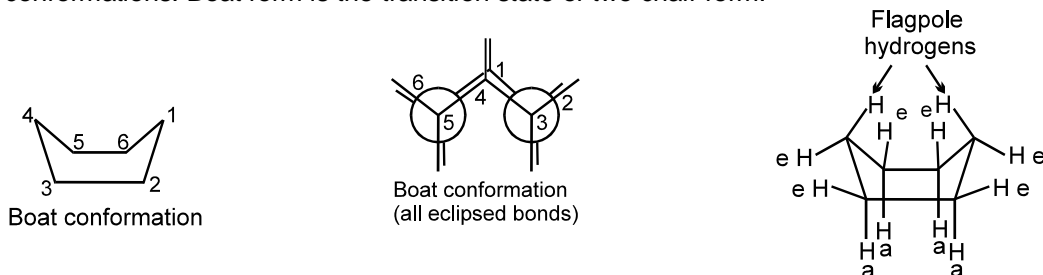
In boat form of cyclohexane **6 hydrogen are equatorial**, **4 hydrogen are axial** and **two hydrogen are flagpoles.** It is an **unstable conformation** of cyclohexane due to **torsional strain** among axial hydrogen and due to **Vander Waal strain** caused by crowding between the "flagpole" hydrogen.

Conformational inversion (Ring flipping) in cyclohexane:

Like alkanes cyclohexane too is conformationally mobile. Through a process known as ring inversion, chair-chair interconversion, or more simply ring flipping one chair conformation is converted to another chair through the half chair, twist boat and boat form.
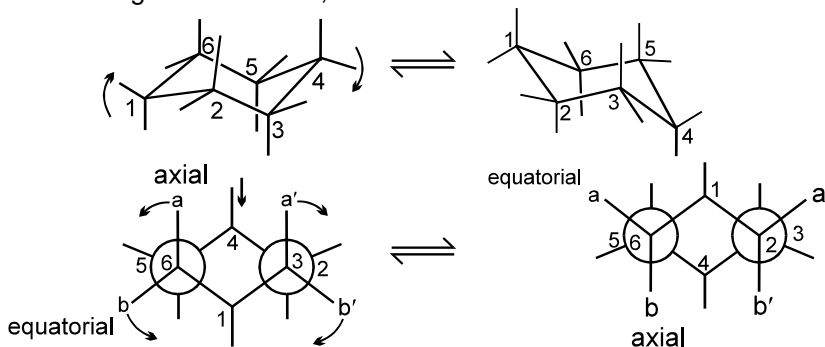
By ring flipping all axial bonds convert to equatorial and vice-versa. The activation energy for cyclohexane ring inversion is 45 kJ/mol. It is a very rapid process with a half-life of about 10^{-5} sec. at 25°C.

The relative energy profile of various conformations of cyclohexane

Chair   half-chair   twist-boat

true boat   twist-boat   half-chair   Chair

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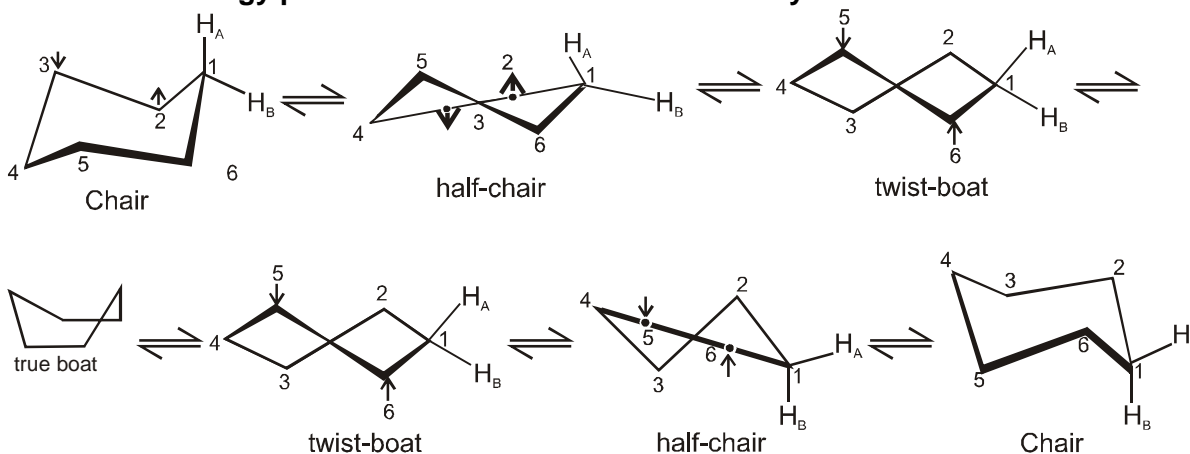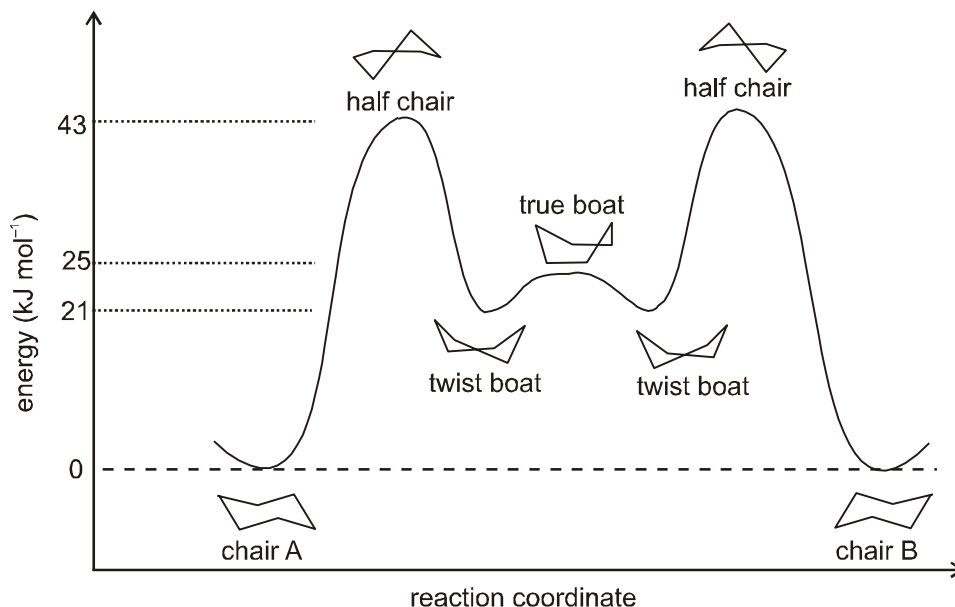
Because of the greater stability of the chair form, more than 99% of the molecules are estimated to be in a chair conformation of any given moment.

Note: (a) Twist boat form of cyclohexane is **chiral**.

(b) Some molecules due to intra molecular hydrogen bond stabilization exist in **boat form** rather than chair form.

Ex.

1, 2, 2, 6,6-Pentamethy-4-hydroxyl-4-phenylpiperidine
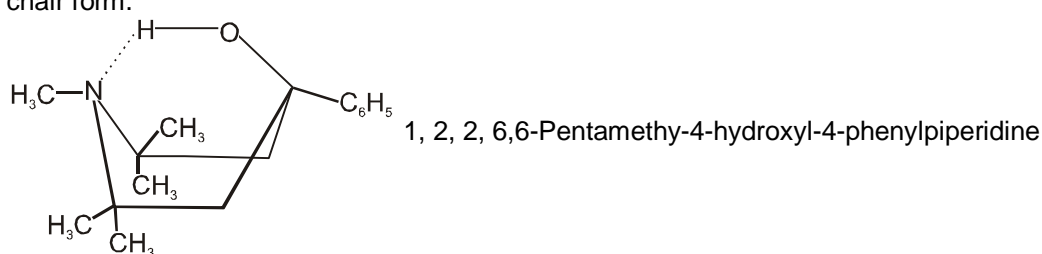
Conformational analysis of monosubstituted cyclohexane:

In ring inversion in methylcyclohexane the two chair conformations are not equivalent. In one chair the methyl group is axial; in the other it is equatorial. At room temperature 95% of the methylcyclohexane exist in **equatorial** methyl group whereas only 5% of the molecule have an **axial** methyl group.
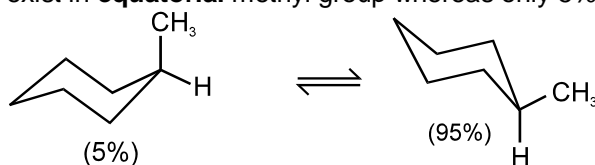
1, 3-diaxial repulsion:

A methyl group is less crowded when it is equatorial than when it is axial. The distance between the axial methyl groups at C-1 and two hydrogen at C-3 & C-5 is less than the sum of their Vander Waal radii which causes Vander Waal strain in the axial conformation. This type of crowding is called 1,3-diaxial repulsions. When the methyl group is equatorial, it experience no significant crowding.

Vander waals strain between hydrogen of axial CH₃ and axial hydrogens at C-3 and C-5

No vander waals strain between axial hydrogen at C–1 and axial hydrogens at C–3 & C-5
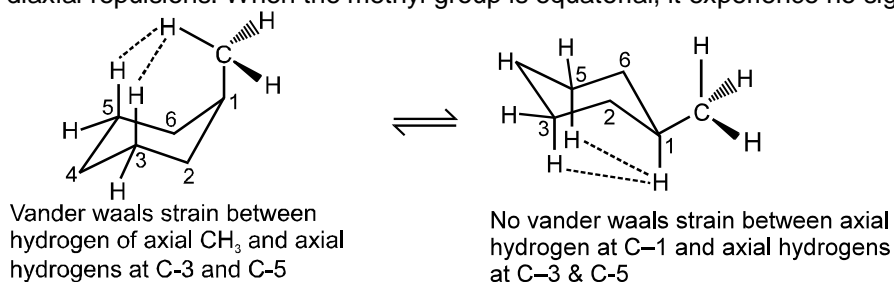
Que. Draw the most stable conformation of (a) 1,2-dimethylcyclohexane. (b) cyclohexane-1,3-diol

Ans. (a)

(b)

Que. Which is the most stable conformer among the given conformers?

(A)

(B)

(C)

(D)
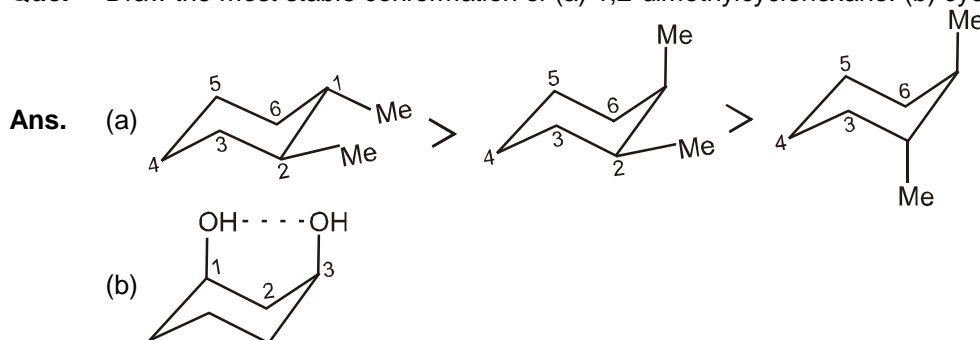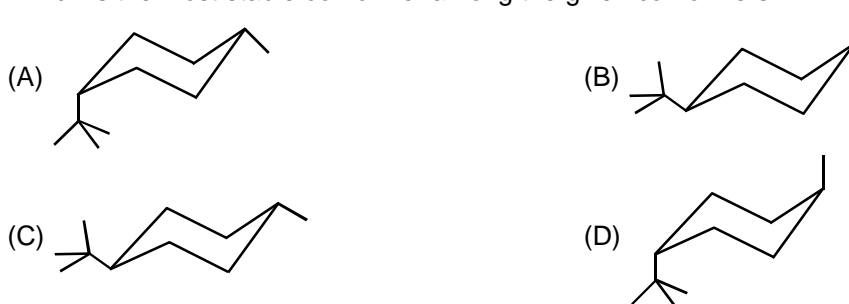
Sol. Conformer (C) is most stable.

Que. Which is the most stable conformer among the given conformers?

(A)

(B)

(C)

(D)
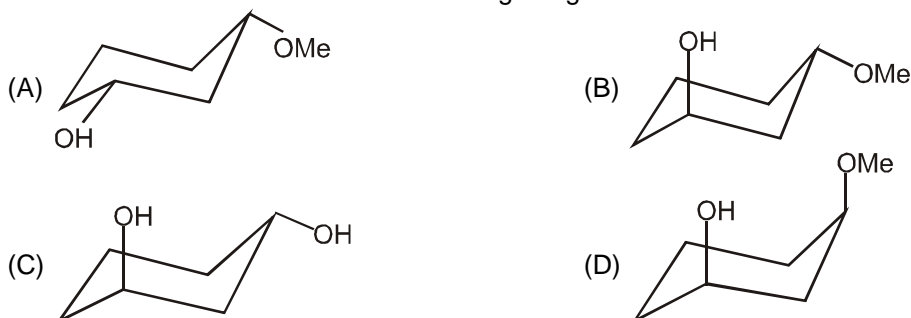
Sol. Conformer (D) is most stable due to hydrogen bonding.

CHECK LIST
Definitions (D)

D1	Geometrical isomerism	☐	D13	Specific rotation (α)	☐
D2	Optically active compounds	☐	D14	Stereo Centre	☐
D3	Chirality	☐	D15	Conformations	☐
D4	Chiral center	☐	D16	Conformers	☐
D5	Plane of symmetry (σ)	☐	D17	Conformational Energy	☐
D6	Centre of symmetry (i)	☐			
D7	Axis of symmetry (C_n)	☐			
D8	Alternating axis of symmetry (S_n)	☐			
D9	Enantiomers	☐			
D10	Racemic mixture	☐			
D11	Optical diastereomers	☐			
D12	Meso compound	☐			

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Exercise-1

✎ **Marked questions are recommended for Revision.**

PART - I : SUBJECTIVE QUESTIONS

Section (A) : Geometrical isomerism

A-1.✎ Which of the following compounds have restricted rotation and out of which can show geometrical isomerism?

(i)   (ii)   (iii) ClCH=CHCl   (iv) Ph–N=N–Ph

(v) $CH_3CH=C(CH_3)_2$ (vi) $CH_3CH = CH_2$ (vii) $CH_3CH=CHCH_3$ (viii) $CH_3–C\equiv C–CH_3$
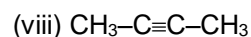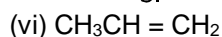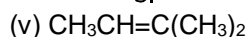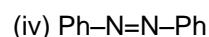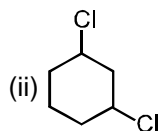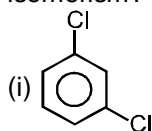
A-2. Write the essential conditions for geometrical isomerism.

A-3. Define restricted rotation and give one example each of acyclic and cyclic compound, which can show geometrical isomersm.

A-4. Which of the following can show geometrical isomerism.
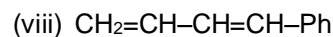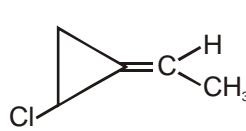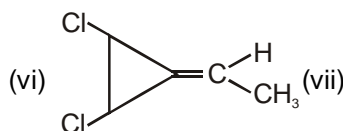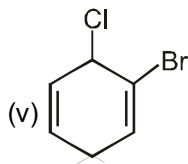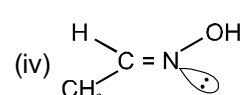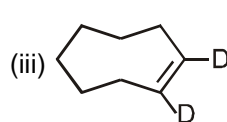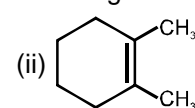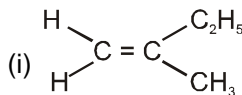
(i)   (ii)   (iii)   (iv)

(v)   (vi)   (vii)   (viii) $CH_2=CH–CH=CH–Ph$

A-5.✎ Which of the following carbonyl compound will give two products after reaction with NH_2OH :

(i)   (ii) $CH_3–CHO$ (iii)

(iv) DCHO   (v)   (vi)
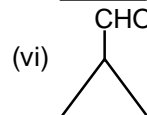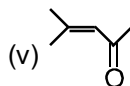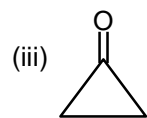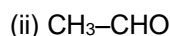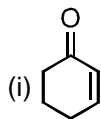
Section (B) : CIP Rules (E/Z Naming) & Physical Properties of G.I

B-1. Indicate whether each of the following compound is 'E' or 'Z'.

(i)   (ii)   (iii)   (iv)
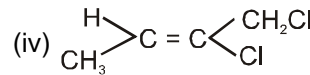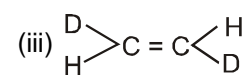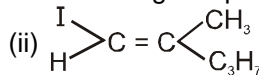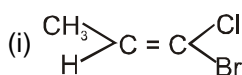
B-2.✎ **(a)** BrHC=CHBr exists as two diastereomers draw them and compare their dipole moment.
(b) trans-Butenedioic acid has higher melting point than cis-butenedioic acid. Why ?
(c) Draw the cis and trans structures of hex-2-ene. Which isomer will have higher b.p. and why ?

Section (C) : Chiral carbon and Projection Formula

C-1. Number of chiral carbon atoms in the compound W, X, Y and Z respectively would be :
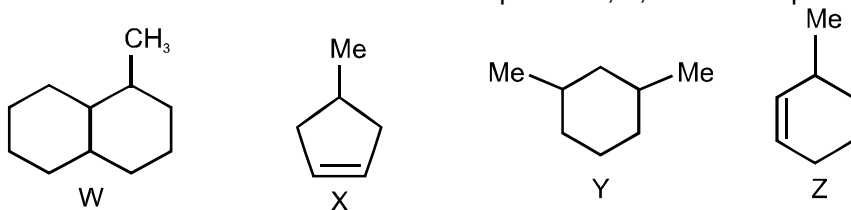
C-2. How many number of chiral centres present in the following compounds ?

(i)   D(+)-Sucrose   (ii)
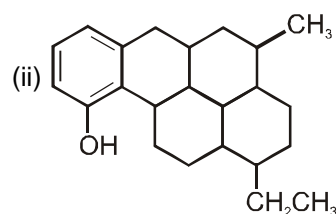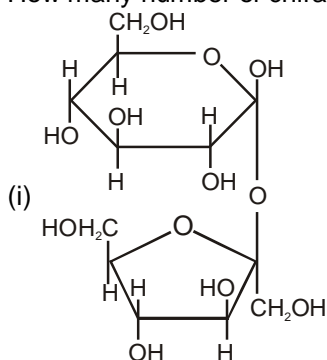
Section (D) : R/S & D/L Naming.

D-1. Find R/S configuration of following compounds.
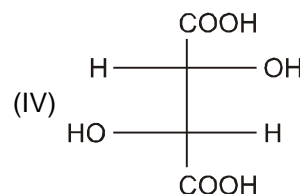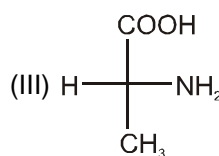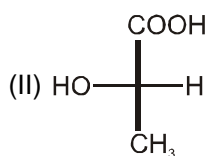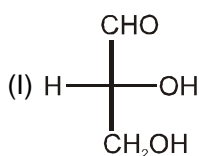
D-2. Find D/L configuration in the following molecules.
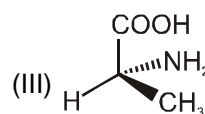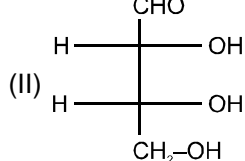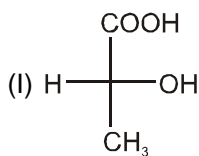
D-3. The R/S configuration of following compounds are :
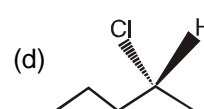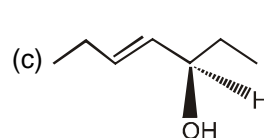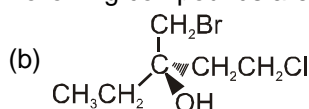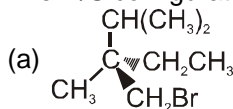
Section (E) : Element of Symmetries (POS, COS, AOS)

E-1. Find plane of symmetry and centre of symmetry (if possible) in the following compounds.

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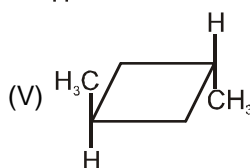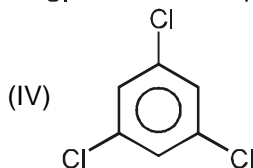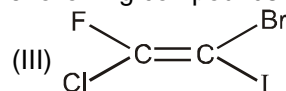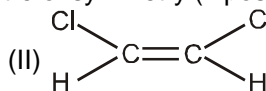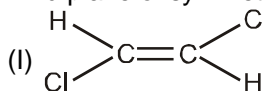
E-2. Find plane of symmerty, centre of symmerty and axis of symmetry (if possible) in the following molecules.

(i) H_3C—C(H)—CO–NH—C(H)—CH$_3$ ... CO–NH ...

(ii) Br, Cl cyclopropane

(iii) Cl, Cl, H, H cyclobutane

(iv) Br, H, H, Br cyclohexane

(v) Et, D, CH$_2$CH$_3$, H

(vi) CH$_3$, Br, H, D
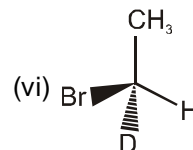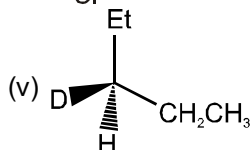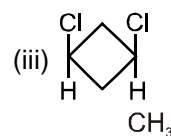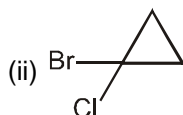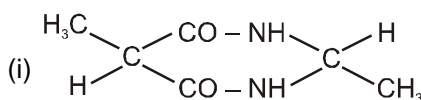
Section (F) : Definition and Properties of Enantiomers, Diastereomers, Mesocompounds

F-1. Identify the pairs of enantiomers and diastereomers from the following compounds I, II and III :

(I) CH$_3$ / H—OH / HO—H / CH$_3$

(II) CH$_3$ / HO—H / HO—H / CH$_3$

(III) CH$_3$ / HO—H / H—OH / CH$_3$
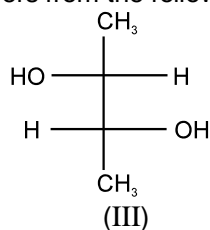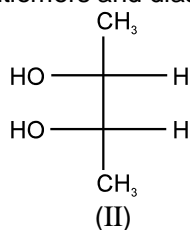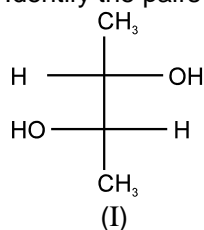
F-2. Find relationship between the given pairs.

(I) Br—Cl (F top, I bottom) and I—F (Br top, Cl bottom)

(II) H—Cl (F top, Br bottom), D—I and D—F (I top, Cl bottom), Br—H

(III) H—OH (COOH top, COOEt bottom), HO—H and H—OH (COOEt top, COOH bottom), HO—H

(IV) H—OH (COOH top, COOH bottom), HO—H and HO—H (COOH top, OH bottom), H—COOH
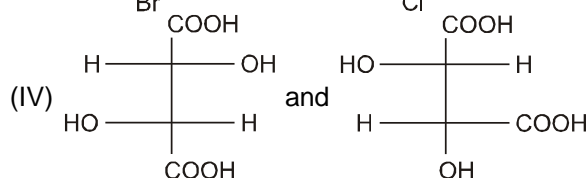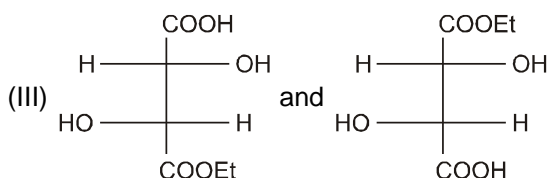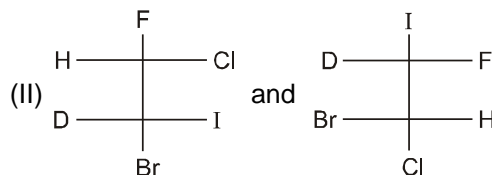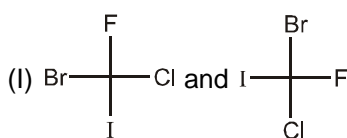
F-3. Give the relationship between the following pairs of compounds.

	Compounds	Relationship
(a)	CH$_3$, H / C=C / H, CH$_2$–CH$_2$–OH and H, H / C=C / H$_3$C, CH$_2$–O–CH$_3$	....
(b)	CH$_3$, Cl, Cl, Br, C$_2$H$_5$, Cl and Cl, H$_5$C$_2$, Br, Cl, Cl, CH$_3$ (Newman projections)	....
(c)	(trans alkene) and (cis alkene)	....
(d)	CH$_3$ / H—OH / H—Cl / H—OH / C$_2$H$_5$ and CH$_3$ / H—OH / Cl—H / H—OH / C$_2$H$_5$	....

F-4.

(i) Total number of fractions on fractional distillation of I, II and III. (ii) Optical active compounds.
(iii) Relation between I and II. (iv) Relation between I and III.

Section (G): Specific rotation, optical purity, enantiomeric excess and Optical Resolution

G-1. What does D/L & d/ℓ represent.

G-2. Write the definition of specific rotation.

G-3. Write the formula for optical purity & enantiomeric excess.

G-4. The total number of fractions (n) obtained in the following reaction is ....
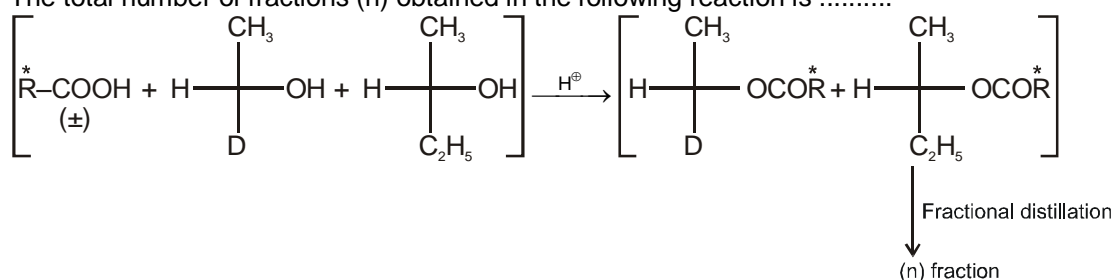
Section (H) : Optical active compounds without chiral carbon and Amine inversion

H-1. Which of the following are chiral compound.
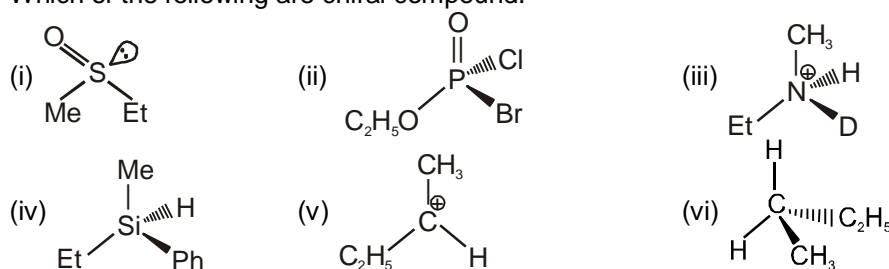
H-2. Which of the following are chiral molecules

(i) Ph–CH=C=C=CH–Cl (ii) CH_3–CH=C=C=C=CH–CH_3
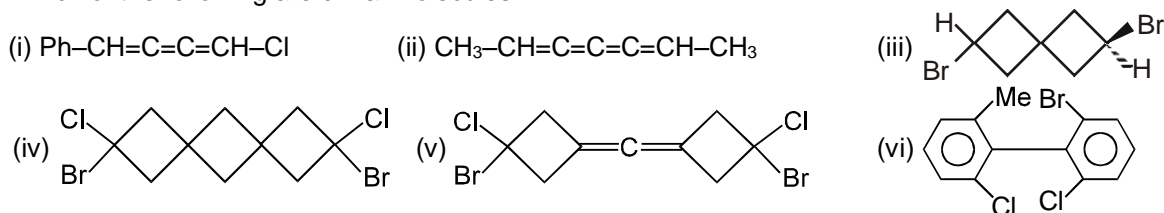
Section (I) : Calculation of no. of Stereoisomers

I-1. Find the number of geometrical isomers possible of the following compounds.
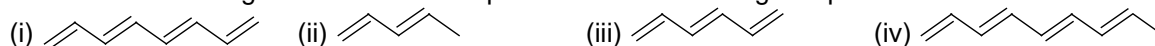
I-2. How many n-octene can show geometrical isomerism ?

I-3. How many geometrical isomers are possible for Hepta-2, 5-dienoic acid :

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I-4. For the given compound $CH_3 - \underset{\underset{OH}{|}}{CH} - CH = CH - CH_3$.

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

I-5. The total number of possible isomers with molecular formula C_6H_{12} that contain a cyclobutane ring.

I-6. The number of isomers for the compound with molecular formula $C_2BrClFI$ are :

Section (J) : Conformational Isomerism

J-1. Which conformational state of n-butane lies in higher energy state when rotated along C_2–C_3 bond?

J-2. Draw the most stable conformation of meso-CH_3CHD–$CHDCH_3$

J-3. Write the most polar and most stable conformer of 1-nitropropane.

J-4. Draw the most stable conformer of 3-hydroxypropanal.

J-5. Write the Newman projection formula of the following compounds
(I) Cl–CH_2–CH_2–CH_3 in its most polar form.
(II) HO–CH_2–CH_2–OH in its most stable form.
(III) $HOOC$–CH_2–CH_2–$COOH$ in its least stable staggered form.

J-6. Draw the most stable Newman projection formula along C_1–C_2 bonds of following compounds.

(i) $\overset{1}{C}H_3$–$\overset{2}{C}H_2$–CH_3
(ii) CH_3–$\underset{\underset{CH_3}{|}}{\overset{1}{C}H}$–$CH_3$
(iii) CH_3–$\underset{1}{\overset{\overset{CH_3}{|}}{C}H}$–$\underset{2}{\overset{\overset{CH_3}{|}}{C}H}$–$CH_3$
(iv) HO–$\overset{1}{C}H_2$–$\overset{2}{C}H_2$–F

Section (K) : Cyclohexane

K-1. Which of the following combination of axial & equitorial bonds show Cis or Trans orientation in Dimethyl cyclohexane.
(i) 1e, 2e   (ii) 1e, 3e   (iii) 1e, 4e   (iv) 1e, 2a   (v) 1e, 3a   (vi) 1e, 4a   (vii) 1a, 3a

K-2. Which one is more stable and why?

(I)   (II)
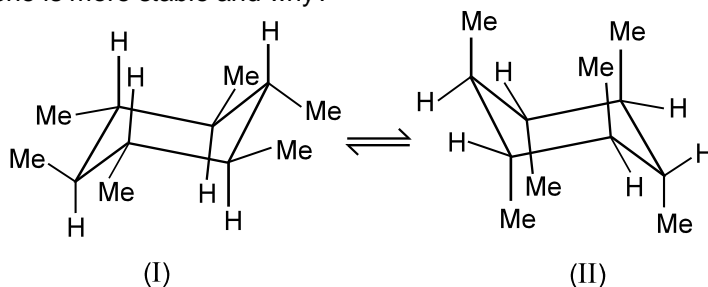
PART - II : ONLY ONE OPTION CORRECT TYPE

Section (A) : Geometrical isomerism

A-1. Stereoisomers have different :   .
(A) Molecular formula
(B) Structural formula
(C) Configuration
(D) Molecular mass

A-2. Which can show the cis-trans isomerism :
(A) $ClCH_2CH_2Cl$ (B) $Cl_2C=CH_2$ (C) $Cl_2C=CCl_2$ (D) $ClCH=CHCl$

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A-3. Which of the following compounds will not show geometrical isomerism :
(A) Azomethane   (B) 1-Bromo-2-chloroethene
(C) 1-Phenylpropene   (D) 2-Methyl-2-butene

A-4. Which of the following compound can not show geometrical isomerism ?

(A)   (B)   (C)   (D)
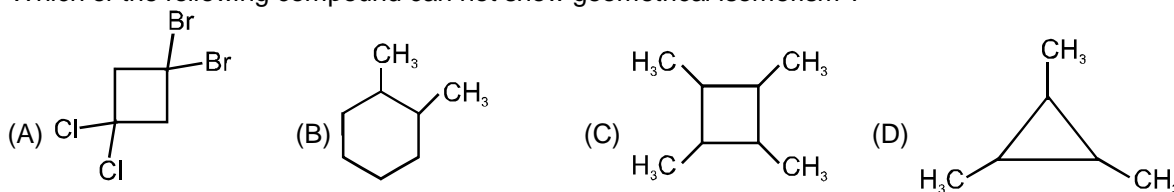
A-5.* Which of the following will form only one oxime on reaction with NH_2OH solution ?

(A)   (B)   (C)   (D)
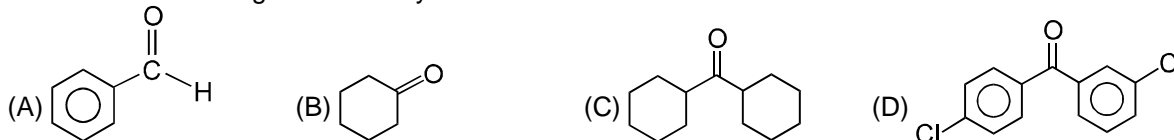
Section (B) : CIP Rules (E/Z Naming) & Physical Properties of G.I

B-1. Identify (Z)-2-pentene :

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

B-2. The 'E'-isomer is/are :

(A)   (B)

(C)   (D)

B-3. The correct order/s for the given pair of isomers is

(A) ... > ...   (Melting point)

(B) ... < ...   (Dipole moment)

(C) ... > ...   (Boiling point)

(D) ... > ...   (Water solubility)
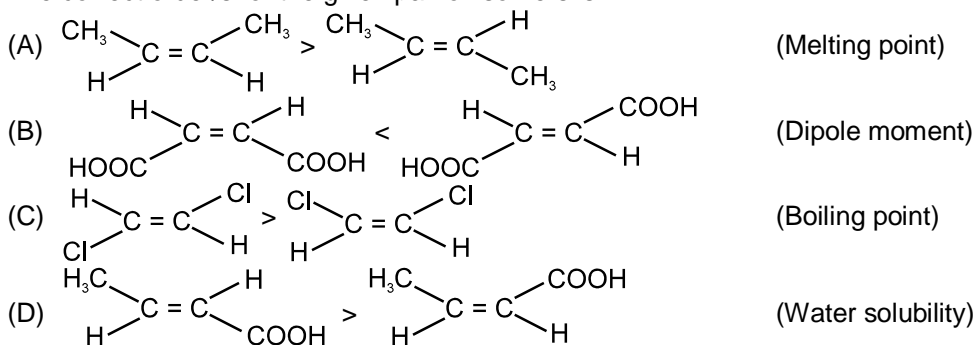
Section (C) : Chiral carbon and Projection Formula

C-1. Chiral molecules are :
(A) Superimposable on their mirror image
(B) Not superimposable on their mirror image
(C) unstable molecules
(D) capable of showing geometrical isomerism

C-2. Number of chiral carbon persent in the following compound :

$$CH_3 - CH - CH_2 - CH - CH - CH_3$$
$$\quad\quad\; | \quad\quad\quad\quad\;\; | \quad\; |$$
$$\quad\quad OH \quad\quad\quad\; Br \;\; C_2H_5$$

(A) 2   (B) 3   (C) 4   (D) 5
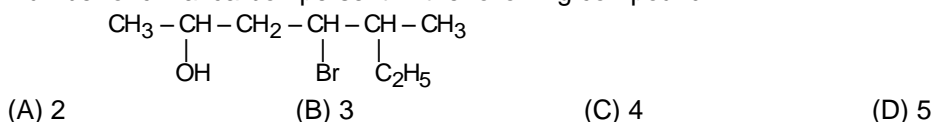
C-3. The compound which has maximum number of chiral centres is

(A)   (B)   (C)   (D)
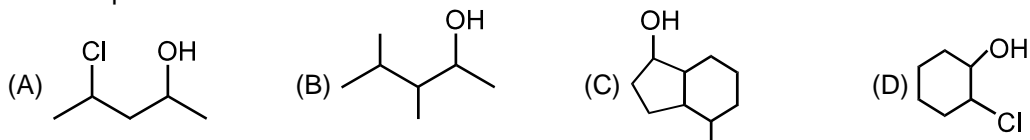
Section (D) : R/S & D/L Naming.

D-1. Which of the following is the structure of (S)-Pentan-2-ol is ?

(A)   (B)   (C)   (D)
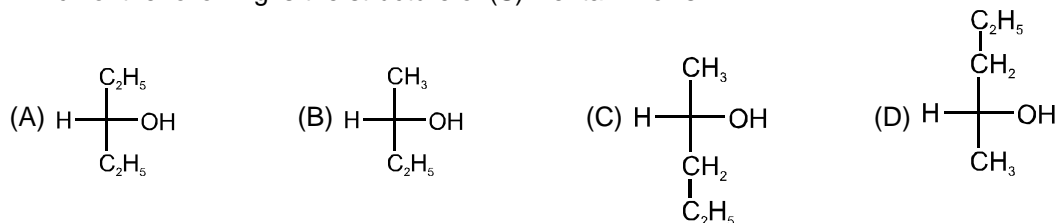
D-2. The configuration of the given compound is :

(A) E (B) R (C) S (D) Z
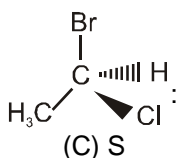
D-3. Which Fisher projection represents the given wedge dash structure :

(A)   (B)   (C)   (D)
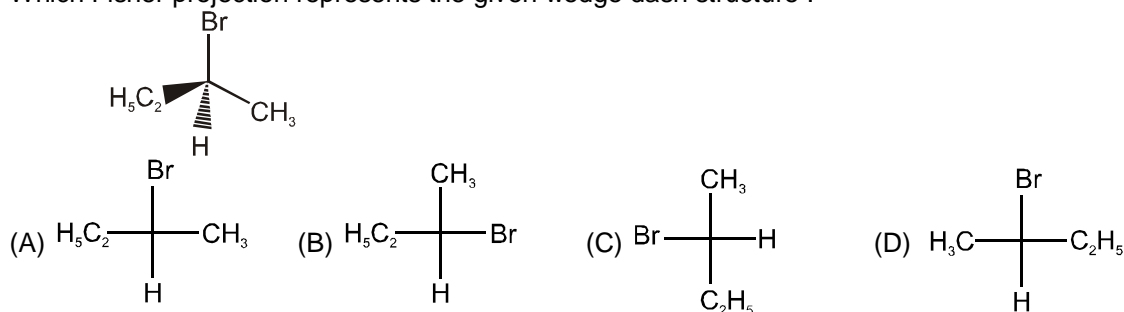
D-4. Which of the following have same configuration.

(A) I & II (B) II & III (C) I & III (D) All
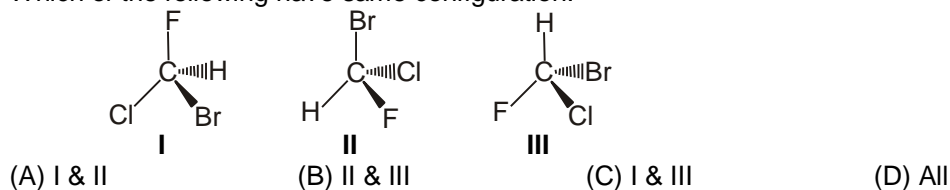
D-5. Which has D configuration.

(A)   (B)   (C)   (D)
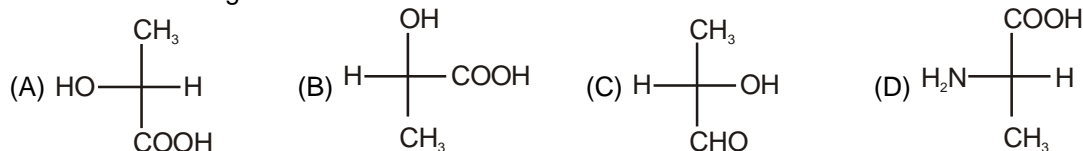
Section (E) : Element of Symmetries (POS, COS, AOS)

E-1. Which of the following compound posses plane of symmetry?

(A)   (B)   (C)   (D)
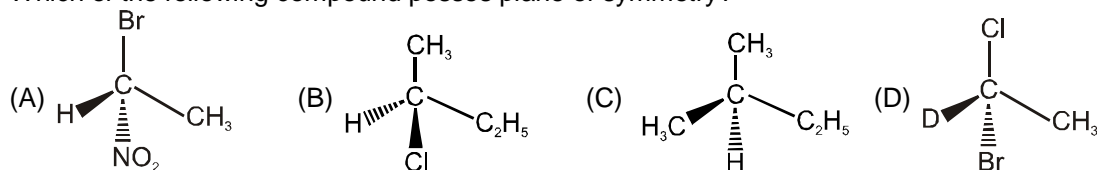
E-2. Which of the following compound posses centre of symmetry ?

(A)

(B)

(C)

(D)
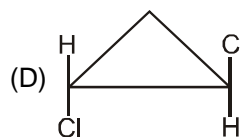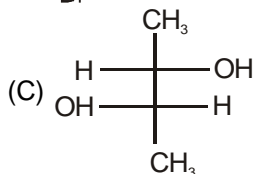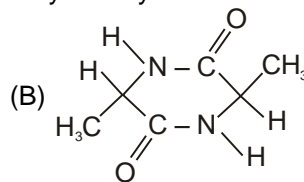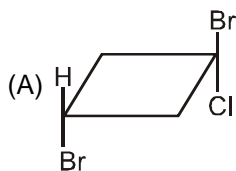
E-3. Which of the following are chiral :

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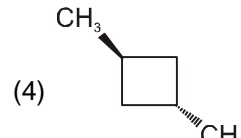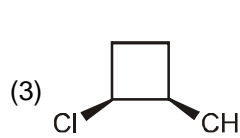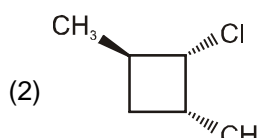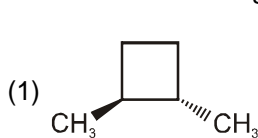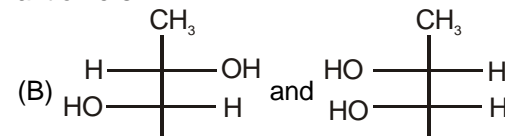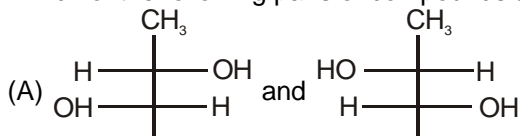
(A) 1, 2, 3   (B) 1, 2, 4   (C) 2, 3, 4   (D) 1, 3, 4

Section (F) : Definition and Properties of Enantiomers, Diastereomers, Meso compounds

F-1. Which is not the pair of enantiomers ?

(A)   (B)

(C)   (D)
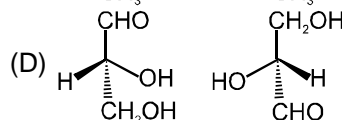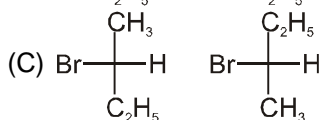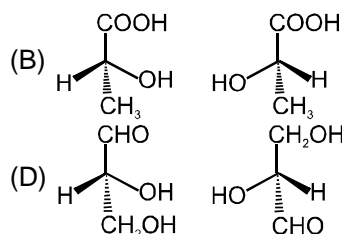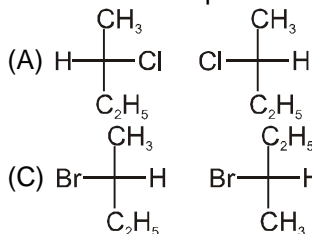
F-2. Which of the following pairs of compounds are enantiomers :

(A)   (B)

(C)   (D)
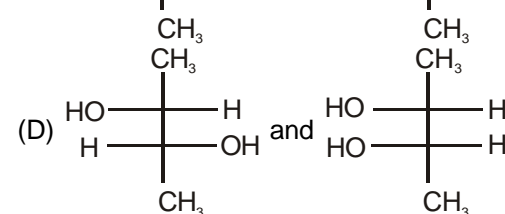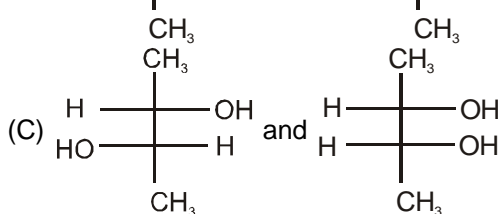
F-3. Stereoisomers which are not mirror image of each other, are called :
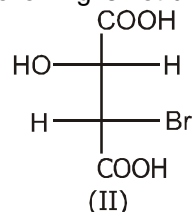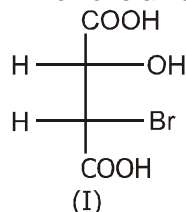
(A) Enantiomers   (B) Tautomers   (C) Meso   (D) Diastereomers

F-4. Which one among the following is not diastereomeric pair.
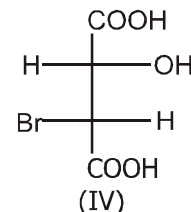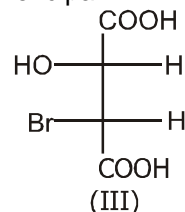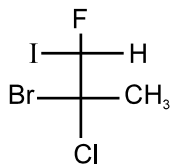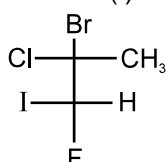

(I)   (II)   (III)   (IV)

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

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F-5. What is the relationship between (I) & (II)

(I)   (II)

(A) Enantiomer   (B) Diastereomers
(C) Constitutional isomer   (D) Identical molecules

F-6.
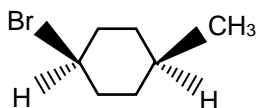
 and are :
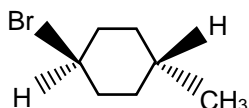
(A) Enantiomers   (B) Optical inactive diastereomers
(C) Optical active diastereomers   (D) Identical

Section (G) : Specific rotation, optical purity, enantiomeric excess and Optical Resolution
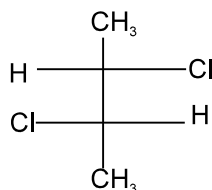
G-1. The instrument which can be used to measure optical activity, i.e., specific rotation:
(A) Refractometer   (B) Photometer   (C) Voltmeter   (D) Polarimeter

G-2. (+) tartaric acid has a specific rotation of +12 unit when measured in 12 cm polarimeter tube and 2g/ml concentration at given temperature and light. When it is diluted to half the concentration, length of tube and other parameters being same, then the specific rotation will be :
(A) +6 unit   (B) +12 unit   (C) –6 unit   (D) +24 unit

G-3. If optical rotation produced by is +36º then that produced by is :
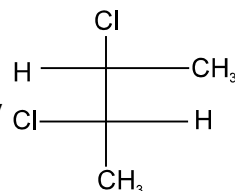
(A) –36º   (B) 0º   (C) +36º   (D) unpredictable

G-4. The enantiomeric excess and observed rotation of a mixture containing 6 gm of (+)-2-butanol and 4 gm of (–)-2-butanol are respectively (If the specific rotation of enantiomerically pure (+)-2-butanol is + 13.5 unit).
(A) 80%, + 2.7 unit   (B) 20%, – 27 unit   (C) 20%, + 2.7 unit   (D) 80%, – 27 unit

G-5. The racemic mixture of Alanine $\left(\begin{array}{c} CH_3-CH-COOH \\ | \\ NH_2 \end{array} \right)$ can be resolved by using,

(1) (+)-2-Butanol   (2) (ℓ)-2-Chlorobutanoic acid
(3) (±) -2-Butanol   (4) (dℓ mix)-2-Chlorobutanoic acid
(A) 1 & 2 only   (B) 1 & 3 only   (C) 2 & 4 only   (D) 3 & 4 only

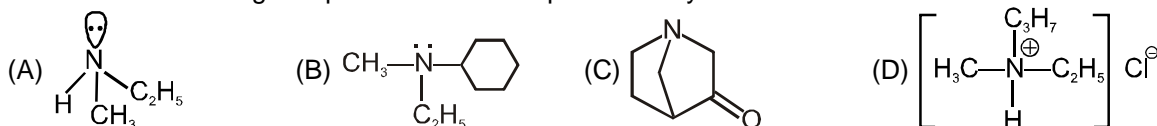**G-6.** The major product (ester) of the following reaction is
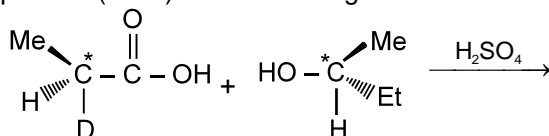
(A) A single stereoisomer (optically active)
(B) A mixture of diastereomers (both optically active)
(C) A racemic mixture (optically inactive)
(D) A mixture of four stereoisomers (two racemic mixtures)

G-7. Which of the following pair of isomers can not be separated by fractional crystallisation or fractional distillation:
(A) Maleic acid and Fumaric acid
(B) (+)-Tartaric acid and meso-tartaric acid
(C) $CH_3 - CH - COOH$ and $H_2N–CH_2–CH_2–COOH$
$\qquad\qquad\ \ |$
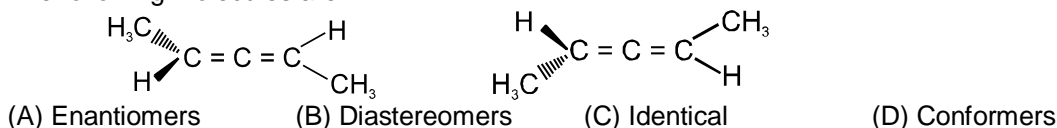$\qquad\qquad NH_2$
(D) (+)-lactic acid and (–)-lactic acid

Section (H) : Optical active compounds without chiral carbon and Amine inversion

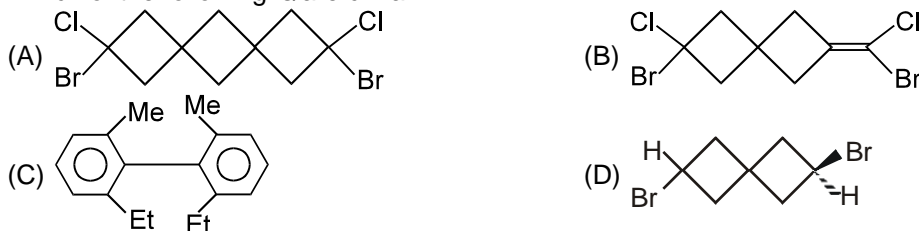**H-1*.** Which of the following compounds will show optical activity ?

(A)

(B) $CH_3—\overset{..}{N}—$ (cyclohexyl)
$\qquad\qquad |$
$\qquad\qquad C_2H_5$

(C)

(D) $\left[H_3C—\overset{\overset{C_3H_7}{|} \oplus}{\underset{\underset{H}{|}}{N}}—C_2H_5 \right] Cl^\ominus$

H-2. Which of the following amine is optically active?
(A) CH_3NH_2
(B) $CH_3NHC_2H_5$
(C) $CH_3CH_2CH_2—N{\overset{CH_3}{\underset{C_2H_5}{<}}}$
(D) sec-Butylamine

H-3. The following molecules are :

(A) Enantiomers
(B) Diastereomers
(C) Identical
(D) Conformers
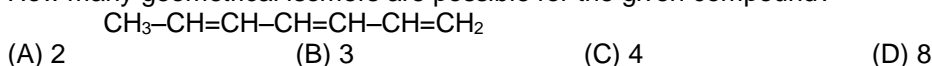
H-4.* Which of the following is/are chiral ?

(A)

(B)

(C)

(D)

Section (I) : Calculation of no. of Stereoisomers

I-1. How many geometrical isomers are possible for the given compound?
Ph–CH=CH–CH=CH–COOH
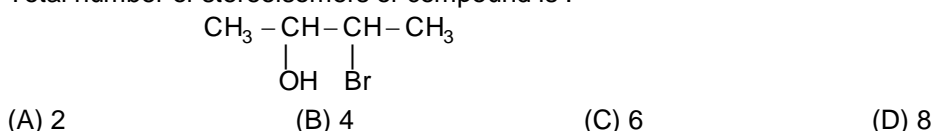(A) 2 (B) 4 (C) 6 (D) 8
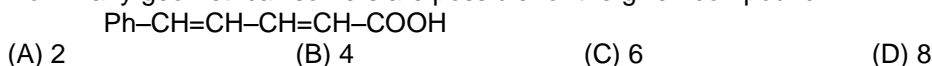
I-2. How many geometrical isomers are possible for the given compound?
$CH_3–CH=CH–CH=CH–CH=CH_2$
(A) 2 (B) 3 (C) 4 (D) 8

I-3. How many geometrical isomers are possible for the given compound?

$CH_3—$ (cyclohexyl) $—CH = N – OH$

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

I-4. Total number of stereoisomers of compound is :
$CH_3 - CH - CH - CH_3$
$\qquad\quad\ |\qquad |$
$\qquad\quad OH\quad Br$
(A) 2 (B) 4 (C) 6 (D) 8

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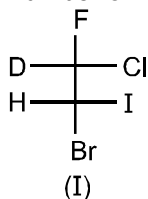ADVSIM - 34
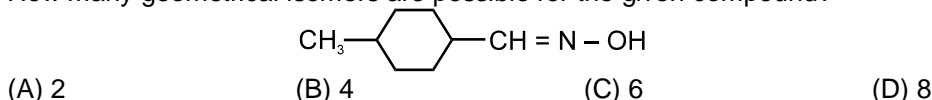
I-5. Total number of optically active stereoisomers of tartaric acid is
(A) 2   (B) 4   (C) 3   (D) 0

I-6. Number of fractions on fractional distillation of mixture of :

(I)   (II)   (III)   (IV)
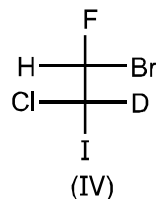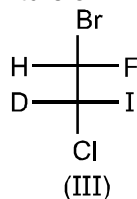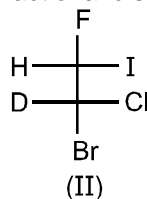
(A) 2   (B) 3   (C) 4   (D) 1

I-7. Total number of optically active stereoisomers of $CH_3 - CH - CH - CH - CH_3$ with Cl, Cl, Cl substituents

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

I-8. The total number of ketones (including stereo isomers) with the molecular formula $C_6H_{12}O$ is :
(A) 4   (B) 5   (C) 6   (D) 7
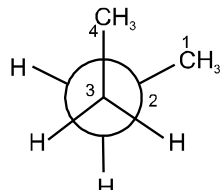
I-9. Total number of optical active stereoisomers of the following compound is :
$CH_3–CH=CH–CHCl–CH=C=CH–CH=CH–CH_3$
(A) 8   (B) 6   (C) 16   (D) 10

Section (J) : Conformational Isomerism

J-1. 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

J-2. Which of the following is associated with Torsional strain ?
(A) Repulsion between bond pair of electrons   (B) Size of the groups present at adjacent atoms
(C) Bond angle strain   (D) Attraction of opposite charges

J-3. The Baeyer's angle strain is expected to be maximum in
(A) Cyclodecane   (B) Cyclopentane   (C) Cyclobutane   (D) Cyclopropane

J-4. The minimum torsional strain developed in butane is at dihedral angle(s)
(A) 0º, 108º   (B) 120°, 240º   (C) 60°, 180°, 300°   (D) 60°, 120°, 180°

J-5. In the following the most stable conformation of *n*-butane is :
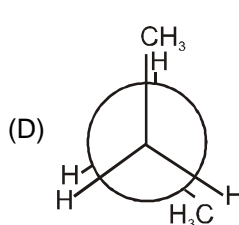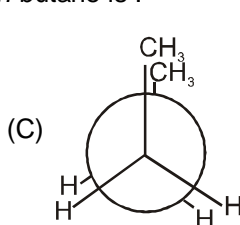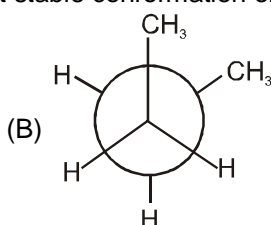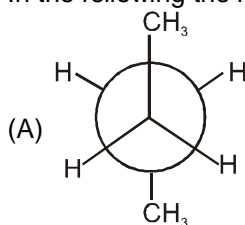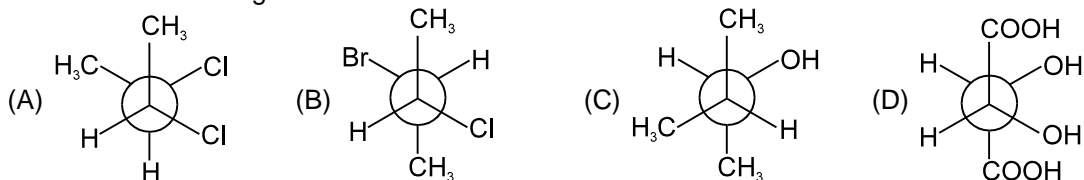

J-6. Newman projection of Butane is given, C-2 is rotated by 120º along C_2–C_3 bond in anticlockwise direction, the conformation formed is :

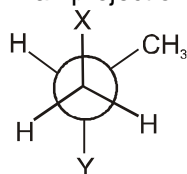(A) anti   (B) fully eclipsed   (C) gauche   (D) partially eclipsed

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J-7. Which of the following is an achiral molecule?

(A) CH_3, H_3C, Cl, Cl, H, H

(B) CH_3, Br, H, H, Cl, CH_3

(C) CH_3, H, OH, H_3C, H, CH_3

(D) $COOH$, H, OH, H, OH, $COOH$

J-8. The newman projection formula of 2,3-dimethylbutane is given as

X, H, CH_3, H, H, Y

X,Y respectively can be :
(A) $-CH(CH_3)_2$ and H
(B) $-CH_3$ and $-C_2H_5$
(C) $-C_2H_5$ and $-CH_3$
(D) H and $-CH(CH_3)_2$

J-9. In 2-Fluoroethanol which conformer will be most stable ?
(A) Eclipsed
(B) Skew
(C) Gauche
(D) Staggered

J-10. The true statement about the following corformation is :

Me, H, F, H, OH, Me
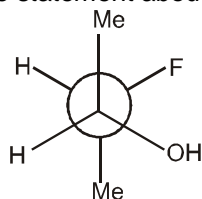
(A) It has maximum angle strain.
(B) It does not have eclipsing strain (tortional strain).
(C) It does not have any intramolecular hydrogen bonding.
(D) It has maximum Vander Waal strain.

J-11.
$COOH$, HO, H, H, OH, $COOH$ and $COOH$, H, OH, HO, H, $COOH$ are
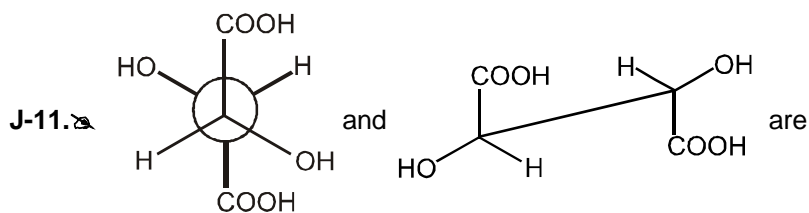
(A) Enantiomers
(B) diastereomers
(C) Identical compounds
(D) Conformers

Section (K) : Cyclohexane

K-1. The least stable conformation of cyclohexane is
(A) Boat
(B) Chair
(C) Twist boat
(D) Half chair

**K-2.** Flagpole interaction is present in :
(A) Boat form of cyclohexane
(B) Chair form of cyclohexane
(C) Anti form of n-butane
(D) Fully eclipsed form of n-butane

**K-3.** Chair form of cyclohexane is more stable than boat form because:
(A) In chair form carbons are in staggered form and in boat form carbons are in eclipsed form
(B) In chair form carbons are in eclipsed form and in boat form all the carbons are in staggered form
(C) Bond angle in chair form is 111° and bond angle in boat form is 109.5°
(D) Bond angle in chair form is 109.5° and in boat form 111°

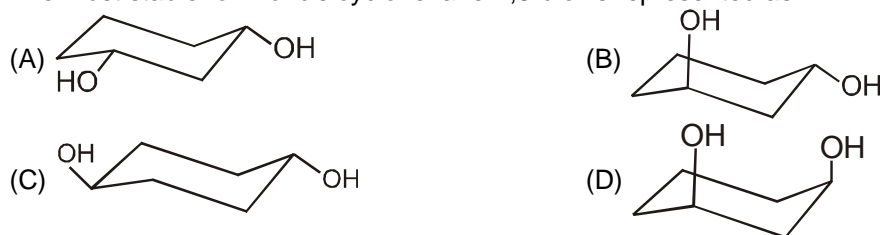**K-4.** The most stable form of trans-1,4-dimethylcyclohexane is represented as :

(A)

(B)

(C)

(D)
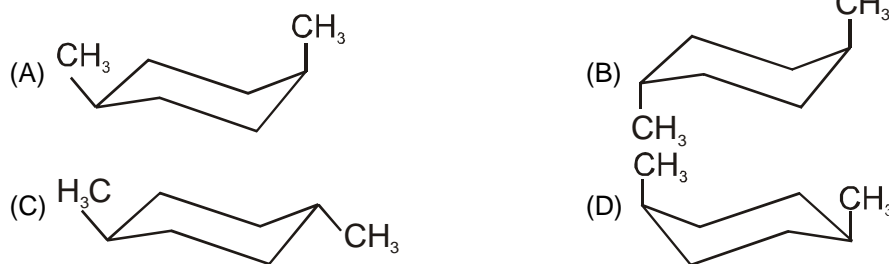
K-5. Geometry of the given compound is:
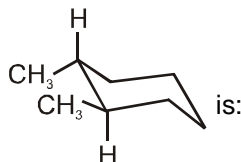
(A) Cis   (B) Trans
(C) Cis and trans both   (D) No geometrical isomerism

K-6. The most stable form of cis cyclohexane-1,3-diol is represented as :

(A)

(B)

(C)

(D)

PART - III : MATCH THE COLUMN

1. Match the column-I with column-II

	Column-I		Column-II	
(A)		(p)	Chiral Molecule	
(B)		(q)	Achiral Molecule	
(C)		(r)	Plane or centre of symmetry present	
(D)		(s)	Axis of symmetry present (except C_1).	

2. Match the following :
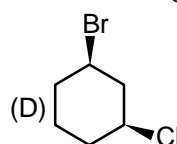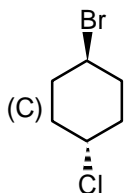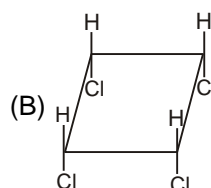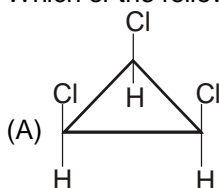
|	Column-I		Column-II
(A)		(p)	Conformation with minimum vander-waal strain
(B)		(q)	Conformation with maximum vander waal strain
(C)		(r)	Conformation of maximum torsional strain
(D)		(s)	Conformation with minimum torsional strain

Exercise-2

✎ **Marked questions are recommended for Revision.**

PART - I : ONLY ONE OPTION CORRECT TYPE

1.✎ Which of the following molecule is chiral.
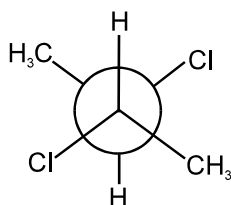

2.✎ Which one of the following compounds will show enantiomerism ?
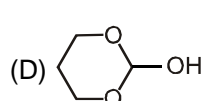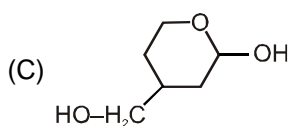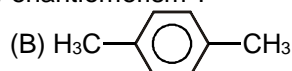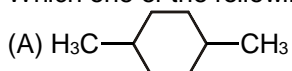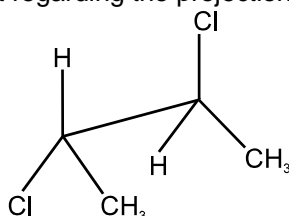
3. Which of the following statement regarding the projections shown below is true ?
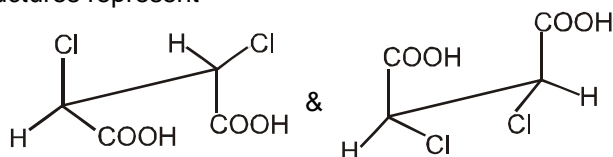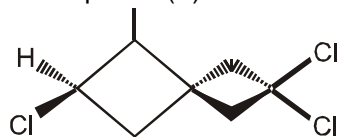

       (a)   (b)

(A) 'a' and 'b' both represent the same configuration
(B) Both 'a' and 'b' are optically active
(C) 'b' alone is optically active
(D) 'a' alone is optically active

4. The structures represent
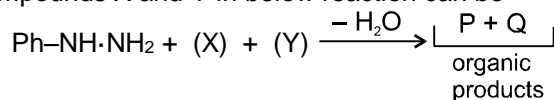

(A) geometrical isomers   (B) positional isomers
(C) conformational isomers   (D) configurational isomers
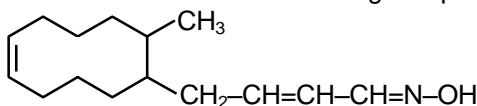
5. The given compound (X) has :

(A) chirality   (B) superimposability on its mirror image isomer
(C) plane of symmetry   (D) C_2 axis of symmetry

6. The compounds X and Y in below reaction can be

$$Ph-NH\cdot NH_2 + (X) + (Y) \xrightarrow[\text{organic products}]{-H_2O} \boxed{P + Q}$$

(A) $CH_3-CH_2-\overset{\underset{\|}{O}}{C}-CH_3$ + $CH_3-\overset{\underset{\|}{O}}{C}-Ph$ (B) $Ph-\overset{\underset{\|}{O}}{C}-CH_3$ + CH_3CHO

(C) $CH_2=O$ + CH_3CHO (D) $CH_2=O$ + $CH_3-\overset{\underset{\|}{O}}{C}-CH_3$

7. No. of Geometrical isomers for following compound is :

(A) 8   (B) 16   (C) 32   (D) 10

8. How many stereoisomers are possible for

?

(A) 128   (B) 64   (C) 32   (D) 16

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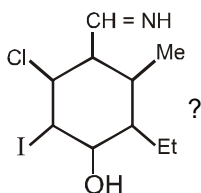
9. How many spatial orientations are possible in the following compound ?
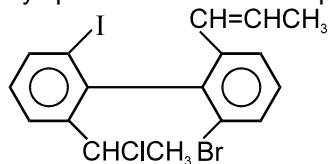
(A) 2   (B) 8   (C) 6   (D) 4

10. Number of conformational isomers of ethane.
(A) 7   (B) 3   (C) 4   (D) Infinite

PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

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

2. In given compounds how many can show geometrical isomerism:

3. In given compounds how many have Z configuration along double bond ?
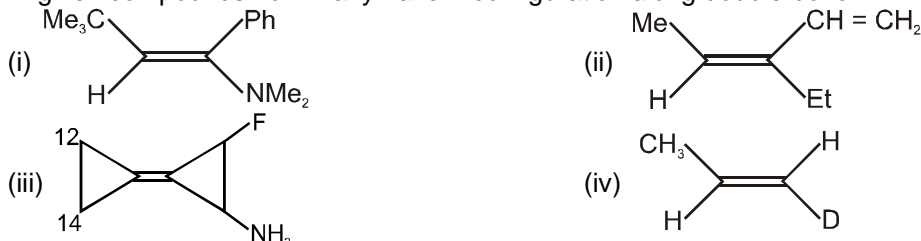
4. Sum of C_2 & C_3 axis of symmetry is

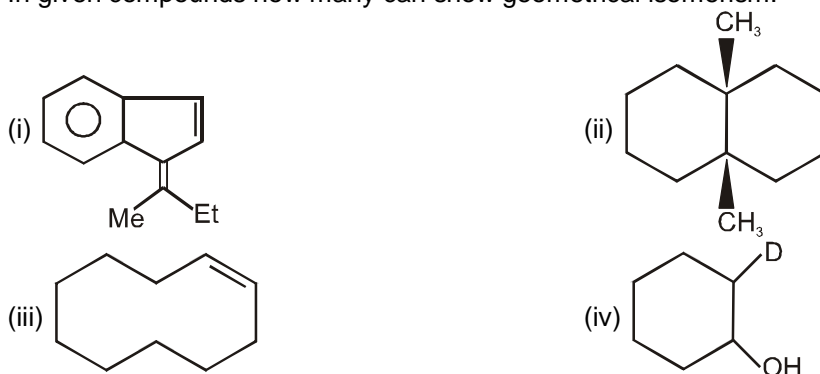**5.** Optical rotaion data are expressed in standard way (specific rotation $[\alpha]_D$).
If magnituded of specific rotation of isomer d-lactic acid is 3.82. What will be the magnitude of specific rotation of acetic acid in degree.

6. How many of the following are (configurational) enantionmers of (A) ?

(p), (q), (r), (s), (t) Newman projections
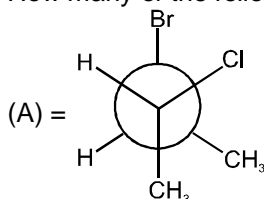
7. Pure cholesterol has a specific rotation of –32. A sample of cholesterol prepared in the lab has a specific rotation of –8. The enatiomeric excess of the sample of chloresterol is x%. x is :
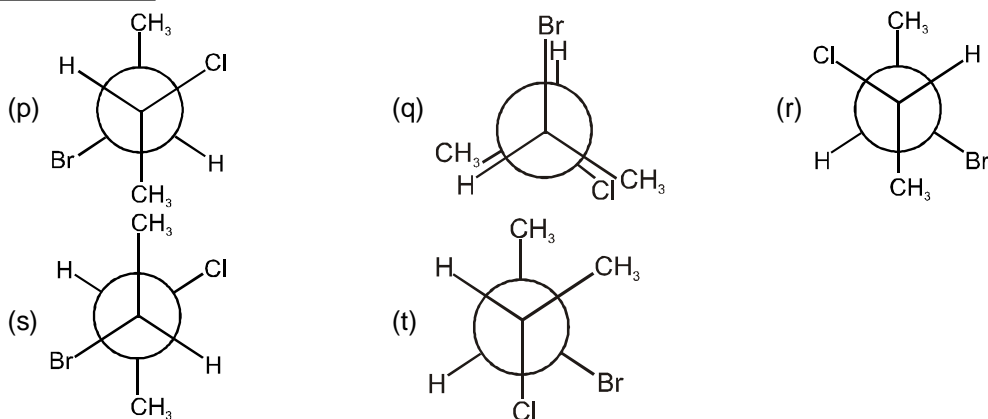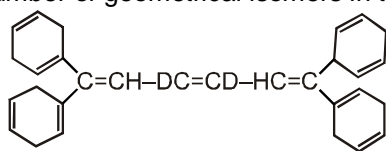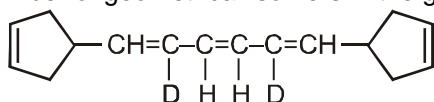
8. Pure (R) Mandelic acid

has specific rotation of –150. If a sample contains 60% of the R and 40% of its enantiomer, then $[\alpha]$ of this solution is.

9. Total number of geometrical isomers in the given compound are

$$C=CH-DC=CD-HC=C$$

10. Total number of geometrical isomers in the given compound are :

$$CH=C-C=C-C=CH$$
$$\quad\quad | \quad | \quad | \quad |$$
$$\quad\quad D \quad H \quad H \quad D$$

11. Total number of stereoisomers of compound $CH_3 - CH = CH - CH - CH = CH - CH_3$ are :
$$\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad | $$
$$\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad Cl$$

12. Total number of optically active stereoisomers of $CH_3 - CH - CH = CH - CH - CH_3$ are :
$$\quad\quad\quad\quad\quad\quad\quad\quad\quad | \quad\quad\quad\quad\quad\quad | $$
$$\quad\quad\quad\quad\quad\quad\quad\quad\quad Cl \quad\quad\quad\quad\quad Cl$$

13. For the compound A–CH$_2$–CH$_2$–A draw the newmann projection formula of all the stable conformational isomers if μ_{obs} = 2D and X_{anti} = 0.75 then find μ_{gauche}. (If A = NO$_2$)

14. Total number of stereoisomers possible for the given structure excluding the configuration mentioned is:
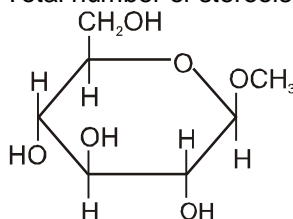
15. Observe the compound 'M'

M =
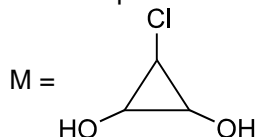
If in this compound

      X = Total number of asymmetric C* atoms

      Y = Number of similar asymmetric C* atoms

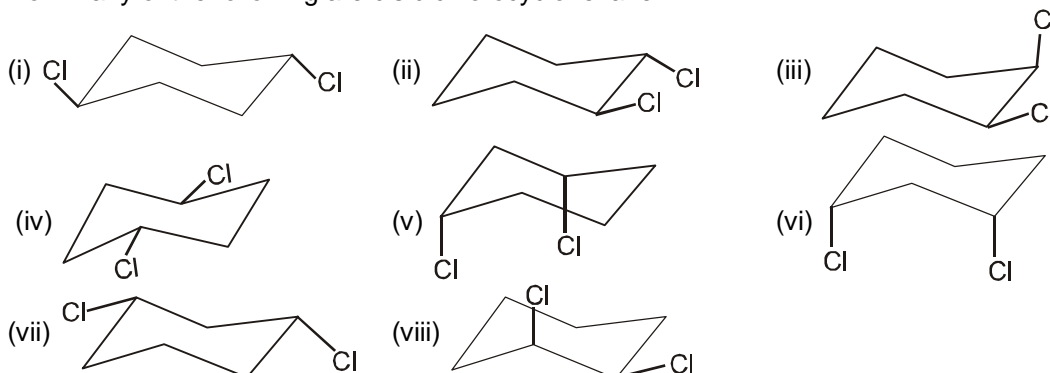   Z = Number of optically active stereoisomers

      W = Number of opticaly inactive isomers

      R = Number of geometrical orientations in space

Report your answer as : X + Y + Z + W + R

**16.** How many of the following are cis dichlorocyclohexane.

PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. What should be the minimum conditions to show geometrical isomerism ?

(A) Restricted rotation about double bond or ring.

(B) Groups which are responsible to show geometrical isomerism differ in their relative distance.

(C) Free rotation about single bond.

(D) Two different groups at both restricted atoms.

2. Which of the following compounds has cis configuration at each double bond ?

(A)   (B)

(C)   (D)

3. Which of the following carbonyl compounds can give two oximes on reaction with hydroxyl amine ?

(A) HCHO   (B) CH_3CHO (C) PhCHO   (D) CH_3COPh

4. Which of the following is true for maleic acid and fumaric acid.

(A) Configurational isomers   (B) Stereo isomers

(C) Z and E isomers   (D) Constitutional isomers

5. Which of the following is correct statement :

(A) Geometrical isomers are not mirror image isomer.

(B) A compound having double bond (restricted bond) always show geometrical isomerism.

(C) Acyclic compoubd having only single bond does not show geometrical isomerism.

(D) Cyclodecene can show cis & trans form.

**6.** Which of the following statement(s) is/are correct for given compound :
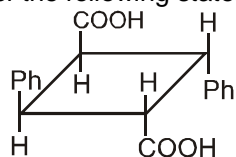
α-truxillic acid

(A) It is a optically active compound
(B) It can show geometrical isomerism
(C) It posses centre of symmetry but not plane of symmetry
(D) It is a meso compound

7. Find out correct statement/s.
(A) All chiral centers are stereogenic centers.
(B) All stereogenic centers are not chiral center.
(C) A compound may be chiral without chiral center.
(D) A compound will be chiral only if it has at least one chiral center.

8. Which is/are not the structure of 3-Methyl butan-2-ol.
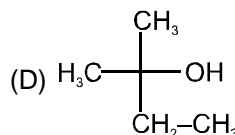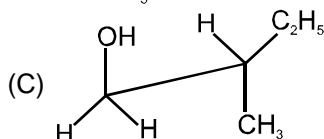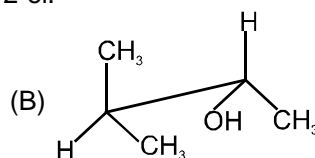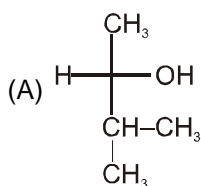
9.
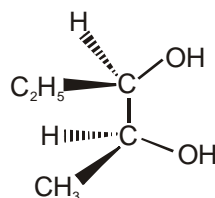
Fischer projection formula of this compound can be represented as :

10. Which of the following compounds will have C_2 axis of symmetry ?

11.

is :
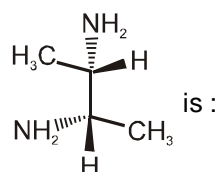
(A) optically active molecule.
(B) having plane of symmetry.
(C) having axis of symmetry.
(D) having centre of symmetry

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12. The correct relation between compound(s) I and II is/are

(I)
```
        COOCH₃
   H ——┼—— OH
   H ——┼—— OH
        COOH
```

(II)
```
         COOH
   H ——┼—— OH
   H ——┼—— OH
        COOCH₃
```
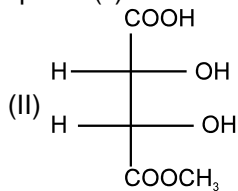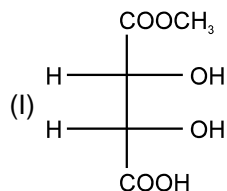
(A) identical.   (B) diastereomers
(C) enantiomers.   (D) configurational isomers

13. Enantiomers have
(A) Similar physical properties (generally).
(B) Similar chemical properties with optical active compounds.
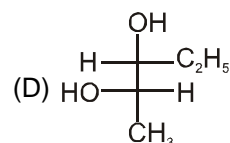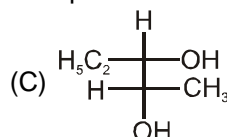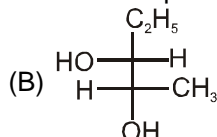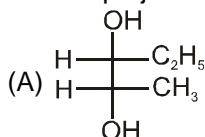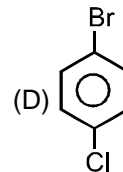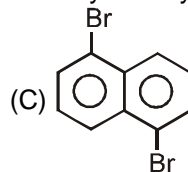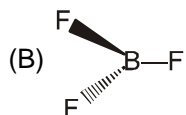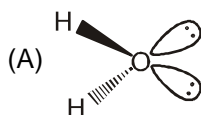(C) Same absolute value of specific rotation.
(D) Different configurations.

14. Which of the following will show geometrical isomerism?

(A) $CH_3–CH=C=C=CH–CH_3$

(B)

(C)

(D)
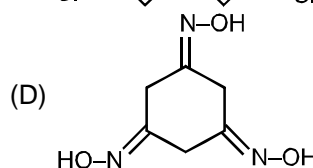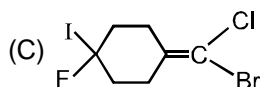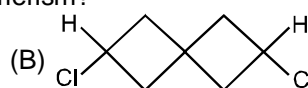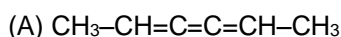
PART - IV : COMPREHENSION

Read the following passage carefully and answer the questions.

Comprehension # 1

Tartaric acid [$HO_2CCH(OH)CH(OH)CO_2H$] was an important compound in history of stereochemistry. Two naturally occuring forms of tartaric acid are optically inactive. One optically inactive form (P) has a melting point of 210-212°C and can be separated into two optically acitve forms, whereas other optically inactive form (Q) cannot be resolved further.

1. Optically inactive form Q is

(A)

(B)

(C)
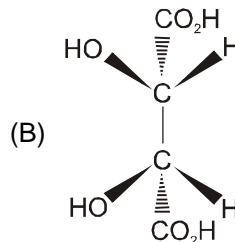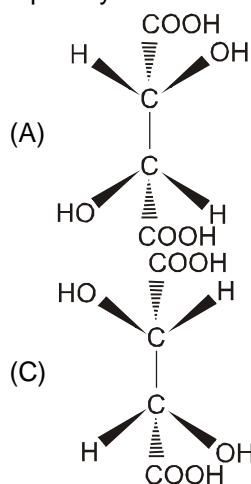
(D) none of these

2. A optically inactive form P is :
(A) Optically inactive due to internal compensation.
(B) Optically inactive due to presence of plane of symmetry.
(C) Optically inactive due to external compensation.
(D) Optically inactive due to intramoleuclar hydrogen bonding.

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Comprehension # 2

Q.3, Q.4 and Q. 5 by appropriately matching the information given in the three columns of the following table.

Column 1	Column 2	Column 3
(I) HO—H, OH—H, CH₃, Cl	(i) CH₃, OH, HO, H, Cl (Newman)	(P) Compounds having same boiling or melting points.
(II) HO—CH₃, Cl—H, OH (Fischer)	(ii) HO, CH₃, H, H, HO, Cl	(Q) Compuonds can be separated by fractional distillation.
(III) CH₃, H—OH, HO—H, H—OH, CH₃ (Fischer)	(iii) H, OH, OH, H, CH₃, CH₃	(R) Compounds having different boiling or melting points.
(IV) CH₃, H, OH, HO, H, CH₃ (Newman)	(iv) CH₃, HO—H, H—OH, HO—H, CH₃ (Fischer)	(S) Compounds which are optical resolvable.

3. The correct combination that represents enantiomers with their correct properties.
    (A) (III) (iv) (S)   (B) (I) (ii) (P)   (C) (II) (i) (S)   (D) (IV) (iii) (P)

4. The correct combination that represents diastereomers with their correct properties.
    (A) (I) (i) (Q)   (B) (II) (ii) (P)   (C) (IV) (ii) (R)   (D) (IV) (iii) (Q)

5.* Which of the following combination gives correct information.
    (A) (I) (ii) (Q)   (B) (II) (iii) (P)   (C) (III) (iv) (P)   (D) (IV) (iii) (P)

Exercise-3

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

* Marked Questions may have more than one correct option.

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

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

3. 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 ? **[IIT-JEE 2004 (M), 2/60]**

(i) Vander–Waal's strain   (ii) Torsional strain   (iii) Combination of both.

4. 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 : **[IIT-JEE 2004, (S) 2/84]**
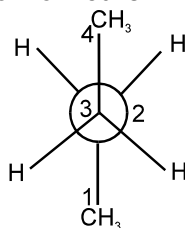
(A) staggered   (B) fully eclipsed   (C) gauche   (D) partially eclipsed

5. It is given that for conformational isomers, the net dipole moment is **[IIT-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)

6. **Statement-1 :** Molecules that are not superimposable on their mirror images are chiral. because

Statement-2 : All chiral molecules have chiral centres. **[IIT-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.

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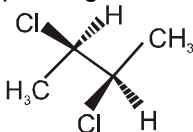
(A) The compound is optically active

(B) The compound possesses centre of symmetry

(C) The compound possesses plane of symmetry

(D) The compound possesses axis of symmetry

8.* The correct statement(s) about the compound $H_3C(HO)HC–CH=CH–CH(OH)CH_3$ **(X)** is(are) :

[IIT-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.

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

10.* In the Newman projection for 2, 2-Dimethylbutane
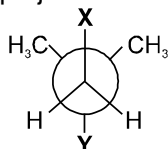
X and **Y** can respectively be : **[IIT-JEE-2010, 3/163]**
(A) H and H (B) H and C_2H_5 (C) C_2H_5 and H (D) CH_3 and CH_3

11.* 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, 4/180]**

(A)   (B) $H-C\equiv C-$ (C) $H_2C=C=O$ (D) $H_2C=C=CH_2$

12. The number of optically active products obtained from the **complete** ozonolysis of the given compound is:
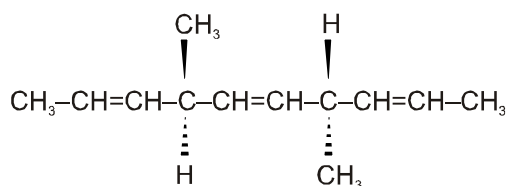
$CH_3-CH=CH-C-CH=CH-C-CH=CH-CH_3$ **[IIT-JEE 2012, 3/136]**

(A) 0 (B) 1 (C) 2 (D) 4

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

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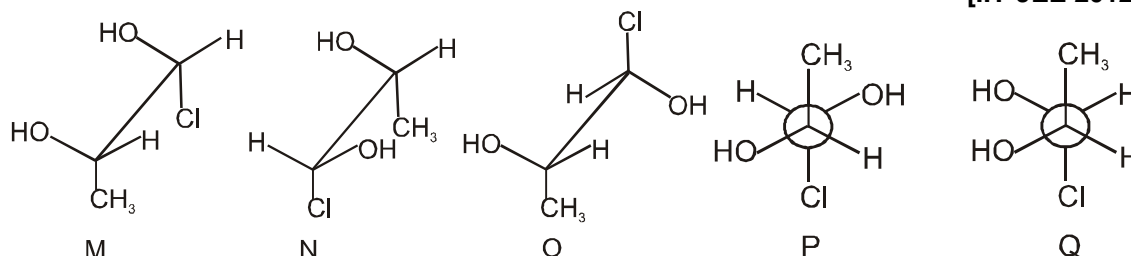
(A) M and N are non-mirror image stereoisomers
(B) M and O are identical
(C) M and P are enantiomers
(D) M and Q are identical

14. The total number(s) of **stable** conformers with non-zero dipole moment for the following compound is (are): **[JEE(Advanced)-2014, 3/120]**
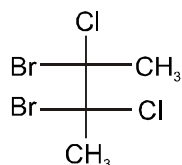
15. The total number of stereoisomers that can exist for **M** is **[JEE(Advanced)-2015, 4/168]**

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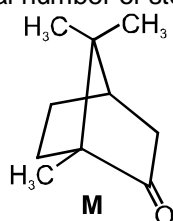
16.* Compound(s) that on hydrogenation produce(s) optically inactive compound(s) is (are)

[JEE(Advanced)-2015, 4/168]

(A)

(B)

(C)

(D)
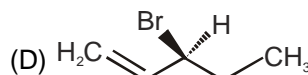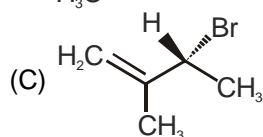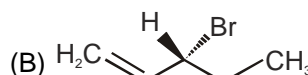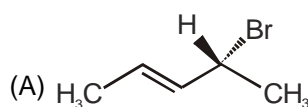
17. For the given compound X, the total number of optically active stereoisomers is …….

[JEE(Advanced)-2018, 3/120]

— This type of bond indicates that the configuration at the specific carbon and the geometry of the double bond is fixed

∼∼∼ This type of bond indicates that the configuration at the specific carbon and the geometry of the double bond is **NOT** fixed

X

PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

JEE(MAIN) OFFLINE PROBLEMS

1. Racemic mixture is formed by mixing two : **[AIEEE 2002, 3/225]**
(1) Isomeric compounds   (2) Chiral compounds
(3) Meso compounds   (4) Optical isomers

2. Which of the following does not show geometrical isomerism ? **[AIEEE 2002, 3/225]**
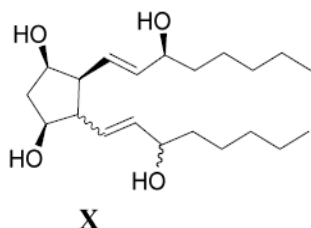(1) 1,2-Dichloro-1-pentene   (2) 1,3-Dichloro-2-pentene
(3) 1,1-Dichloro-1-pentene   (4) 1,4-Dichloro-2-pentene

3. Among the following four structures I to IV.

it is true that : **[AIEEE 2003, 3/225]**
(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

4. Which of the following will have a meso-isomer also ? **[AIEEE 2004, 3/225]]**
(1) 2-Chlorobutane   (2) 2,3-Dichlorobutane
(3) 2,3-Dichloropentane   (4) 2-Hydroxypropanoic acid

5. Amongst the following compounds, the optically acitve alkane having lowest molecular mass is

[AIEEE 2004, 3/225]

(1) CH_3–CH_2–CH_2–CH_3

(2) CH_3–CH_2–$\underset{\underset{CH_3}{|}}{CH}$–$CH_3$

(3)

(4) CH_3–CH_2–C≡CH

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ADVSIM - 48
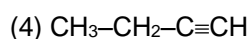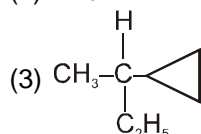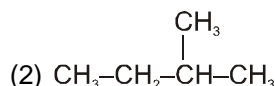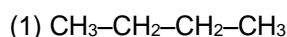
6. Which of the following compounds is not chiral ?   **[AIEEE 2004, 3/225]**
   (1) 1–Chloropentane   (2) 2-Chloropentane
   (3) 1-Chloro-2-methylpentane   (4) 3-Chloro-2-methylpentane

7. Which type of isomerism is shown by 2,3-dichlorobutane ?   **[AIEEE 2005, 3/225]**
   (1) diastereomerism   (2) optical-isomerism
   (3) geometric-isomerism   (4) structural-isomerism

8. Increasing order of stability among the three main conformations (i.e. eclipse, anti, gauche) of 2-fluoroethanol is   **[AIEEE- 2006, 3/165]**
   (1) eclipse, gauche, anti   (2) gauche, eclipse, anti
   (3) eclipse, anti, gauche   (4) anti, gauche, esclipse

9. Which of the following molecules is expected to rotate the plane of polarized light? **[AIEEE 2007, 3/120]**
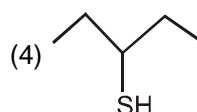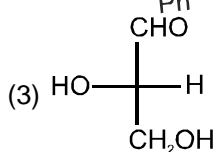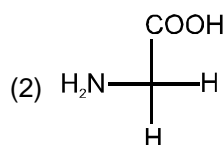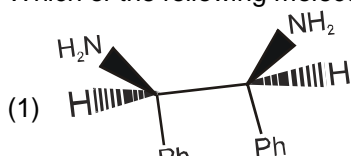
10. Which one of the following conformations of cyclohexane is chiral?   **[AIEEE-2007, 3/120]**
   (1) Chair   (2) Boat   (3) Twist boat   (4) Rigid

11. The absolute configuration of

is   **[AIEEE 2008, 3/105]**

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

12. 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

13. 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

14. 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

15. Which of the following compound will exhibit geometrical isomerism ?   **[JEE(Main) 2015, 4/120]**
   (1) 1-Phenyl-2-butene   (2) 3-Phenyl-1-butene
   (3) 2-Phenyl-1-butene   (4) 1,1-Diphenyl-1-propane

16. The absolute configuration of

is   **[JEE(Main) 2016, 4/120]**

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

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JEE(MAIN) ONLINE PROBLEMS

1. Which one of the following acids does not exhibit optical isomerism?

   [JEE(Main) 2014 Online (12-04-14), 4/120]

   (1) Lactic acid   (2) Tartaric acid   (3) Maleic acid   (4) α-amino acid

2. The optically inactive compound from the following is :   **[JEE(Main) 2015 Online (10-04-15), 4/120]**

   (1) 2-chloropentane   (2) 2-chloropropanal

   (3) 2-chloro-2-methylbutane   (4) 2-chlorobutane

3. In the following structure, the double bonds are marked as I, II, III and IV

   [JEE(Main) 2017 Online (09-04-17), 4/120]
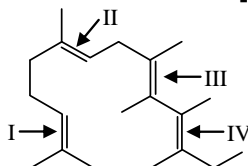
   Geometrical isomerism is not possible at site (s) :

   (1) I   (2) III   (3) I and III   (4) I and IV

Answers

EXERCISE - 1

PART - I

A-1. Restricted rotation present in all the options but geometircal isomersim shown by ii, iii, iv, vii.

A-2. Essential conditions for geometrical isomerism are
(1) Restricted rotation must present.
(2) Two different groups must be present on both restricted atoms.
(3) Groups responsible to show geometrical isomerism must be nearly in the same plane.

A-3. The bond across which atoms cannot rotate without breaking the bonds is called restricted rotation. e.g.

C=C, C=N, ring etc. (a ≠ b, d ≠ e)
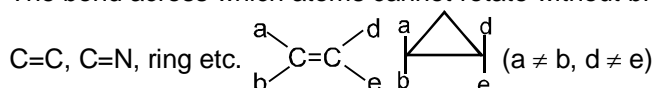
A-4. (iii), (iv), (vi), (vii) and (viii)   **A-5.**   5 (i, ii, iv, v, vi)   **B-1.**   (i) = E, (ii) = E, (iii) = E, (iv) = Z

B-2. **(a)**
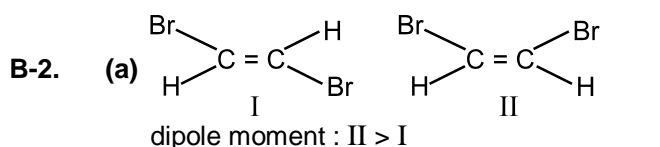
dipole moment : II > I
(b) Because of good packing of trans isomers.

(c)
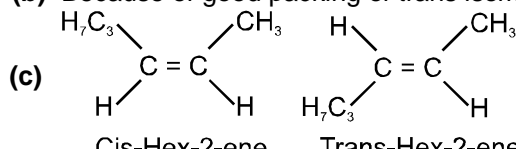
Cis-Hex-2-ene   Trans-Hex-2-ene
Cis has higher boiling point due to more polarity.

C-1. W has 3, X has zero, Y has 2 and Z has only one chiral centres.

C-2. (i)

 = 9   (ii) = 8
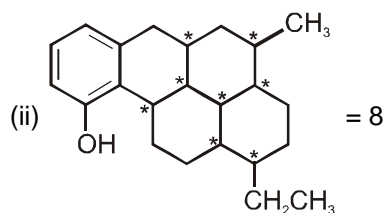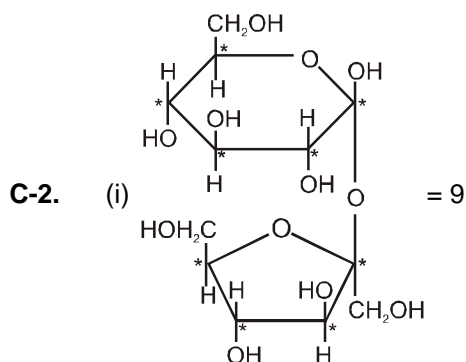
D-1. (I) R   (II) S   (III) R   (IV) (R, R)

D-2. (I) D   (II) (2D, 3D)   (III) Equivalent fischer projection is

 and configuration L.
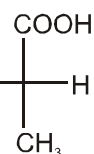
D-3. RRRR

E-1. (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.

E-2. (i) POS present and COS, AOS absent.   (ii) POS present and COS, AOS absent.
      (iii) POS, AOS present and COS absent.   (iv) POS, COS present and AOS present.
      (v) POS present and COS, AOS absent.   (vi) POS, COS and AOS absent.

Compound $\underset{D}{\overset{CH_3}{\underset{|}{Br \cdots C \cdots H}}}$ has a single chiral centre which has no plane of symmetry.

F-1. Enantiomeric pair $\equiv$ (I & III)
Diastereomeric pairs $\equiv$ (I & II), (II & III)

F-2. (I) Enantiomers   (II) Position isomers   (III) Identical   (IV) Diastereomers
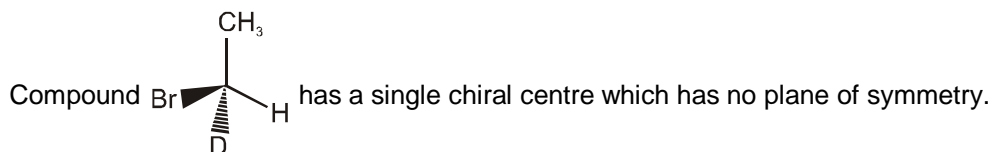
F-3. (a) functional isomers   (b) Enantiomers   (c) Geometrical isomers   (d) Diastereomers

F-4. (i) Mixture of I, II and III give two fraction on fractional distillation.
(ii) I, II and III all are optically active
(iii) I and II are pair of enantiomers
(iv) I and III are optical diastereomer.

G-1. D/L represent nomenclature (relative configuration) while d/ℓ represents direction of optical rotation.

G-2. Specific rotation is the number of degrees of rotation observed if a 1-dm (10-cm) tube is used and the compound has concentration 1gm/mL.Thus specific rotation [α] is

$$[\alpha]_t^\lambda = \frac{\theta}{\ell \times C}$$

Where, [α] = Specific rotation; θ = observed angle of rotation (degree)
         ℓ = Pathlength (dm);   C = concentration (gm/ml)
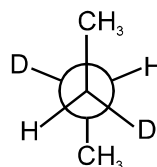 λ = wavelength (nm);   t = temperature (25°C)

G-3. % Optical purity = $\dfrac{\text{observed optical rotation}}{\text{optical rotation of pure enantiomer}} \times 100$

% Enantiomeric excess = $\dfrac{|d-\ell|}{d+\ell} \times 100 = \dfrac{\text{excess of one enantiomer over other}}{\text{entire mixture}} \times 100$

G-4. 4   **H-1.** i, ii, iii, iv   **H-2.** ii, iii, v, vi   **I-1.** (i) 3, (ii) 2, (iii) 2, (iv) 8

I-2. 3 (oct-2-ene, oct-3-ene, oct-4-ene)

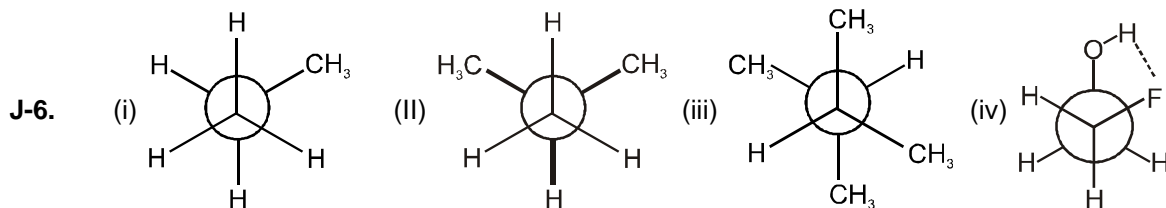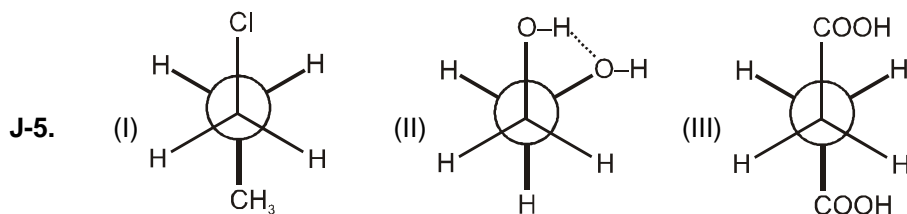**I-3.** $CH_3–HC=CH–CH_2–CH=CH–COOH$
Four geometrical isomers are possible.

I-4. (I) $CH_3 - \overset{*}{C}H - CH\overset{*}{=}CH - CH_3$
            |
          OH

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.

I-5. Total=7   cis   trans(d & ℓ)   (cis & trans)

I-6. 6   **J-1.** Fully Eclipsed   **J-2.**

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J-3.

 antiform, it is most polar & stable.

J-4. CH$_2$CH$_2$CH=O ;
OH

J-5. (I) (II) (III)

J-6. (i) (II) (iii) (iv)
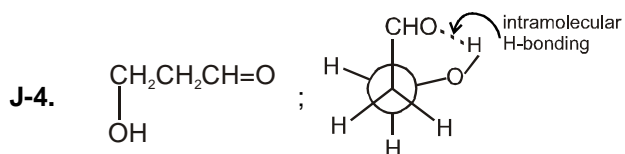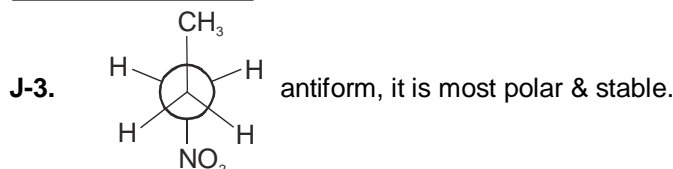
K-1. (i) trans (ii) cis (iii) trans (iv) cis (v) trans (vi) cis (vii) cis

K-2. First is more stable because of less steric repulsion between groups at equitorial position.

PART - II

A-1.	(C)	**A-2.**	(D)	**A-3.**	(D)	**A-4.**	(A)	**A-5.***	(BC)
B-1.	(A)	**B-2.**	(D)	**B-3.**	(D)	**C-1.**	(B)	**C-2.**	(B)
C-3.	(C)	**D-1.**	(C)	**D-2.**	(B)	**D-3.**	(A)	**D-4.**	(A)
D-5.	(A)	**E-1.**	(C)	**E-2.**	(B)	**E-3.**	(A)	**F-1.**	(D)
F-2.	(A)	**F-3.**	(D)	**F-4.**	(A)	**F-5.**	(B)	**F-6.**	(B)
G-1.	(D)	**G-2.**	(B)	**G-3.**	(B)	**G-4.**	(C)	**G-5.**	(A)
G-6.	(A)	**G-7.**	(D)	**H-1.***	(CD)	**H-2.**	(D)	**H-3.**	(A)
H-4.	(CD)	**I-1.**	(B)	**I-2.**	(C)	**I-3.**	(B)	**I-4.**	(B)
I-5.	(A)	**I-6.**	(C)	**I-7.**	(A)	**I-8.**	(D)	**I-9.**	(C)
J-1.	(A)	**J-2.**	(A)	**J-3.**	(D)	**J-4.**	(C)	**J-5.**	(A)
J-6.	(C)	**J-7.**	(A)	**J-8.**	(D)	**J-9.**	(C)	**J-10.**	(B)
J-11.	(C)	**K-1.**	(D)	**K-2.**	(A)	**K-3.**	(A)	**K-4.**	(C)
K-5	(B)	**K-6.**	(D)						

PART - III

1. (A - p,s); (B - p,s); (C - p,s); (D - q,r) **2.** (A - r); (B - q, r); (C - p, s); (D - s)

EXERCISE - 2

PART - I

1.	(D)	**2.**	(C)	**3.**	(C)	**4.**	(D)	**5.**	(A)
6.	(D)	**7.**	(B)	**8.**	(A)	**9.**	(B)	**10.**	(B)

PART - II

1.	2	**2.**	4 (i, ii, iii, iv)	**3.**	1 (ii)	**4.**	3 + 1 = 4	**5.**	0
6.	4 (q, r, s, t)	**7.**	25	**8.**	30	**9.**	4	**10.**	6
11.	4	**12.**	4	**13.**	8	**14.**	31	**15.**	12
16.	5 (iii, v, vi, vii, viii)								

PART - III

1.	(ABD)	**2.**	(BD)	**3.**	(BCD)	**4.**	(ABC)	**5.**	(ACD)
6.	(BC)	**7.**	(ABC)	**8.**	(CD)	**9.**	(ABCD)	**10.**	(ABCD)
11.	(AC)	**12.**	(CD)	**13.**	(ACD)	**14.**	(AD)		

PART - IV

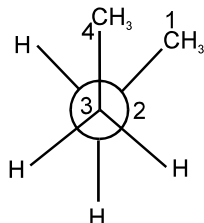|									
1.	(B)	**2.**	(C)	**3.**	(C)	**4.**	(D)	**5.**	(AC)

EXERCISE - 3

PART - I

1. (A)

2.
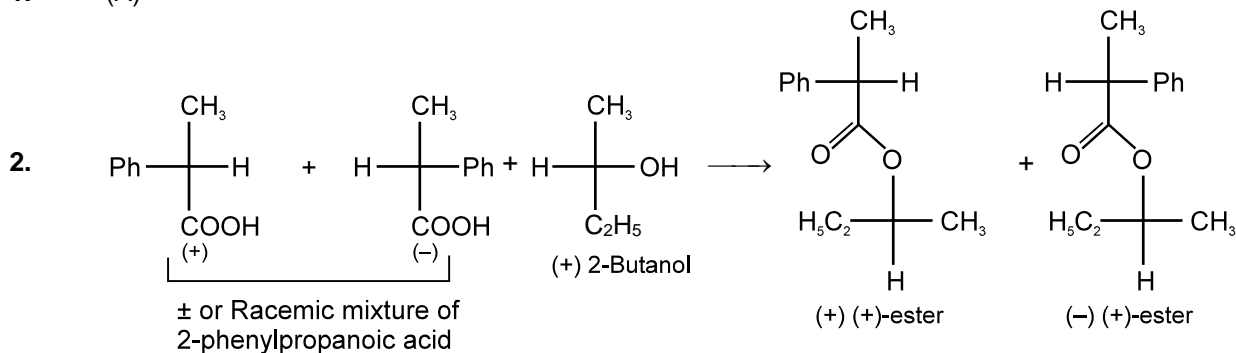
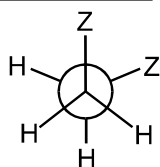**3.** Least stable staggered form of n–butane is

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 $60°$.
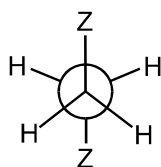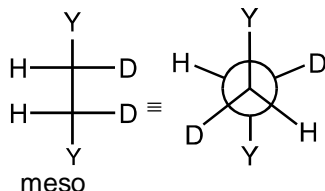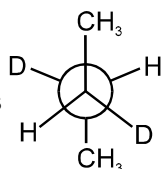
4. (C)

5.

Gauche form   Anti form

$\mu_{obs} = 1D$ $x_{gauche} = 0.18$

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

meso

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

.

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

.
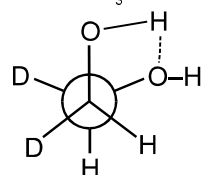
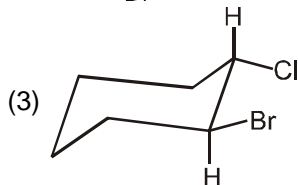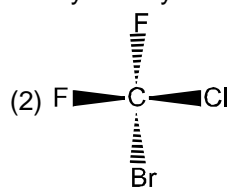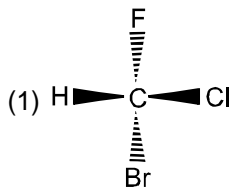|										
6.	(C)	**7.***	(AD)	**8.***	(AD)			**9.**	7	**10.**	(BD)
11.	(BC)	**12.**	(A)	**13.**	(ABC)			**14.**	3	**15.**	2
16.	(BD)	**17.**	7							

PART - II
JEE(MAIN) OFFLINE PROBLEMS

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

JEE(MAIN) ONLINE PROBLEMS

1.	(3)	**2.**	(3)	**3.**	(1)

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Additional Problems for Self Practice (APSP)

✎ **Marked questions are recommended for Revision.**

This Section is not meant for classroom discussion. It is being given to promote self-study and self testing amongst the Resonance students.

PART - I : PRACTICE TEST-1 (IIT-JEE (MAIN Pattern))

Max. Marks : 120   **Max. Time : 1 Hr.**

Important Instructions
1. The test is of **1 hour** duration.
2. The Test Booklet consists of **30** questions. The maximum marks are **120.**
3. Each question is allotted **4 (four)** marks for correct response.
4. Candidates will be awarded marks as stated above in Instructions No. 3 for correct response of each question.
   ¼ (one fourth) marks will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.
5. There is only one correct response for each question. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted accordingly as per instructions 4 above.

1. Which is the pair of geometrical isomers :

(i)   (ii)

(iii)   (iv)

(1) i & ii   (2) i & iii   (3) iii & iv   (4) i & iv

2.✎ How many geometrical isomers are possible for :

(1) 2   (2) 3   (3) 4   (4) 8

3. Which will not show geometrical isomerism ?
(1) Maleic acid   (2) Fumaric acid   (3) Cinnamic acid   (4) Salicylic acid

4. Which of the following has highest number of geometrical isomers.

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

5.✎ Total number of position isomers of trichlorocyclohexane which can show geometrical isomerism.
(1) 2   (2) 3   (3) 4   (4) 6

6._ The total number of stereoisomers of 2,3-pentanediol are
(1) four   (2) two   (3) six   (4) three.

7.✎ The most stable form of meso-tartaric acid is
(1) Gauche form   (2) Anti form   (3) Fully eclipsed form   (4) Partially eclipsed

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8. Which of the following molecules possess a plane of symmetry?

(1) H—C—Cl with F (hashed wedge up), Br (down), Cl (bold wedge)

(2) F—C—Cl with F (hashed wedge up), Br (down), F (bold wedge), Cl (bold wedge)

(3) cyclohexane with H, Cl and Br, H substituents

(4) More than one of these

9. Select correct order of stability of different forms of 1-Chloro-4-iodo cyclohexane.

(I) cyclohexane with Cl and I
(II) cyclohexane with I and Cl
(III) cyclohexane with Cl and I
(IV) cyclohexane with Cl and I
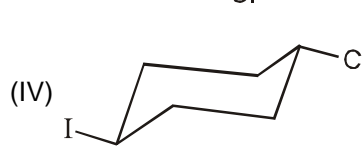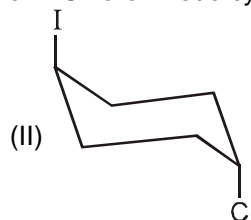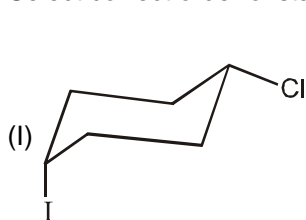
(1) IV > III > I > II   (2) IV > I > III > II   (3) III > II > I > IV   (4) II > I > III > IV

10. Which of the following statement is incorrect ?
(1) Diastereomers can be chiral.
(2) Diastereomers can be achiral.
(3) Enantiomers have similar physical and chemical properties always.
(4) Presence of plane of symmetry confirms optical inactivity.

11. Which type of isomerism is shown by 2,3-Dichlorobutane?
(1) Tautomerism   (2) Optical
(3) Geometrical   (4) Functional isomerism

12. Increasing order of stability among the three main conformations of 2-Fluoroethanol is :
(1) Eclipse, Gauche, Anti   (2) Gauche, Eclipse, Anti
(3) Eclipse, Anti, Gauche   (4) Anti, Gauche, Eclipse

13. The unusually stable three membered unsaturated compound, Feist acid was found to be chiral in nature. Its structure is

(1) cyclopropane with CH_2, HOOC and COOH

(2) cyclopropane with CH_2, HOOC and COOH

(3) cyclopropene with COOH, COOH, CH_3

(4) cyclopropane with CH_3, COOH
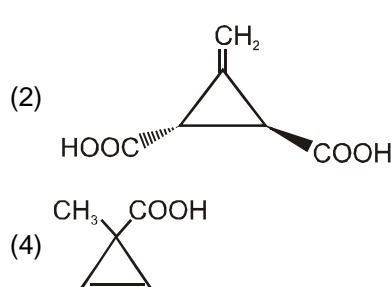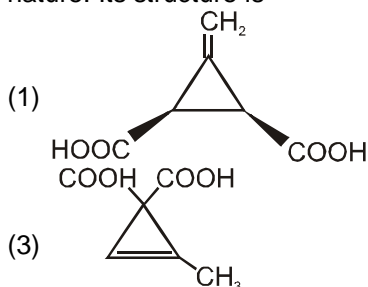
14. Which of the following depict the same stereoisomer ?

(I)   (II)   (III)
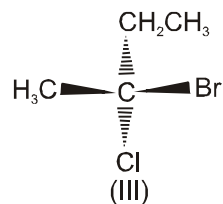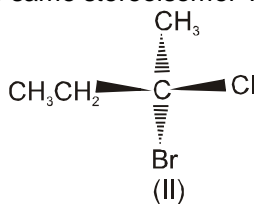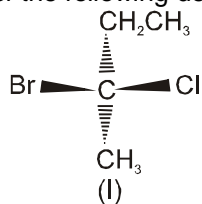
(1) I and II   (2) I and III   (3) II and III   (4) I, II and III

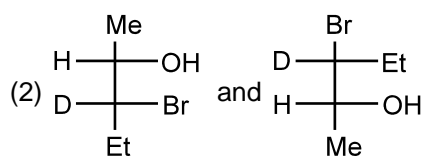**15.** The total number of chiral centres present in the artificial sweetener Aspartam are
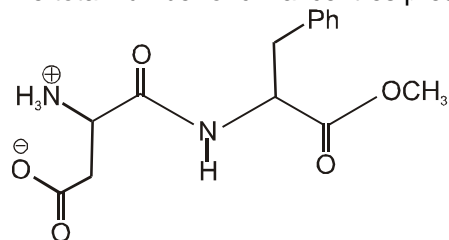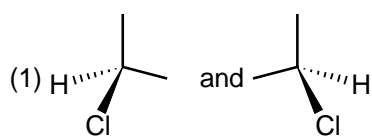

(1) 1   (2) 2   (3) 3   (4) 4

16. Which pair is identical ?
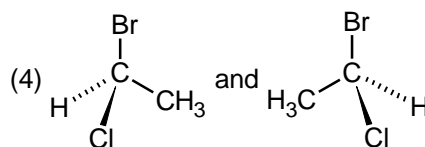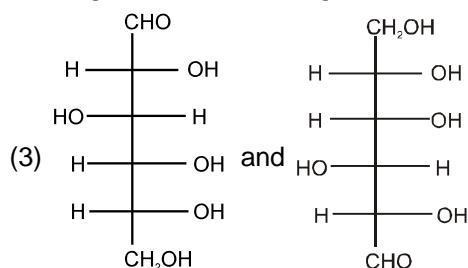
17. Identify the relation between molecules given in Newman and Fischer projections.
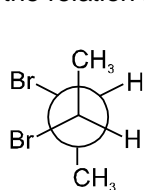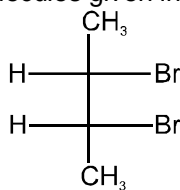
II   III

(1) Identical   (2) Enantiomers   (3) Diastereomers   (4) Conformers

18. The correct IUPAC name of D-Glucose is :
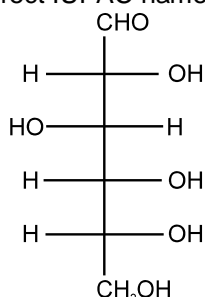
(D-Glucose)

(1) (2D, 3D, 4L, 5D)-2, 3, 4, 5, 6-pentahydroxyhexanal   (2) D-2, 3, 4, 5, 6-pentahydroxyhexanal
(3) 6-oxo-(2D, 3L, 4D, 5D)-2, 3, 4, 5, 6-pentahydroxohexane
(4) (2D, 3L, 4D, 5D)-2, 3, 4, 5, 6-pentahydroxyhexanal

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19. Which of the following species will be optically active?

(1)
$$\underset{Cl}{\overset{H}{>}}C=C\underset{CHO}{\overset{CH_3}{<}}$$

(2)
$$H_3C-\underset{\underset{C_3H_7}{|}}{\overset{\overset{C_2H_5}{|}}{N}}$$

(3)

(4)
$$\underset{Cl}{\overset{H}{\diagup}}C=C=C=C\underset{Br}{\overset{H}{\diagdown}}$$
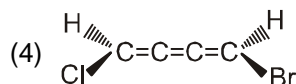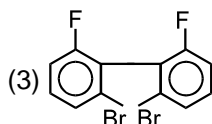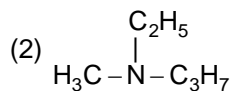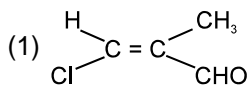
20. Which of the following compounds exhibits stereoisomerism ?
(1) 2-methylbutene-1
(2) 3-methylbutyne-1
(3) 3-methylbutanoic acid
(4) 2-methylbutanoic acid

21. In which of the following alcohol chiral carbon atom is present :
(1) n-pentyl alcohol
(2) neopentyl alcohol
(3) pentan-3-ol
(4) pentan-2-ol

22. Which of the following conformer of n-Butane is associated with maximum potential energy.
(1) Gauch
(2) partially eclipsed
(3) Anti
(4) Fully eclipsed

23. The R/S designation for the following stereoisomers of 1,3-dichloro-2-methylbutane is :
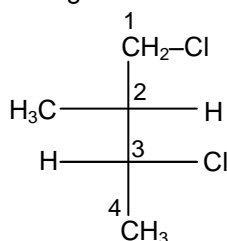
(1) 2S, 3R
(2) 2S, 3S
(3) 2R, 3S
(4) 2R, 3R

24. Which of the following will not show geometrical isomerism ?
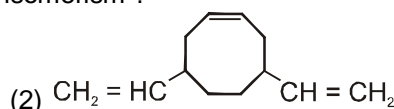
(1) $CH_3-N=N-CH=CH_2$
(2) $CH_2=HC$ $CH=CH_2$
(3) $CH_3-CH=N-OH$
(4) $Cl-CH=C=CH-Cl$

25. The racemic mixture in liquid/gaseous state will have
(1) Same boiling point as that of its pure enantiomer.
(2) Same refractive index as that of its pure enantiomer.
(3) Same density as that of its pure enantiomer.
(4) All of the above.

26. True statement(s) regarding the given molecule is /are :
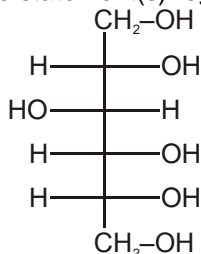
(1) This is optically inactive.
(2) If the last chiral carbon configuration is changed then it is converted from dextro to laevo.
(3) By changing the configuration at C_3 or C_4 carbon, it is converted into meso compound.
(4) Its all diastereomers have zero optical rotation.

27. Most stable conformation of 1,4-Di(tert-butyl) cyclohexane is
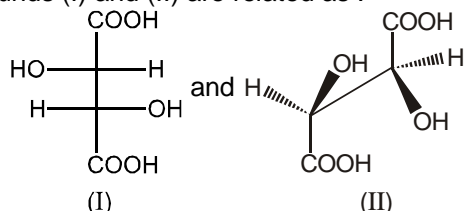(1) chair
(2) Boat
(3) Half chair
(4) Twist boat

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28. The two compounds (I) and (II) are related as :
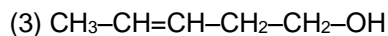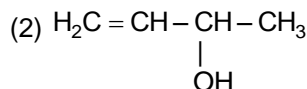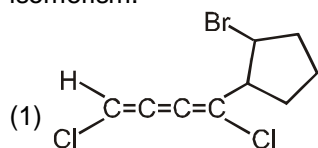

(I)   (II)

(1) Enantiomers   (2) Anomers   (3) Diastereomers   (4) Identical

29. How many stereoisomers of a drug for healing the wounds are possible & how many of them are optically active?
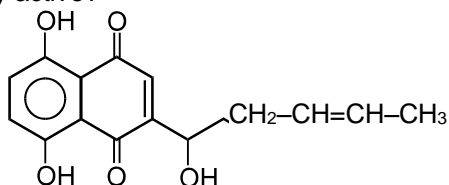
(1) 4, 2   (2) 4, 4   (3) 8, 4   (4) 16, 4

30. Which of the following compounds is capable of showing geometircal, optical and conformational isomerism.
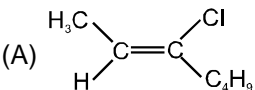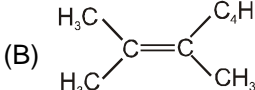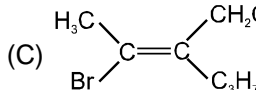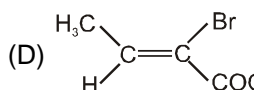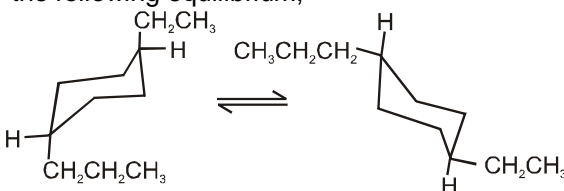
(1) [structure with C=C=C=C, H, Cl, Cl, Br, cyclopentane]

(2) $H_2C = CH – CH – CH_3$
                      |
                      OH

(3) $CH_3–CH=CH–CH_2–CH_2–OH$

(4) $H_2C=CH–CH_2–OH$

Practice Test-1 (IIT-JEE (Main Pattern))
OBJECTIVE RESPONSE SHEET (ORS)

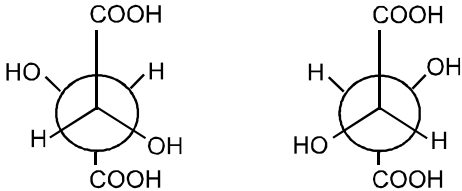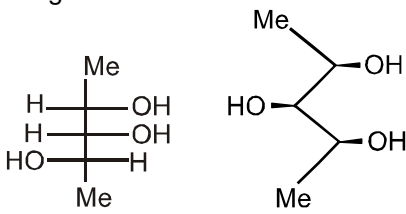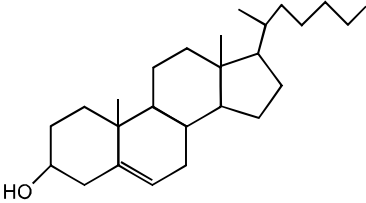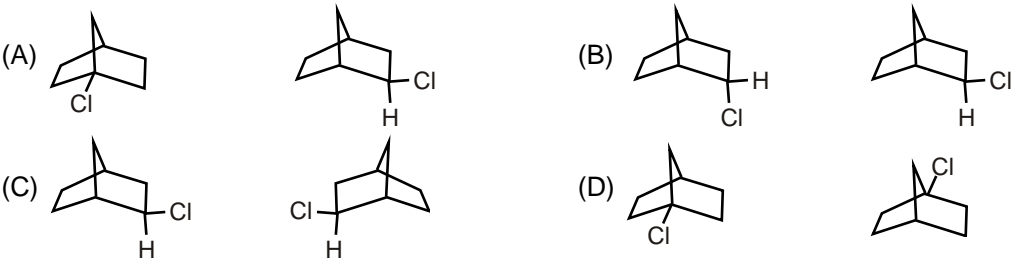| Que.	1	2	3	4	5	6	7	8	9	10
Ans.										
Que.	11	12	13	14	15	16	17	18	19	20
Ans.										
Que.	21	22	23	24	25	26	27	28	29	30
Ans.										

PART - II : NATIONAL STANDARD EXAMINATION IN CHEMISTRY (NSEC)STAGE-I

1. Which of the following is a chiral molecule ?   [NSEC-2000]
   (A) 2,4-dimethyl-1,3-hexadiene   (B) 2,4-octadiene
   (C) 2,3-octadiene   (D) None of these

2. Which of the following has the highest potential energy for pentane ?   [NSEC-2000]
   (A) anti conformation   (B) eclipsed conformation
   (C) gauche conformation   (D) all have same potential energy

3. Which of the following does not exist as geometric isomers ? **[NSEC-2000]**
(A) 3-bromo-2-methyl-2-butene
(B) cyclodecene
(C) 3-bromo-1-Chloro-1-pentene
(D) 3-methyl-2-pentene

4. Which of the following is an E isomer ? **[NSEC-2000]**

5. Consider the following equilibrium,

Which of the following best describes the equilibrium constant K of this interconversion ? **[NSEC-2000]**
(A) K < 1
(B) K > 1
(C) K = 1
(D) K cannot be deduced from this information

6. Which of the following best describes the stability of the cis and trans isomers of 1, 1, 3, 5 tetraethylcyclohexan ? **[NSEC-2000]**
(A) The trans isomer is more stable than the cis.
(B) The cis isomer is more stable than the trans.
(C) Both have the same stability
(D) The information given is not sufficient to deduce the stability of the isomers.

7. Which of the following has the greatest angle strain ? **[NSEC-2000]**
(A) methyl cyclobutane
(B) methyl cyclopentane
(C) methyl cyclohexane
(D) methyl cyclopropane

8. Which would be the most stable conformation of trans-1- ethyl-3-methylcyclohexane? **[NSEC-2000, 01]**
(A) equatorial (methyl)-equatorial (ethyl)
(B) axial (methyl)-equatorial (ethyl)
(C) axial (methyl)-axial (ethyl)
(D) axial (ethyl)-equatorial (methyl)

9. The method used to distinguish optical isomers is **[NSEC-2000]**
(A) polarimetry
(B) spectroscopy
(C) chemical analysis
(D) boiling point determination

10. Isomers which can be interconverted through rotation around a single bond are : **[NSEC-2001]**
(A) enantiomers
(B) diastereomers
(C) conformers
(D) positional isomers

11. Which of the following will have least hindered rotation about carbon-carbon bond ? **[NSEC-2001]**
(A) ethylene
(B) hexachloroethane
(C) ethane
(D) acetylene

12. In cis-trans isomerism, the compound generally **[NSEC-2002]**
(A) contains a triple bond
(B) contains a double bond
(C) possesses an asymmetric carbon atom
(D) rotates the plane of polarized light.

13. The number of optical isomers for a compound having two similar asymmetric carbon atoms in the molecule is given as **[NSEC-2002]**
(A) 2
(B) 2^2
(C) $> 2^2$
(D) $< 2^2$

14. Optical activity of a substance is due to **[NSEC-2002]**
(A) presence of aldehyde group
(B) high molecular weight
(C) chemical reactivity
(D) presence of an asymmetric carbon atom

15.

The above pair represents [NSEC-2003]
(A) enantiomers (B) diastereomers
(C) identical compounds (D) positional isomers.

16. The following stereoisomers are [NSEC-2004]

(A) enantiomers (B) epimers (C) diastereomers (D) none of these.

17. The compound that has the highest dipole moment is [NSEC-2004]
(A) cis-1,2-dichloroethene (B) trans-1,2-dichloroethene
(C) cis-1-bromo -2-chloroethene (D) trans-1-bromo-2-chloroethene.

18. How many optically active stereoisomers are possible for Butane-2,3-diol ? [NSEC-2004]
(A) 1 (B) 2 (C) 3 (D7) 4.

19. The number of theoretically possible stereoisomers in the following steroid is [NSEC-2005]

(A) 256 (B) 64 (C) 8 (D) 16.

20. The diastereomeric pair in the following four pairs of compounds is [NSEC-2005]

21. The compound that will not be able to exhibit stereoisomerism is : [NSEC-2006]
(A) 1,2-Dibromocyclopropane (B) Lactic acid
(C) 1-Bromopropene (D) 1-Methylcyclopropane.

22. The total number of stereoisomers of 2,3-butanediol are [NSEC-2006]
(A) four (B) two (C) six (D) three.

23. A compound is chiral even if [NSEC-2006]
(A) a mirror plane is present
(B) a centre of inversion exists
(C) a rotation axis exists
(D) an improper rotation axis is present.

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24. Identify the chiral species among the following : **[NSEC-2007]**

(A) [structure: cyclopropane with Br, H, H, Br] (B) [structure with Br, Br] (C) [cyclobutane with Br, Br] (D) [allene structure H, H, Br, Br]

25. The achiral species among the following is : **[NSEC-2007]**
(A) a car (B) a screw driver (C) a screw (D) a hand

26. Which one of the following compounds has (Z) configuration about the C–C double bond?
[NSEC-2007]

(A) [structure with H_3C, H_3C, CH_3, alkyne, dioxane and dioxolane rings]

(B) [structure with H_3C, CH_3, CO_2Me, $CONH_2$]

(C) [structure with Br, Cl, CH_2CH_2OH, $CH(CH_3)_2$]

(D) [structure with Br, Cl, CH_2OH, CHO]
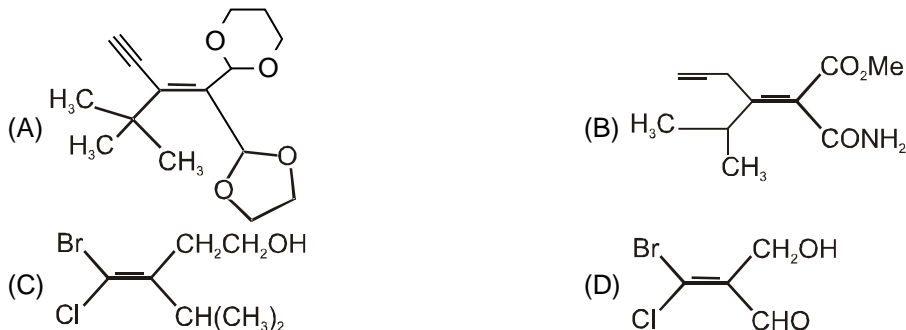
27. The following symmetry element is present in the 'd' as will as the 'ℓ' form of Tartaric acid [$CO_2HCH(OH) CH(OH)CO_2H$] **[NSEC-2007]**
(A) centre of symmetry (B) axis of symmetry (C_2)
(C) plane of symmetry (D) None

28. Conformational changes in a molecule leads to change in **[NSEC-2007]**
(A) torsional angle (B) bond angle (C) bond length (D) all of the above

29. How many chiral carbon atoms does Tetrachycline A (a broad spectrum antibiotic) have ? **[NSEC-2008]**

[structure of Tetracycline A]
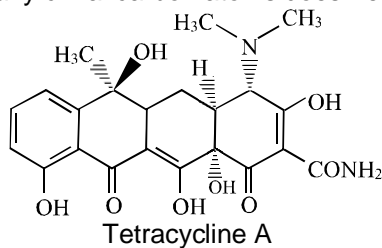
Tetracycline A
(A) 3 (B) 4 (C) 5 (D) 6

30. How many sterioisomers does the following compound have ? **[NSEC-2008]**

$CH_3–CH_2–CH–CH_2–CH=CH–CH_3$
          |
          Br
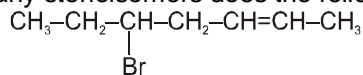
(A) None (B) 2 (C) 4 (D) 6

31. For cyclohexane, which of the following factors does not make the boat conformation less stable than the chair conformation **[NSEC-2008]**
(A) 1,3-diaxial interactions (B) flag pole interactions
(C) angle strain (D) torsional strain

32. The following molecule has a **[NSEC-2008]**

[structure with CO_2H, HO, OH, HO, HO]
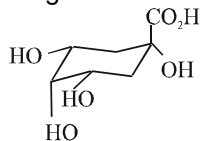
(A) centre of symmetry (B) plane of symmetry
(C) axis of symmetry (D) none of the above

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33. The absolute configurations of the chiral centres 1, 2 and 5 in the following molecule are **[NSEC-2008]**
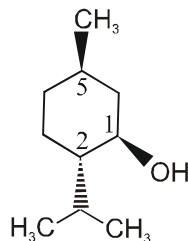
(A) 1R, 2R, 5R   (B) 1S, 2S, 5S   (C) 1R, 2S, 5R   (D) 1S, 2R, 5S

34. The following structures are   **[NSEC-2008]**
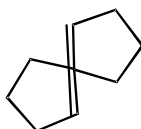
(A) enantiomers   (B) identical   (C) diastereomers   (D) rotamers

35. The isomeric alcohol which has a chiral carbon atom is :   **[NSEC-2009]**
(A) n-butyl alcohol   (B) iso-butyl alcohol   (C) sec-butyl alcohol   (D) tert-butyl alcohol

36. Geometrical isomerism results because the molecule :   **[NSEC-2009]**
(A) rotates the plane of polarized light
(B) has a plane of symmetry
(C) has a centre of symmetry
(D) has two dissimilar groups attached to both ends of double bond.

37. The pair of enantiomers among the following compound are :   **[NSEC-2009]**
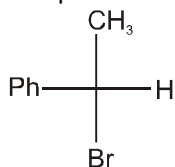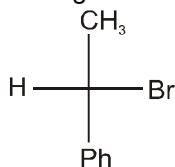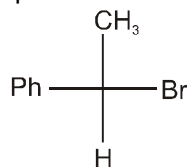
(A) I and IV   (B) II and IV   (C) II and III   (D) I and II
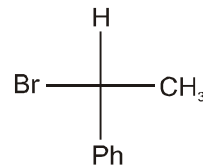
38. The number of all types of isomers of chlorobutane is   **[NSEC-2010]**
(A) 2   (B) 4   (C) 6   (D) 5

39. (i) $CH_2=CH–CH_2–CH=CH_2$
(ii) $CH_2=CH–CH=CH–CH_3$
(iii) $CH_3–CH=CH–CH=CH–CH_3$
The numbers of possible geometrical isomers for the above compounds respectively are **[NSEC-2010]**
(A) 0,2,4   (B) 2,2,4   (C) 0,3,3   (D) 0,2,3

40. The configurations of the carbon atoms C_2 and C_3 in the following compound are respectively.
[NSEC-2011]
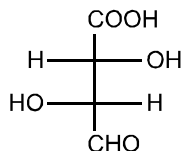
(A) R, R   (B) S, S   (C) R, S   (D) S, R

41. The compound that is chiral.   **[NSEC-2011]**
(A) 3-Methyl-3-hexene   (B) 1-Chloro-4-methylcyclohexane
(C) 2-Phenylpentane   (D) 1,3-Diisopropylbenzene

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42. The number of stereoisomers of compound $CH_3–CH=CH–CH(Br)CH_3$ is : **[NSEC-2011]**
(A) 2   (B) 3   (C) 4   (D) 6

43. The **R/S** designation for the following stereoisomer of 1,3-Dibromo-2-methylbutane is : **[NSEC-2012]**

$$CH_2Br$$

H₃C——H

H——Br

$$CH_3$$
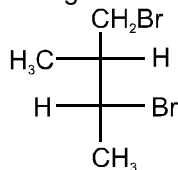
(A) 2R, 3R   (B) 2R, 3S   (C) 2S, 3R   (D) 2S, 3S

44. Among the isomers of Dimethylcyclohexanes, the chiral ones are **[NSEC-2012]**
(A) 1, 2-trans and1, 3-cis   (B) 1, 2-cis and 1,3-trans
(C) 1, 3-trans and 1, 4-trans   (D) 1, 2-trans and 1,3-trans

45. Which one of the following compound has R configuration? **[NSEC-2012]**

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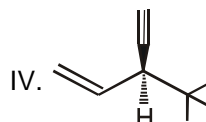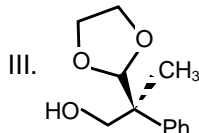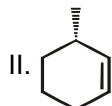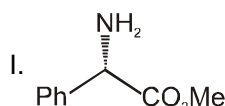
(A) I   (B) II   (C) III   (D) IV

46. The number of optically active stereoisomers of tartaric acid, (HOOC.CHOH.CHOH.COOH) is **[NSEC-2013]**
(A) 4   (B) 2   (C) 1   (D) 3

47.

CHO	CHO	CHO
H —— OH	HO —— H	H —— OH
HO —— H	HO —— H	HO —— H
H —— OH	H —— OH	HO —— H
H —— OH	H —— OH	H —— OH
CH₂OH	CH₂OH	CH₂OH
D-Glucose	D-Mannose	D-Galactose
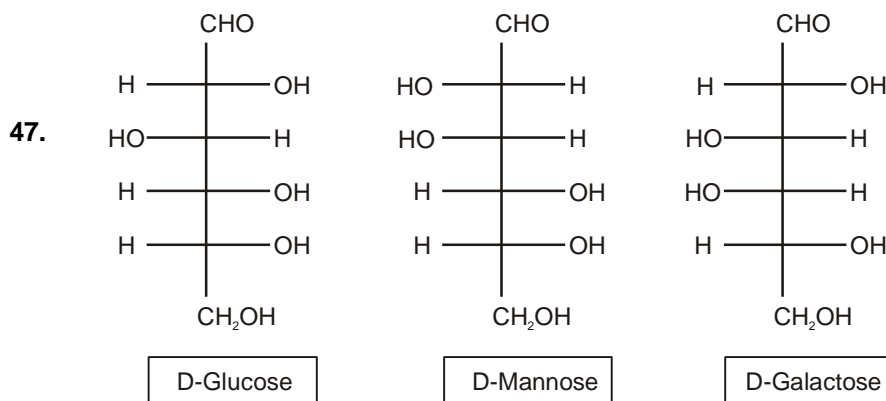
The above structures are related to each other as **[NSEC-2013]**
(A) identical substance   (B) diastereomers   (C) enantiomers   (D) epimers

48. Which of the following molecules cannot show geometric isomerism ? **[NSEC-2013]**

(A) $CH_3CH=NOH$ (B) $(CH_3)_2C=NOH$ (C) HO–N=N–OH   (D) Cl—△—Cl

49. 2-methylpentane is : **[NSEC-2014]**

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

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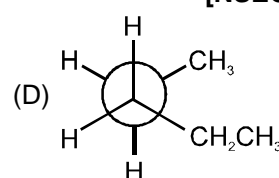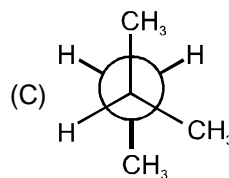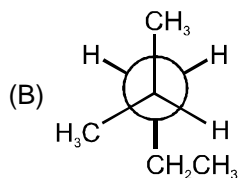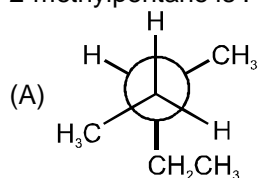
50. The two projection formulae that represent a pair of enantiomers are. **[NSEC-2015]**
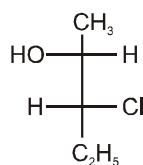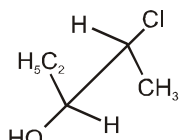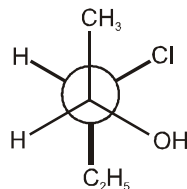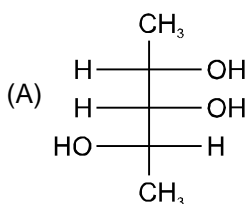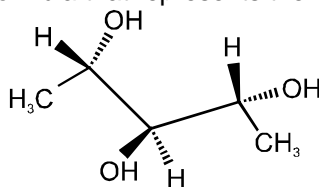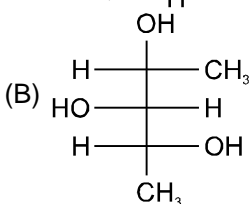

(A) I and II   (B) III and IV   (C) I and III   (D) II and IV
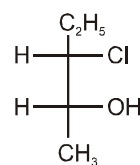
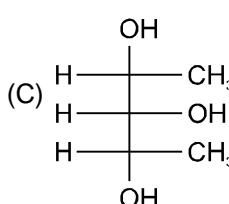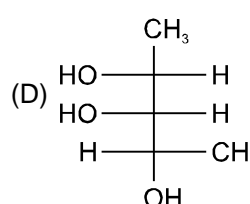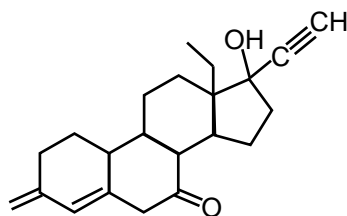**51.** The Fischer projection formula that represents the following compounds is **[NSEC-2015]**

52. Levonorgestrel is a commonly used contraceptive. The number of chiral centres present in this molecule is : **[NSEC-2017]**
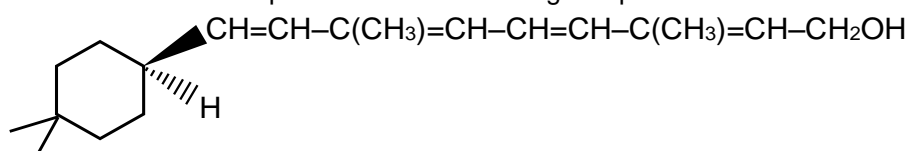

Levonorgestrel

(A) 4   (B) 5   (C) 6   (D) 7

53. The number of stereoisomers possible for the following compound. **[NSEC-2018]**

$$CH=CH-C(CH_3)=CH-CH=CH-C(CH_3)=CH-CH_2OH$$

(A) 4   (B) 2   (C) 16   (D) 32

54. The number of quaternary and chiral carbon atoms present in elatol, isolated from an algae are respectively **[NSEC-2018]**
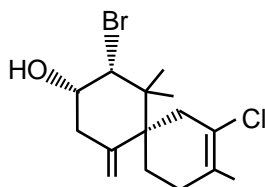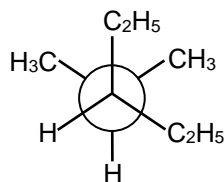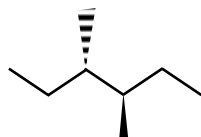

Elatol

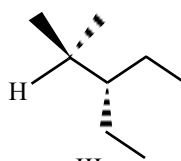(A) 2, 3   (B) 4, 2   (C) 3, 2   (D) 1, 3

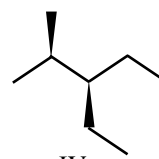**55.** The Newman projection shown is the same as **[NSEC-2018]**
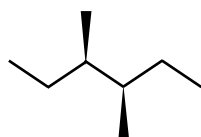
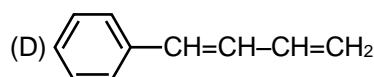(A) I and IV   (B) II and III   (C) III and IV   (D) I and II

56. The molecule in which all atoms are not coplanar is **[NSEC-2018]**

(A) —$CH=C=C=CH_2$

(B) —$CH=CH–C\equiv CH$

(C) —$CH=C=CH_2$

(D) —$CH=CH–CH=CH_2$
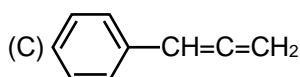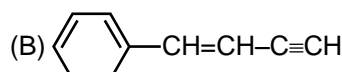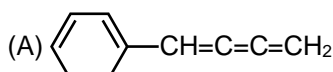
PART - III : PRACTICE TEST-2 (IIT-JEE (ADVANCED Pattern))

Max. Time : 1 Hr.   **Max. Marks : 69**

Important Instructions
A.   General :
1.   The test is of 1 hour duration.
2.   The Test Booklet consists of 23 questions. The maximum marks are 69.
B.   Question Paper Format :
3.   Each part consists of five sections.
4.   Section 1 contains 8 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE is correct.
5.   Section 2 contains 6 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE OR MORE THAN ONE are correct.
6.   Section 3 contains 6 questions. The answer to each of the questions is a single-digit integer, ranging from 0 to 9 (both inclusive).
7.   Section 4 contains 1 paragraphs each describing theory, experiment and data etc. 2 questions relate to paragraph. Each question pertaining to a partcular passage should have only one correct answer among the four given choices (A), (B), (C) and (D).
8.   Section 5 contains 1 multiple choice questions. Question has two lists (list-1 : P, Q, R and S; List-2 : 1, 2, 3 and 4). The options for the correct match are provided as (A), (B), (C) and (D) out of which ONLY ONE is correct.
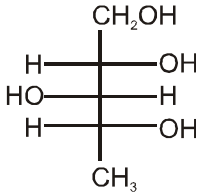**C.   Marking Scheme :**
9.   For each question in Section 1, 4 and 5 you will be awarded 3 marks if you darken the bubble corresponding to the correct answer and zero mark if no bubble is darkened. In all other cases, minus one (– 1) mark will be awarded.
10.   For each question in Section 2, you will be awarded 3 marks. If you darken all the bubble(s) corresponding to the correct answer(s) and zero mark. If no bubbles are darkened. No negative marks will be answered for incorrect answer in this section.
11.   For each question in Section 3, you will be awarded 3 marks if you darken only the bubble corresponding to the correct answer and zero mark if no bubble is darkened. No negative marks will be awarded for incorrect answer in this section.

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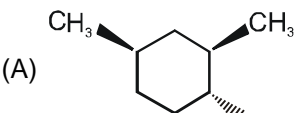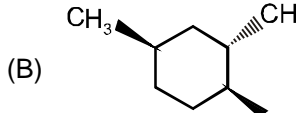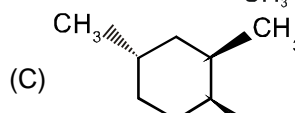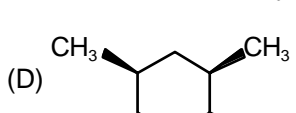**SECTION-1 : (Only One option correct Type)**
This section contains 8 multiple choice questions. Each questions has four choices (A), (B), (C) and (D) out of which Only ONE option is correct.

1.
$$
\begin{array}{c}
CH_2OH \\
H \!-\!\!\!-\!\!\!-\! OH \\
HO \!-\!\!\!-\!\!\!-\! H \\
H \!-\!\!\!-\!\!\!-\! OH \\
CH_3
\end{array}
$$
is a Fischer projection of one of_____stereoisomers?

(A) 2   (B) 4   (C) 8   (D) 12

2. Which of the following has maximum number of two-fold axis of symmetry.
(A) Ethylene   (B) Cyclopropane   (C) Cyclobutane   (D) Benzene

3. ✎ The following compounds are :

(I)   (II)
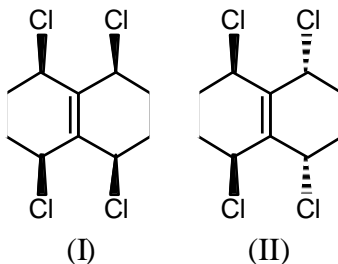
(A) Enantiomer   (B) Identical   (C) Diastereomer   (D) Geometrical isomer

4. Which conformation of Bicyclo [2, 2, 2]-octane is more stable ?
(A) Chair   (B) Half Boat   (C) Boat   (D) Twisted boat

5. In the given energy graph for cyclohexane, the point "B" represent.
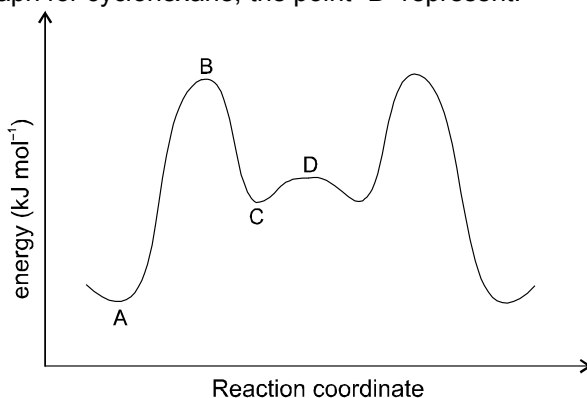
(A) Chair conformation   (B) Half chair conformation
(C) Twist boat conformation   (D) Boat conformation

6. ✎ Identify the most stable stereoisomer :

7. Molecular formula of smallest ester which contain one chiral carbon is :
(A) $C_4H_8O_2$ (B) $C_5H_{12}O$ (C) $C_6H_{12}O_2$ (D) $C_5H_{10}O_2$

8. Which of the following has/have potential energy diagram for conformations closely resembling to ethane.

(I) 2,2-Dimethylpropane   (II) 2,3-Dimethylbutane
(III) 2,2,3-Trimethylbutane   (IV) 2,2-Dimethylbutane

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


Section-2 : (One or More than one options correct Type)
This section contains 6 multiple choice questions. Each questions has four choices (A), (B), (C) and (D) out of which ONE or MORE THAN ONE are correct.

---

9. Which statement(s) is/are correct for the given reaction and compounds.


(d + ℓ)   one isomer only
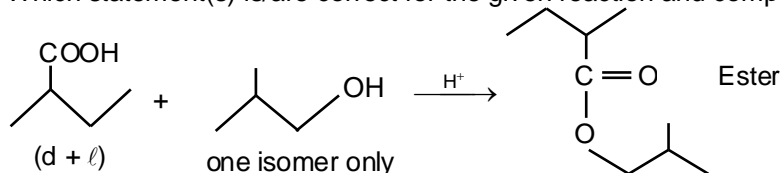
(A) Two esters are formed.   (B) All the esters are chiral.
(C) Both esters are diastereomers.   (D) Racemic mixture is formed as a product.

10. Intra-molecular H-bonding is possible in which of the following.
(A) cis-cyclohexane-1,2-diol   (B) trans-cyclohexane-1,2-diol
(C) cis-cyclohexane-1,3-diol   (D) cis-cyclohexane-1,4-diol

11. Which of the following statement(s) is/are correct?
(A) Anti conformation of H_2N–CH_2–CH_2–NH_2 is more stable than its Gauche confromation.
(B) Gauche conformation of HO–CH_2–CH_2F is more stable than its anti conformation at room temperature.
(C) On increasing temperature, dipole moment of pure F–CH_2–CH_2–F increases.
(D) In case of 1,4-Dihydroxycyclohaxane chair conformer is most stable.

12. Which of the following compounds can show Optical isomerism as well as geometrical isomerism?
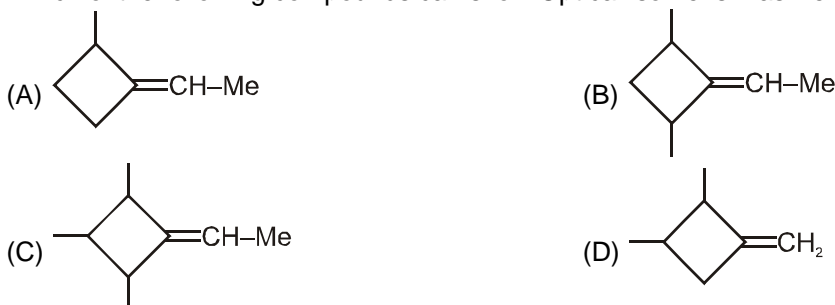
13. Which of the following compounds can show geometrical isomerism.
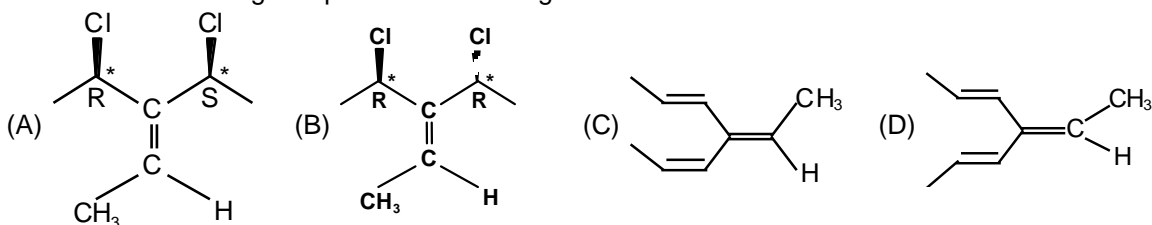
14. Which of the following statement(s) is/are true about the following compounds?


(I)   (II)   (III)
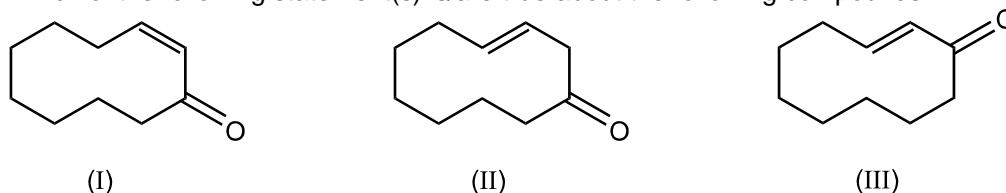
(A) (I) and (III) are identical   (B) (I) and (III) are geometrical diastereomers
(C) (I) and (II) are structural isomers.   (D) (II) and (III) are structural isomers.

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Section-3 : (Single/ Double Integer Value Correct Type.)
This section contains 6 questions. Each question, when worked out will result in one integer from 0 to 9 (both inclusive)

15. An organic compound P exists in two enantiomeric forms, which have specific optical rotation values $[\alpha]$ = ±100°. The optical rotation of a mixture of these two enantiomers is –50°. Calculate the percentage of that enantiomer which is in lower concentration in the mixture.

16. Total number of meso forms possible for 1,2,3,4-Tetrachlorocyclobutane.

17. If "A" is total number of meso compounds and "B" is total number of optically active isomers; then find (A+B) for
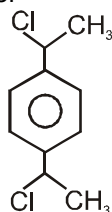
18. Sum of total no. of stereoisomers (A) and total no. of fractions (B) for the compound

is.

19. How many of the following carbonyl compound will give two products after reaction with NH_2OH :

(i)

(ii)

(iii)

(iv)

(v)

(vi)

(vii)

(viii)

(ix) $CH_3–CH=O$
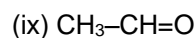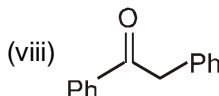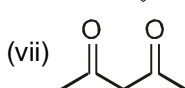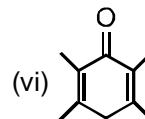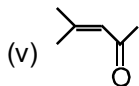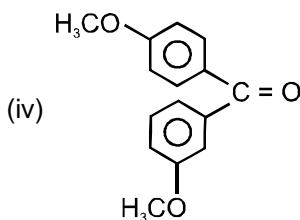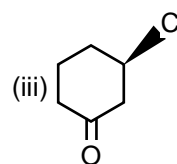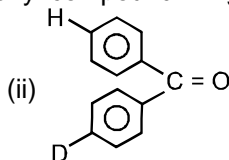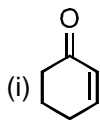
**20.** Total number of stereoisomers of truxillic acid are :

SECTION-4 : Comprehension Type (Only One options correct)
This section contains 1 paragraphs, each describing theory, experiments, data etc. 2 questions relate to the paragraph. Each question has only one correct answer among the four given options (A), (B), (C) and (D)

Paragraph for Questions 21 to 22
An unknown substance (P) shows optical activity. This optical activity disappears on treatment of (P) with acidified $KMnO_4$ (which produces Q), or with heated copper (which produces R). (P) Produces silver mirror with Tollen's reagent, thereby producing (S). (S) is chiral. Based on this information, answer the following questions :
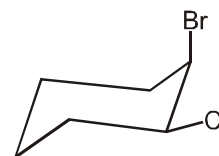
21. (P) may be -

(A)

(B)

(C)

(D)
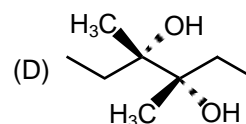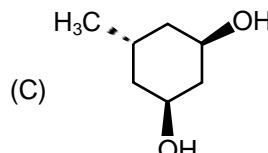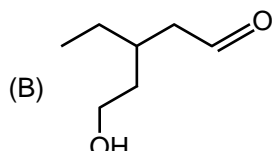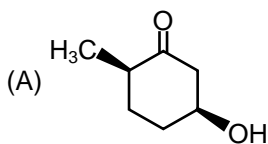
22. Number of stereoisomers possible for (P) is –
(A) 2   (B) 3   (C) 4   (D) 8

SECTION-5 : Matching List Type (Only One options correct)
This section contains 1 questions, each having two matching lists. Choices for the correct combination of elements from List-I and List-II are given as options (A), (B), (C) and (D) out of which one is correct.

23. Match the compounds of **Column-I** with their relationship with mentioned in **Column-II.**

	Column-I		Column-II
P.		1.	Geometrical isomer
Q.		2.	Conformation
R.		3.	Positional isomer
S.		4.	Identical

Code:

	P	Q	R	S			P	Q	R	S
(A)	4	2	3	1		(B)	1	2	4	3
(C)	2	1	3	4		(D)	1	2	3	4

Practice Test-2 ((IIT-JEE (ADVANCED Pattern))
OBJECTIVE RESPONSE SHEET (ORS)

Que.	1	2	3	4	5	6	7	8	9	10
Ans.										
Que.	11	12	13	14	15	16	17	18	19	20
Ans.										
Que.	21	22	23							

APSP Answers

PART – I

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

PART – II
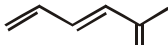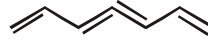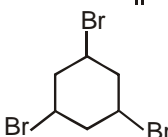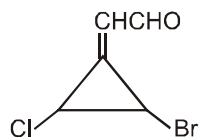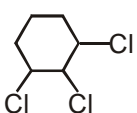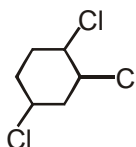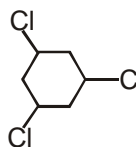
1.	(C)	**2.**	(B)	**3.**	(A)	**4.**	(C)	**5.**	(B)
6.	(B)	**7.**	(D)	**8.**	(B)	**9.**	(A)	**10.**	(C)
11.	(C)	**12.**	(B)	**13.**	(D)	**14.**	(D)	**15.**	(C)
16.	(C)	**17.**	(A)	**18.**	(B)	**19.**	(A)	**20.**	(B)
21.	(D)	**22.**	(D)	**23.**	(C)	**24.**	(A)	**25.**	(B)
26.	(B)	**27.**	(B)	**28.**	(A)	**29.**	(C)	**30.**	(C)
31.	(A)	**32.**	(B)	**33.**	(C)	**34.**	(C)	**35.**	(C)
36.	(D)	**37.**	(C)	**38.**	(D)	**39.**	(D)	**40.**	(A)
41.	(C)	**42.**	(C)	**43.**	(A)	**44.**	(D)	**45.**	(D)
46.	(B)	**47.**	(B)	**48.**	(B)	**49.**	(B)	**50.**	(C)
51.	(D)	**52.**	(C)	**53.**	(C)	**54.**	(A)	**55.**	(C)
56.	(C)								

PART – III

1.	(C)	**2.**	(D)	**3.**	(C)	**4.**	(C)	**5.**	(B)
6.	(A)	**7.**	(D)	**8.**	(A)	**9.**	(ABD)	**10.**	(ABCD)
11.	(BC)	**12.**	(ABCD)	**13.**	(ACD)	**14.**	(BCD)	**15.**	25%
16.	Zero (as none of its stereoisomer is chiral)					**17.**	3 (A = 1, B = 2)		
18.	6	**19.**	7 (i, ii, iii, iv, v, viii, ix)			**20.**	5	**21.**	(B)
22.	(A)	**23.**	(A)						

APSP Solutions

PART – I

4. geometrical isomers = 2 ; geometrical isomers = 0

 geometrical isomers = 2 ; geometrical isomers = 4

5.

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7.

(Anti form)
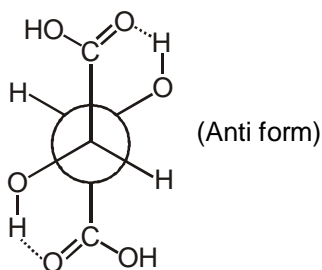
16. Both are identical species H_3C—$\overset{\overset{\displaystyle CH_3}{|}}{CH}$—$Cl$ in 1, there is no asymmetric carbon atom present.

2, 3, 4 have pairs of compounds which have chiral carbon and are non superimposible on each other.
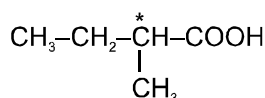
17. Compounds are diastereomers.

18. When –OH is present at right side of horizontal line & high priority at the top than it is consider as D & if left side then L.

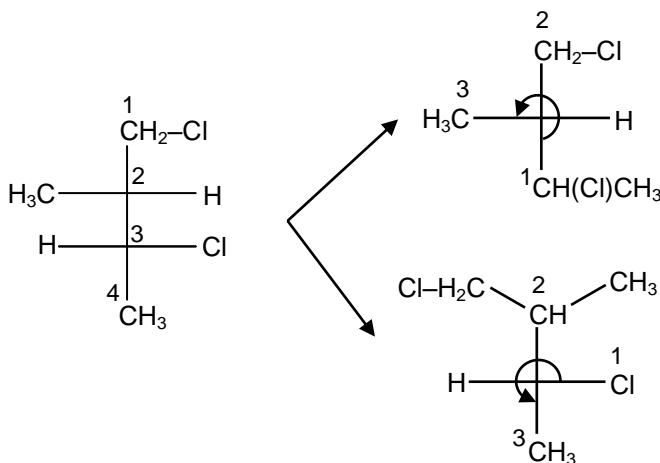**19.** 2, 2`6, 6` tetra substituted biphenyls are optically active

20. CH_3–CH_2–$\overset{\overset{\displaystyle *}{|}}{\underset{\underset{\displaystyle CH_3}{|}}{CH}}$–$COOH$

22. Because bigger methyl groups come closer to each other in fully ellipsed conformer.

23.

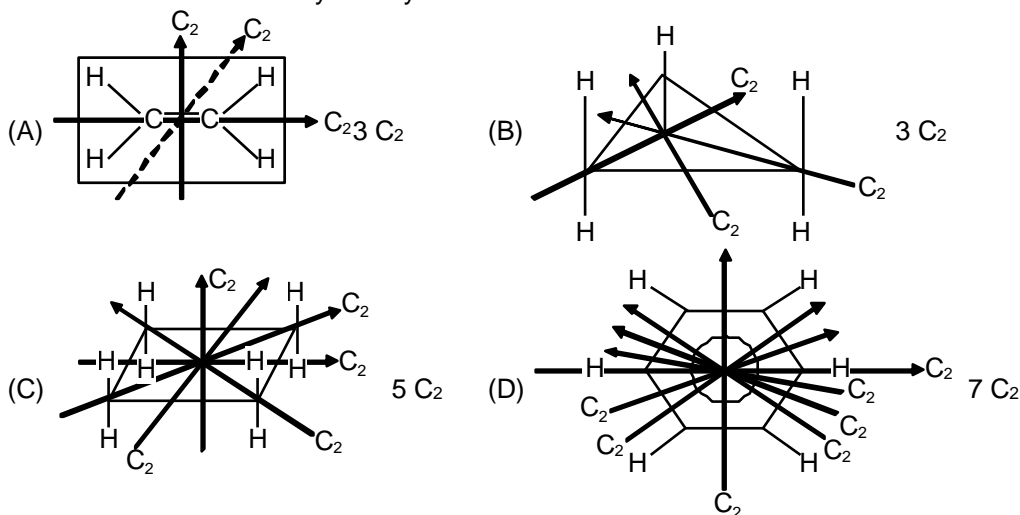**24.** Follow conditions of geometrical isomerism.

28. II

is

, therefore I and II are identical.
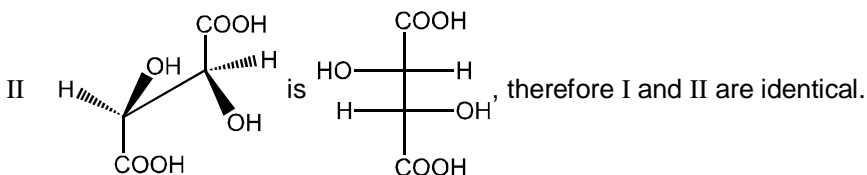
29. There are two stereocentres in the compound, so total stereoisomers = 2^2 = 4. All 4 will be optically active.

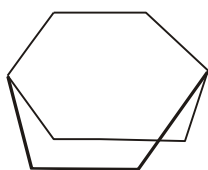Reg. & Corp. Office : CG Tower, A-46 & 52, IPIA, Near City Mall, Jhalawar Road, Kota (Raj.) - 324005
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PART – III

2. Benzene has two-fold of symmetry.

(A) C_2 3 C_2

(B) 3 C_2

(C) 5 C_2

(D) 7 C_2

3. Compound (I) and (II) are diastereomer

4.

5. Infact "B" is the half chair conformation of cyclohexane.

6.

(A)
(e, e, e,)

(B)
(e, e, a,)

(C)
(e, a, e)

(D)
(a, e, e)
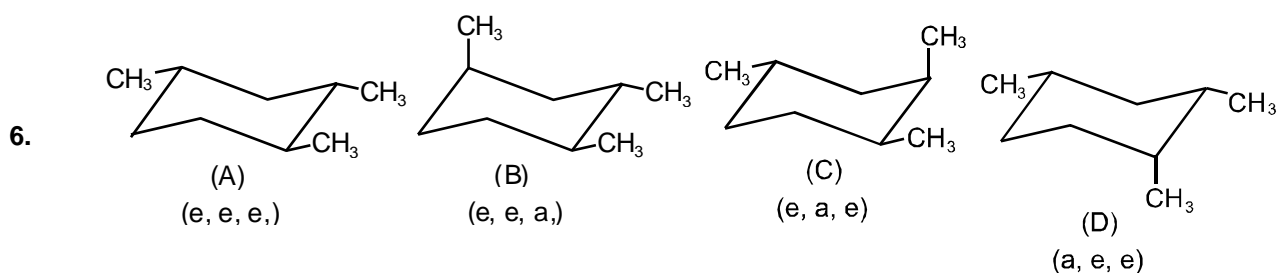
8. All have the P.E. diagram like
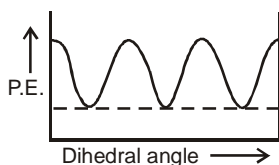
9. The final esters have only one chiral carbon atom and these are mirror image of each other, so product mixture is racemic.

11. Due to Hydrogen bonding Gauche conformation of $H_2N–CH_2–CH_2–NH_2$ and $HO–CH_2–CH_2–F$ are more stable than anti conformations. In case of $ClCH_2CH_2Cl$ on increasing temperature % of Gauche conformation increases. Hence dipole moment increases. In case of option (D) boat conformation is more stable.
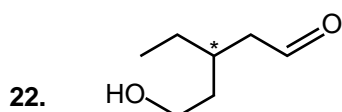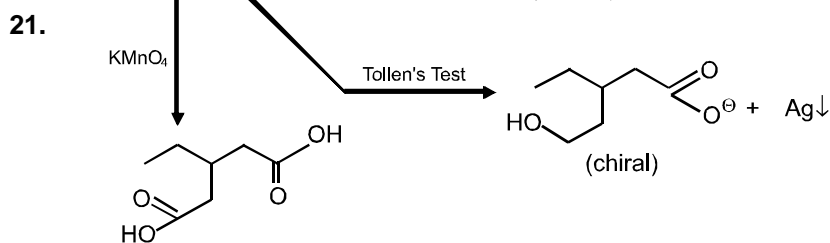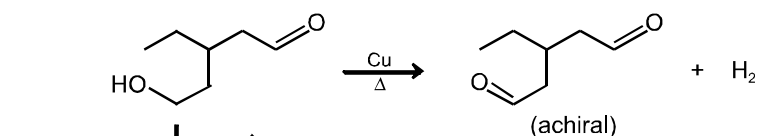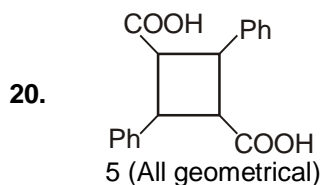
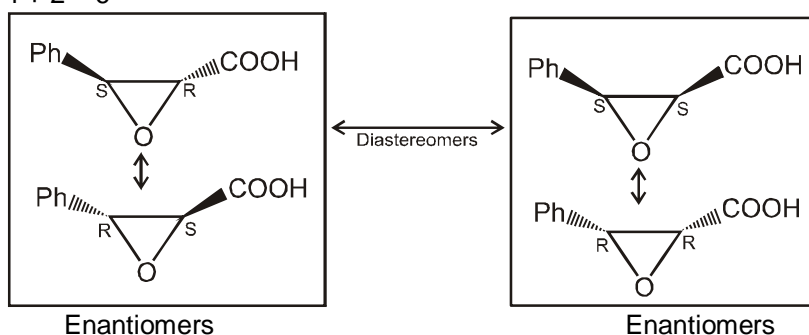**13.** (A) (B) (C) Cis (D) only pesudo chiral carbon exists

G.I.
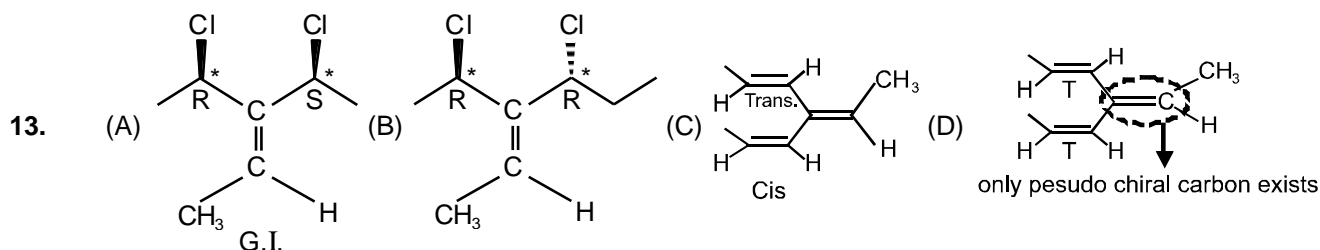
14. I and II have different positions of π-bond, these are positional isomers. Similarly II and III are also positional isomers.

I and III are geometrical isomers.

15. Enatiomeirc excess = $\dfrac{\text{observed rotation}}{\text{specific rotation of pure enantiomer}}$ = $\dfrac{-50°}{-100°} \times 100$ = 50%

% of laevorotatory isomer = 50 + 25%

% of dextrorotatory isomer = 25%

17. A = 1, B = 2 $\Rightarrow$ A + B = 3.

18. 4 + 2 = 6

Enantiomers   Enantiomers

20.

5 (All geometrical)

21.

22.

One chiral center may have (R) or (S) configuration. Hence, two stereoisomers.

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