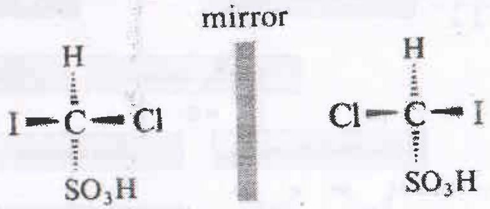
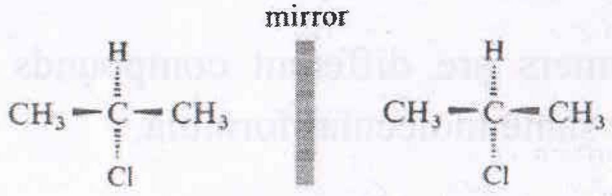
Chiral molecules: molecules that are not superposable on their mirror images.



Chloroiodomethanesulfonic acid

Not superimposable : enantiomers

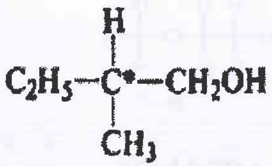
Achiral molecule: molecule that are superposable on their mirror images.



Isopropyl chloride

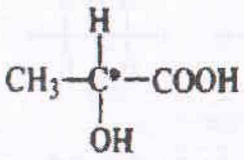
Superimposable : no enantiomers

Stereogenic center or chiral center: carbon atom with four different groups attached to it (market with an asterisk).



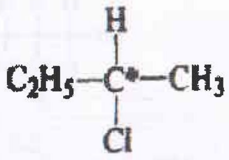
$$C_2H_5-\overset{H}{\underset{CH_3}{C^*}}-CH_2OH$$

2-Methyl-1-butanol



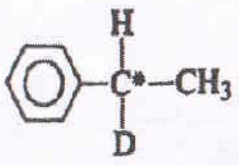
$$CH_3-\overset{H}{\underset{OH}{C^*}}-COOH$$

Lactic acid



$$C_2H_5-\overset{H}{\underset{Cl}{C^*}}-CH_3$$

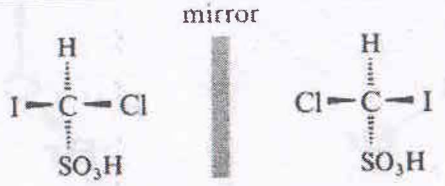
***sec*-Butyl chloride**



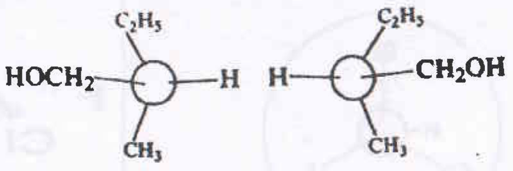
α-Deuterioethylbenzene

- Many but not all molecules that contain a chiral center are chiral.
- If there is only one chiral center in the molecule we can certain that the molecule is chiral.

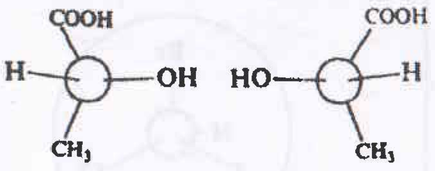
Enantiomers are a pair of molecules related as nonsuperimposable mirror images.



Chloroiodomethanesulfonic acid
Not superimposable: enantiomers



2-Methyl-1-butanol



Lactic acid

Prediction of enantiomerism

- Molecules that are not superposable on their mirror images are chiral.
- A compound whose molecules are chiral can exist as enantiomers.

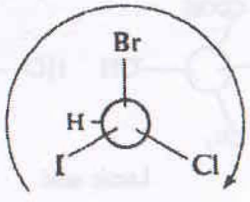
Specification of Configuration: R and S

Enantiomers differ in the arrangement of the groups attached to the stereogenic center (chiral center). This arrangement of groups is called configuration of the stereogenic center.

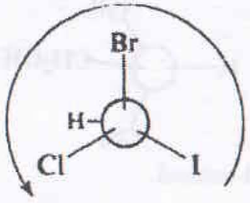
R, S system or cahn-Ingold-Prelog system

Step 1. Following a set of sequence rules, In the case of CHClBrI, for example, the four atoms attached to the chiral center are all different and priority depends simply on atomic number, the atom of higher number having higher priority. Thus I, Br, CI, H.

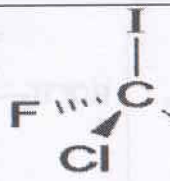
Step 2. We visualize the molecule oriented so that the group of lowest priority is directed away from us, and observe the arrangement of the remaining groups. If, in proceeding from the group of highest priority to the group of the second priority and thence to the third, our eye travels in a clockwise direction, the configuration is specified R (Latin : rectus, right); if counterclockwise, the configuration is specified S (Latin: sinister, left).



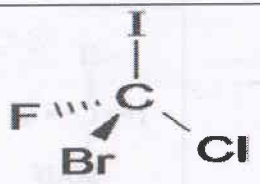
R



S



R

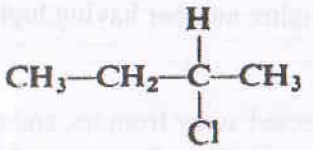


S

Sequence rules

Sequence Rule 1. If the four atoms attached to the chiral center are all different, priority depends on atomic number, with the atom of higher atomic number getting higher priority. If two atoms are isotopes of the same element, the atom of higher mass number has the higher priority.

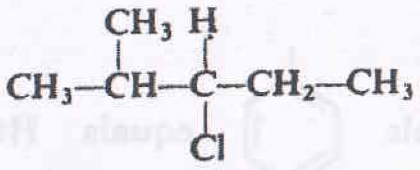
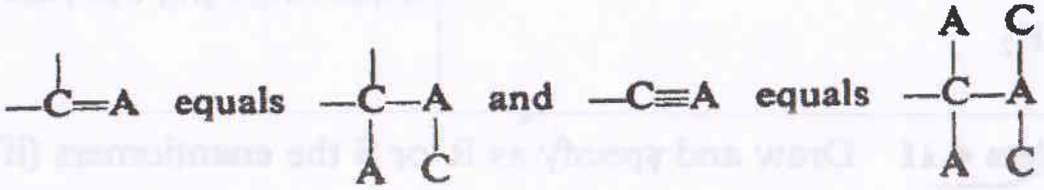
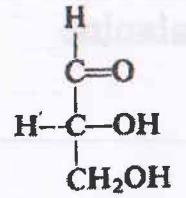
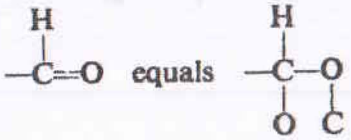
Sequence Rule 2. If the relative priority of two groups cannot be decided by Rule I, it shall be determined by a similar comparison of the next atoms in the groups and so on.



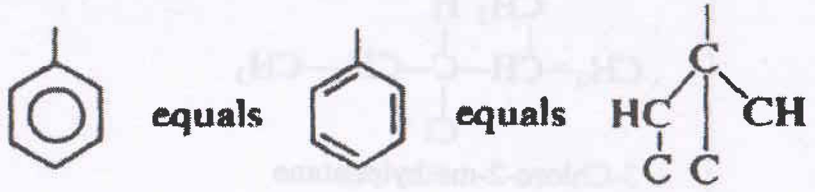
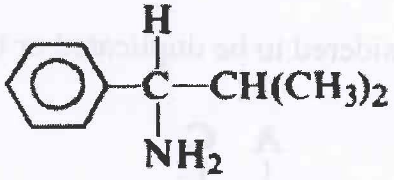
$$CH_3-CH_2-\underset{Cl}{\overset{H}{C}}-CH_3$$

sec-**Butyl chloride**

A complete sequence of priority for sec-butyl chloride is therefore Cl, C_2H_5, CH_3, and H.

<table>
<tr>
<td>
$CH_3-CH(CH_3)-CH(Cl)-CH_2-CH_3$
3-Chloro-2-methylpentane</td>
<td>A complete sequence of priority is Cl, isopropyl, ethyl, H.</td>
</tr>
<tr>
<td colspan="2">Sequence Rule 3. Where there is a double or triple bond, both atoms are considered to be duplicated or triplicated.

 </td>
</tr>
<tr>
<td>
Glyceraldehyde

 </td>
<td>The complete sequence of glyceraldehyde is then OH, CHO, CH_2OH and H.</td>
</tr>
</table>

e 5

The phenyl group, C_6H_5	
	In l-amino-2-methyl-l-phenylpropane, the entire sequence is then NH_2, C_6H_5, C_3H_7, and H.

Problem 4.11 **Draw and specify as R or S the enantiomers (if any) of:**

(a) 3-chloro-1-pentene

(b) 3-chloro-4-methyl-1-pentene

(c) $HOOCCH_2CHOHCOOH$, malic acid

(d) $C_6H_5CH(CH_3)NH_2$

(e) methvlethyl-*n*-propylisopropylmethane

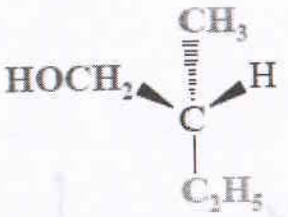
(f) $C_6H_5CHOHCOOH$, mandelic acid

(g) $CH_3CH(NH_2)COOH$, alanine

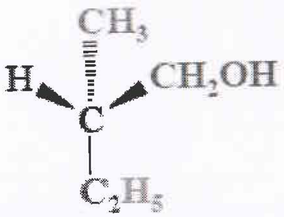
Enantiomers:

- Enantiomers have identical chemical properties except toward optically active reagents .

- Enantiomers have identical physical properties, except for the direction of rotaion of plan of polarized light.



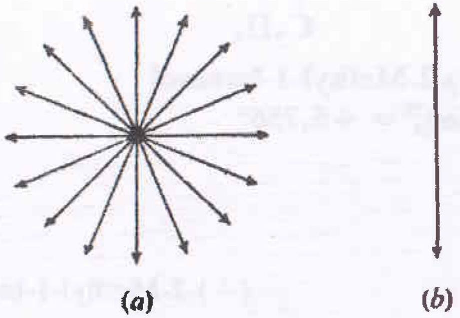
(*R*)-(+)-2-Methyl-1-butanol
$[\alpha]_D^{25} = +5.756°$



(*S*)-(−)-2-Methyl-1-butanol
$[\alpha]_D^{25} = -5.756°$

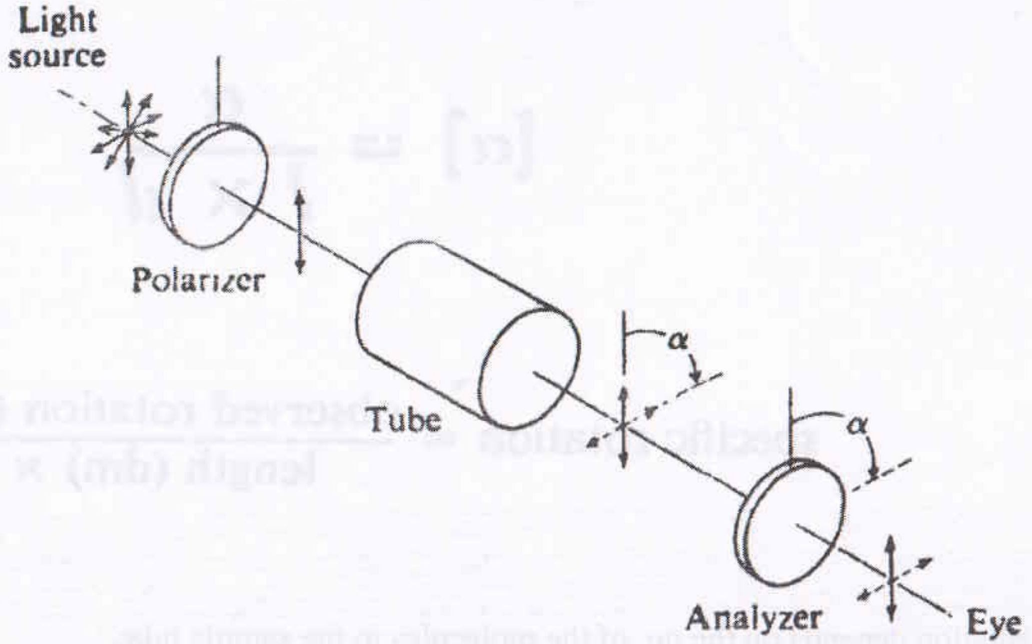
	(+)-2-Methyl-1-butanol	(−)-2-Methyl-1-butanol (Fermentation Product)
Specific rotation	+5.756°	−5.756°
Boiling point	128.9°	128.9°
Density	0.8193	0.8193
Refractive index	1.4107	1.4107

- Enantiomers rotate plane-polarized light in opposite directions, they have specific rotations of the same magnitude but with opposite signs.
- Separate enantiomers rotate the plane of polarized light equal amounts but in opposite direction.
- Separate enantiomers are said to be optical active compounds.
- Plane polarized light is the light whose vibration takes place in only one plane.



(a) Ordinary light and (b) Plane polarized light

Polarimeter: a device used for measuring optical activity of the optical active compound.



If the rotation of the plane of the optical active compound is to the right (clockwise), the substance is dextrorotatory (Latin: dexter, right); if the rotation is to the left (counterclockwise), the substance is Levorotatory (Latin: laevus. left). The symbols + and - are used to indicate rotations to the right and to the left, respectively.

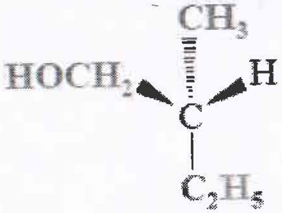
- ***Specific rotation*** is the no of degrees of rotation observed if a 1 dm (10 cm) tube is used and the compound being examined is presend to the extend of 1g/ml.

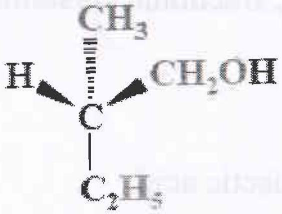
$$[\alpha] = \frac{\alpha}{l \times d}$$

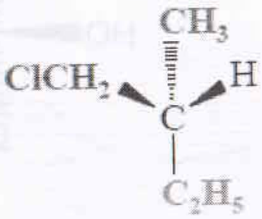
$$\text{specific rotation} = \frac{\text{observed rotation (degrees)}}{\text{length (dm)} \times \text{g/cc}}$$

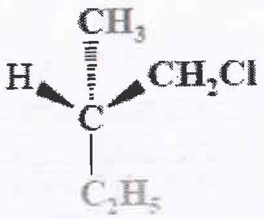
- The rotation depends on the no. of the molecules in the sample tube.

Examples


(*R*)-(+)-2-Methyl-1-butanol
$[\alpha]_D^{25} = +5.756°$


(*S*)-(−)-2-Methyl-1-butanol
$[\alpha]_D^{25} = -5.756°$

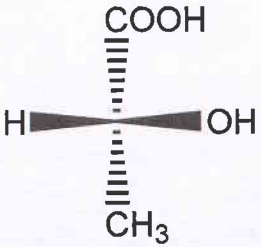

(*R*)-(−)-1-Chloro-2-methylbutane
$[\alpha]_D^{25} = -1.64°$


(*S*)-(+)-1-Chloro-2-methylbutane
$[\alpha]_D^{25} = +1.64°$

The racemic modification:

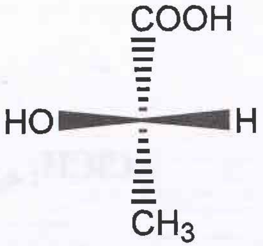
- A mixture of equal part of enantiomers is optical inactive. The prefix ± is used to specify the racemic mixture of the particular sample. Racemic modificatiom cannot be separated from each other by fractional distillation, fractional crystallization or by chromatography.

For example (±)-lactic acid



(R)-Lactic acid

50%

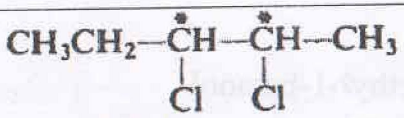


(S)-Lactic acid

50%

Diastereomers: stereoisomers that are not mirror images of each other.

Example 2,3-dichloropentane has two chiral center



$CH_3CH_2-\underset{Cl}{\overset{*}{C}H}-\underset{Cl}{\overset{*}{C}H}-CH_3$

2,3-Dichloropentane

I II

Not superimposable
Enantiomers

(2S,3S)-2,3-dichloropentane (2R,3R)-2,3-dichloropentane

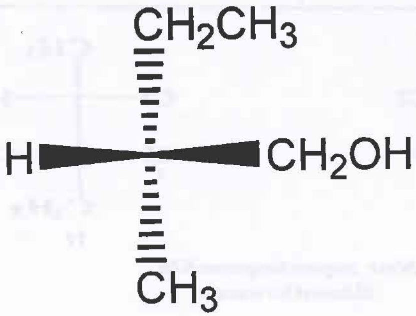
III IV

Not superimposable
Enantiomers

(2S,3R)-2,3-dichloropentane (2R,3S)-2,3-dichloropentane

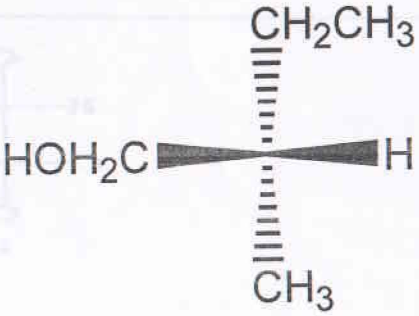
Compound I is an enantiomer of II,
Compound III is an enantiomer of IV.
Compound III is a diastereomer of I, and of II.
Compound IV is a diastereomcr of I and of II.

- (±)-2-methyl-1-butanol



(R)-2-Methyl-1-butanol

50%

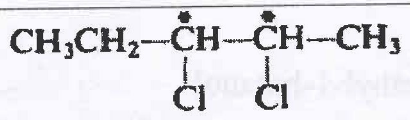


(S)-2-Methyl-1-butanol

50%

Diastereomers: stereoisomers that are not mirror images of each other.

Example 2,3-dichloropentane has two chiral center



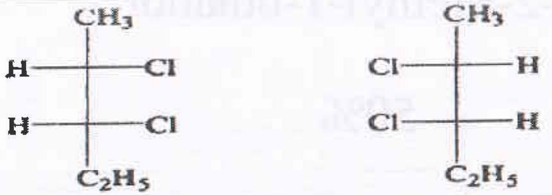
$$CH_3CH_2-\underset{\underset{Cl}{|}}{\overset{*}{C}H}-\underset{\underset{Cl}{|}}{\overset{*}{C}H}-CH_3$$

2,3-Dichloropentane

I II

Not superimposable
Enantiomers

(2S,3S)-2,3-dichloropentane (2R,3R)-2,3-dichloropentane



III IV

Not superimposable
Enantiomers

(2S,3R)-2,3-dichloropentane (2R,3S)-2,3-dichloropentane

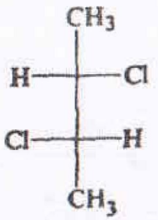
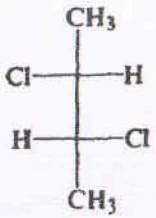
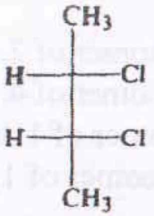
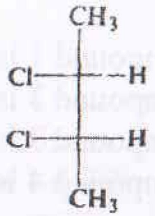
Compound I is an enantiomer of II,
Compound III is an enantiomer of IV.
Compound III is a diastereomer of I, and of II.
Compound IV is a diastereomcr of I and of II.

Meso compound: is one whose molecules are superimposable on their mirror images even though they contain chiral centers (Meso compound is optical inactive).

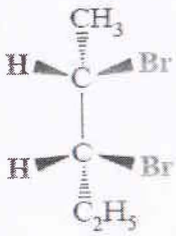
- 2,3-dichlorobutane

$$CH_3-\underset{Cl}{\overset{*}{C}H}-\underset{Cl}{\overset{*}{C}H}-CH_3$$

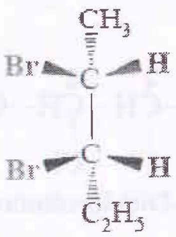
2,3-Dichlorobutane

 I  II	 III  IV
(S,S)-2,3-dichlorobutane (R,R)-2,3-dichlorobutane	(R,S)-2,3-dichlorobutane (S,R)-2,3-dichlorobutane
Compound I is an enantiomer of II Compound III is a meso of IV. Compound III is diastereomer of 1 and of II. Compound IV is a diastereomer of I, and of II.	

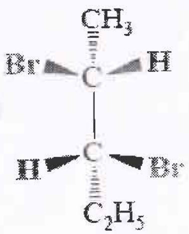
- The maximum no. of of stereoisomers that can exist is equal to the 2^n, where n is the no. of chiral centers. The 2,3-Dibromopentane compounds represented by structures 1– 4 are all optically active compounds. Any One of them, if placed separately in a polarimeter, would show optical activity.



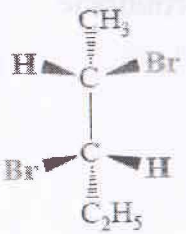
1



2



3

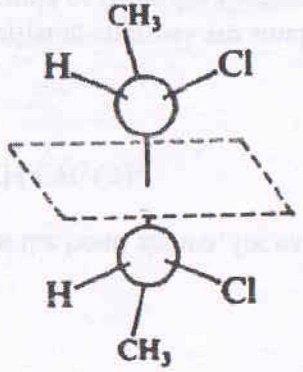


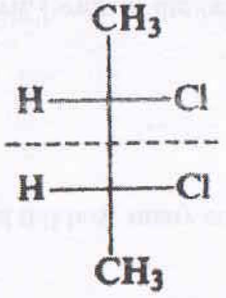
4

Compound 1 is an enantiomer of 2.
Compound 3 is an enantiomer of 4.
Compound 3 is diastereomcr of 1 and of 2.
Compound 4 is a diastereomer of 1, and of 2.

- Diastereomers have similar chemical properties.
- Distereomers have different physical properties:- difrrent melting points, boiling points, solubility, …
- Distereomers can be separated from each other by fractional distillation, fractional crystallization or by chromatography.

- We can regonize the meso structure by the fact that one half of molecue is the mirror image of the other half.

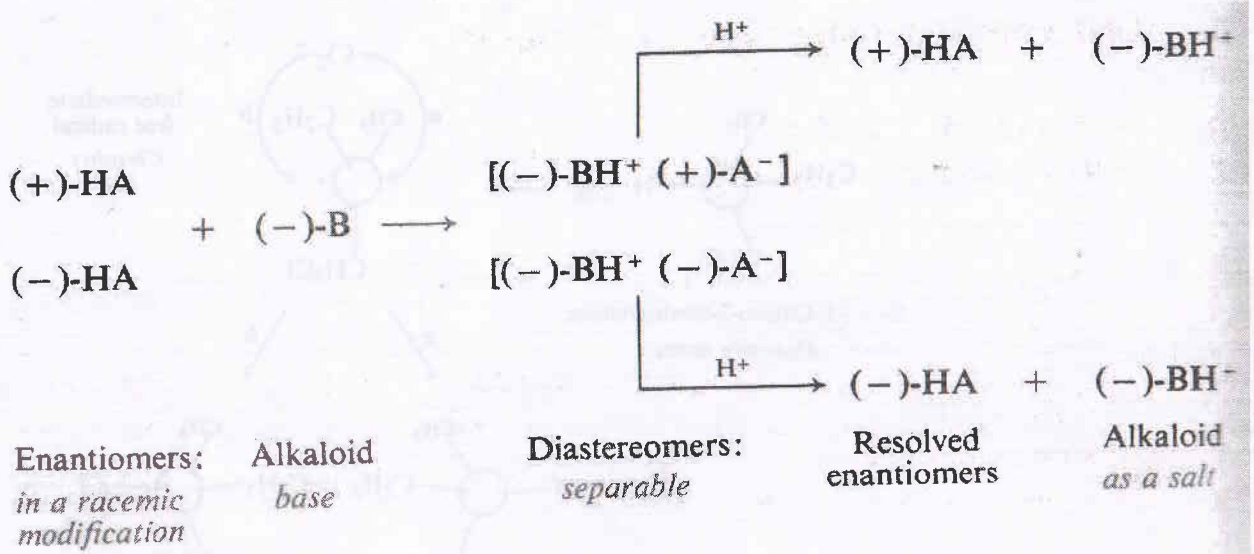




Reactions of chiral molecules with optically active reagents. Resolution of a racemic modification

Resolution of a racemic modification: the separation of a racemic modification into enantiomers.

Reaction of racemic form with a single enantiomer (opticall active reagents) of some other compound changes a racemic form into a mixture of diastereomers; and diasteromers, because they have different melting points, different boiling points, and different solubilities, can be separated by conventional means.



- The majority of resolutions that have been carried out depend upon the reaction of organic bases with organic acids to yield salts. Among the alkaloids commonly used for this purpose are (-)- brucine, (-)-quinine, (-)-strychnine, and (+)-cinchonine.

- Stereoselective reaction: a reaction that yields predominantly one stereoisomer (or one pair of enantiomers) of several diastereomeric possibilities

- stereospecific reaction: A reaction in which stereochemically different reactants give stereochemically different products.

تعریف کنید

- Addition of halide to alkene (stereoselective and stereospecific reaction)

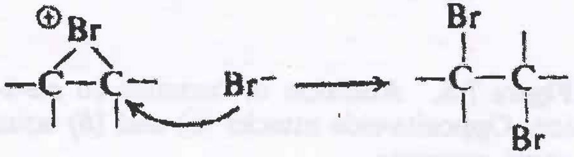
توجه کنید

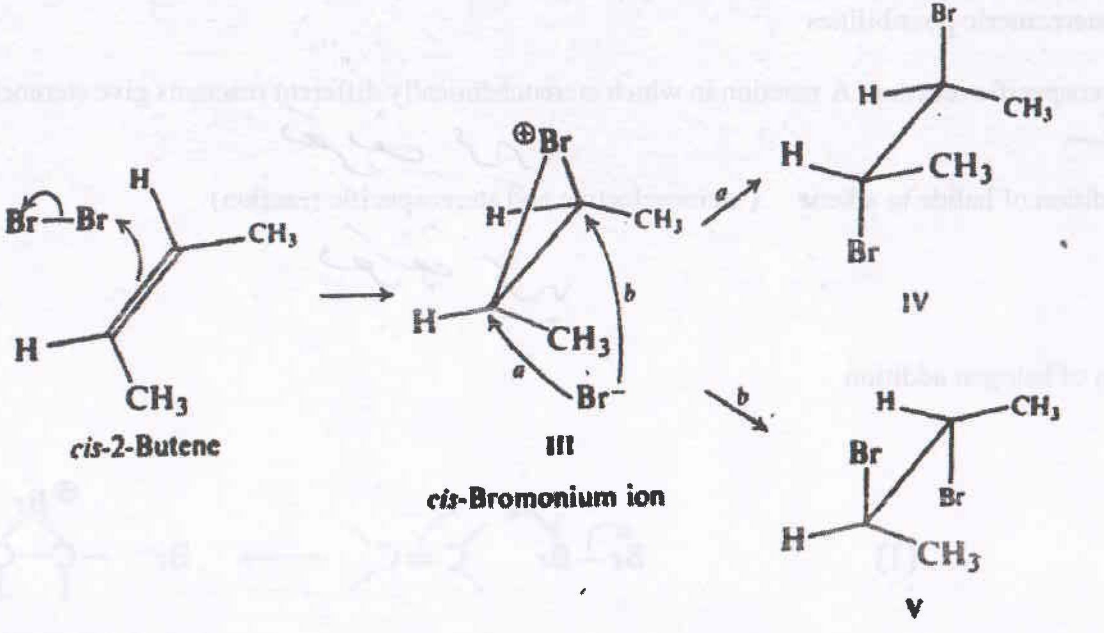
Mechanism of halogen addition

(1)

A bromonium ion

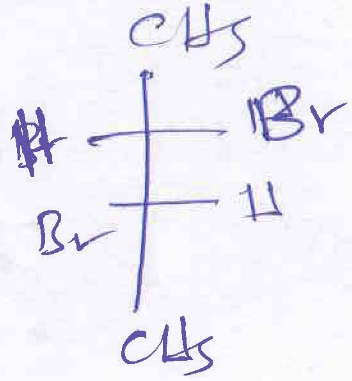
(2)

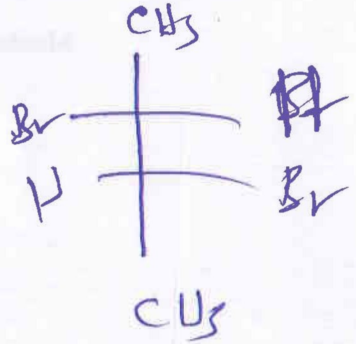




IV *and* V *are enantiomers*
Racemic 2,3-dibromobutane

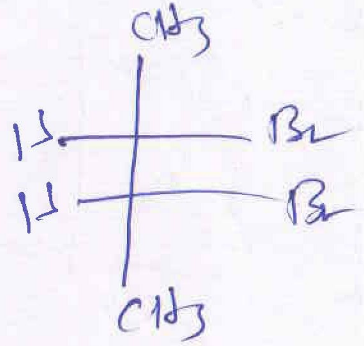
Figure 7.6. Addition of bromine to *cis*-2-butene via cyclic bromonium ion. Opposite-side attacks (*a*) and (*b*) equally likely, give enantiomers in equal amounts.





[illegible] الإسقاط
بصيغة عامة
ثم في أبعاد

28



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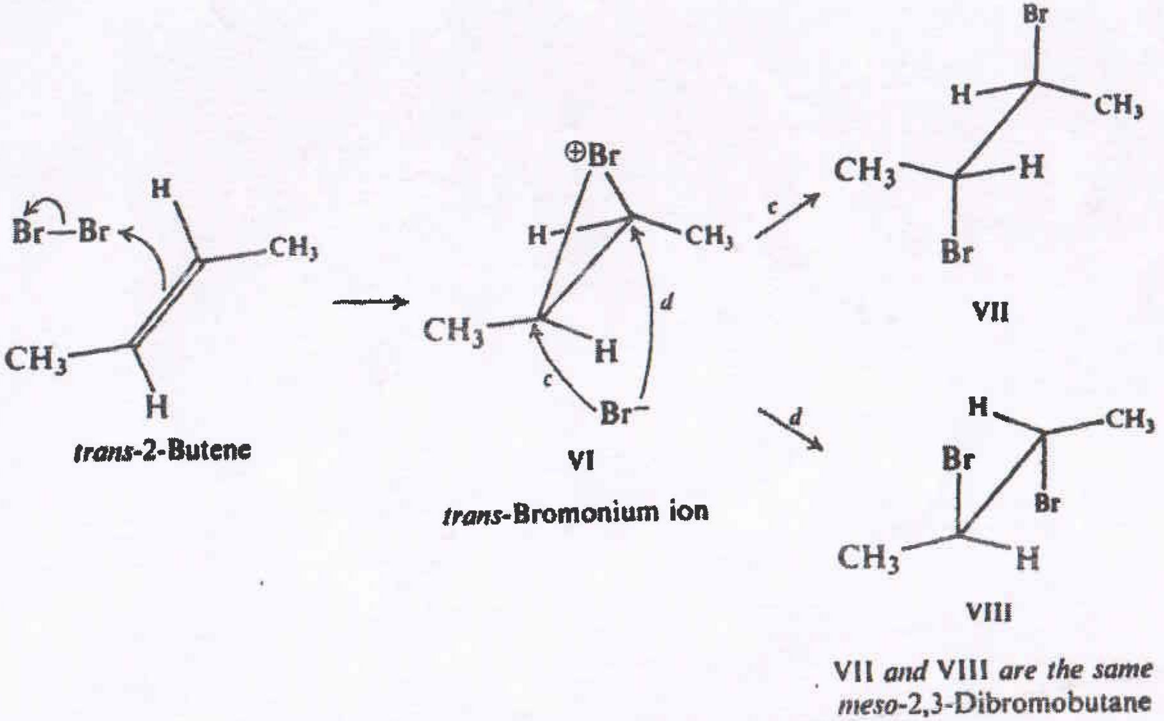

VII and VIII are the same meso-2,3-Dibromobutane

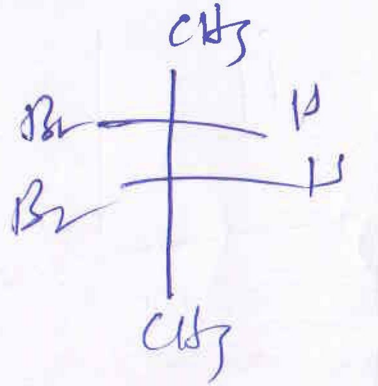

Figure 7.7. Addition of bromine to *trans*-2-butene via cyclic bromonium ion. Opposite-side attacks (*c*) and (*d*) give same product.

29

E,Z وضح العزل لي