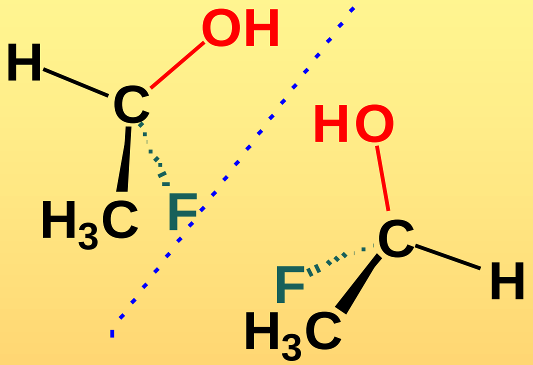
STEREOCHEMISTRY - II

Objective

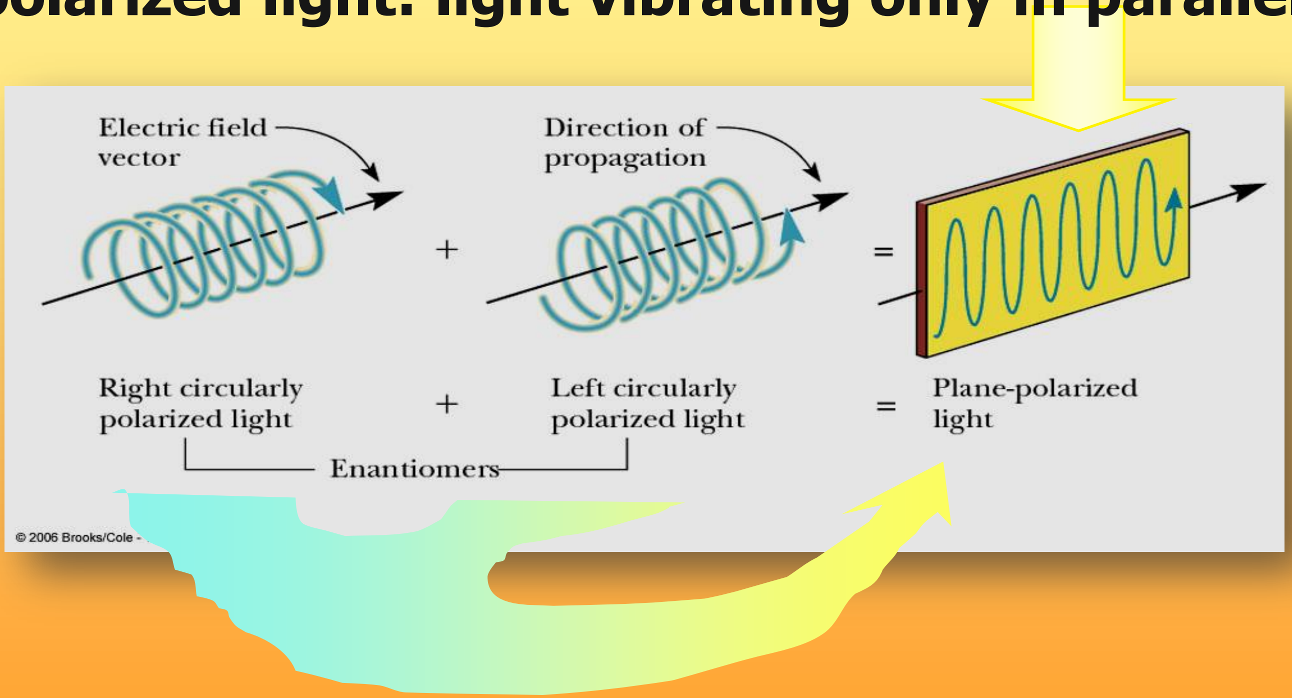


1. Plane polarized light
2. Stereoisomerisms
3. Chirality
4. Naming stereocenters - R/S configuration
5. Molecules with 2 or more stereocenters
6. Optical activity
7. Separation of Enantiomers, Resolution

Plane-Polarized Light

Light vibrating in all planes ⊥ to direction of propagation

Plane-polarized light: light vibrating only in parallel planes

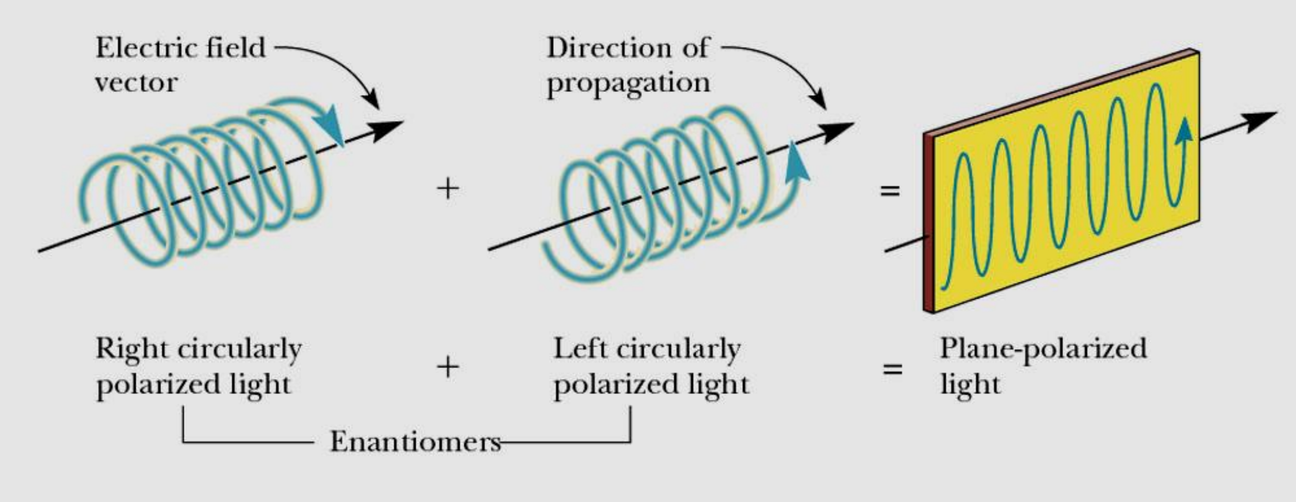


Plane-polarized light the vector sum of left and right circularly polarized light

Optically Activity

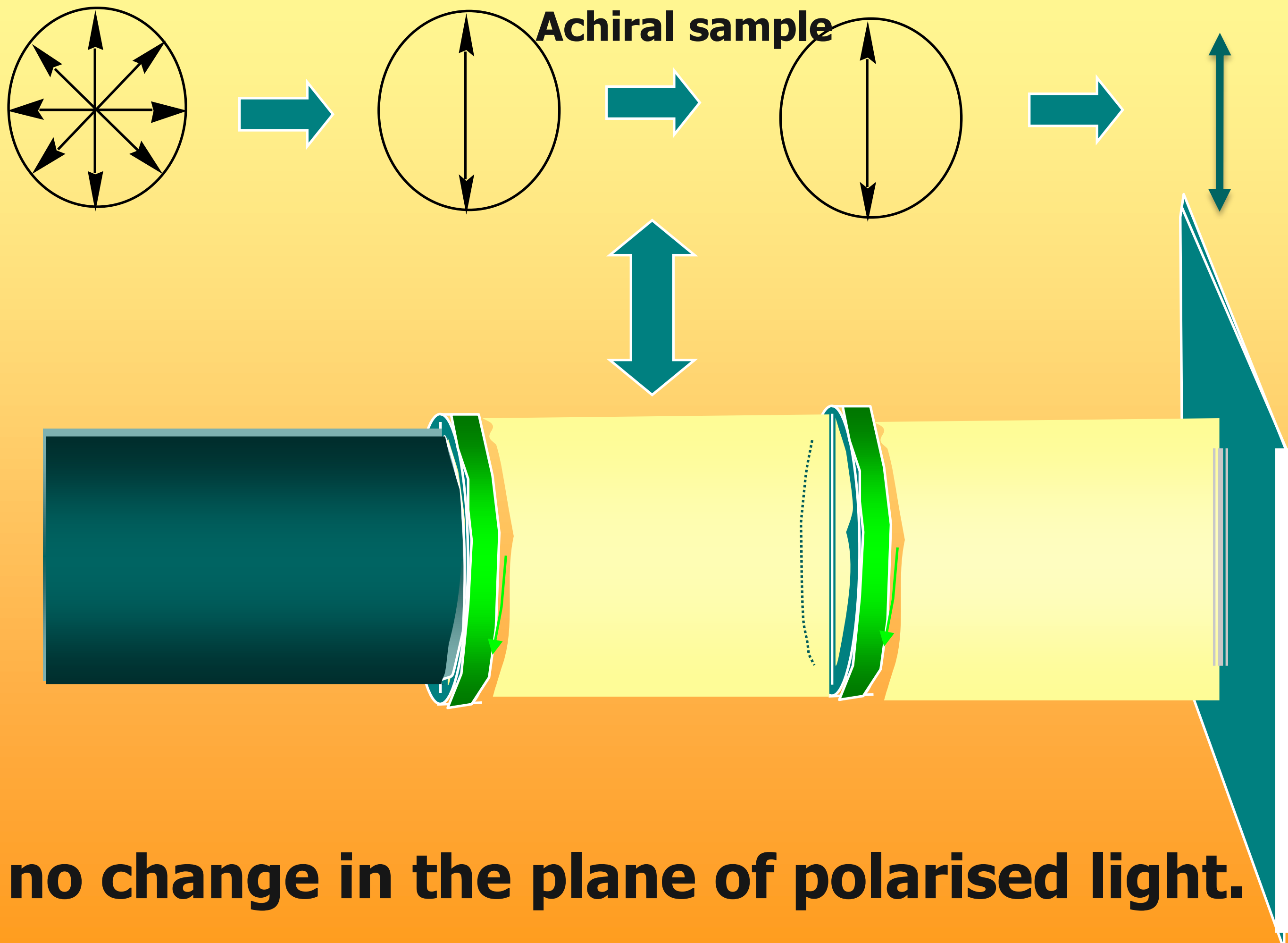
Enantiomers (chiral) interact with circularly polarized light

Rotating the plane one way with R center and opposite way with S.



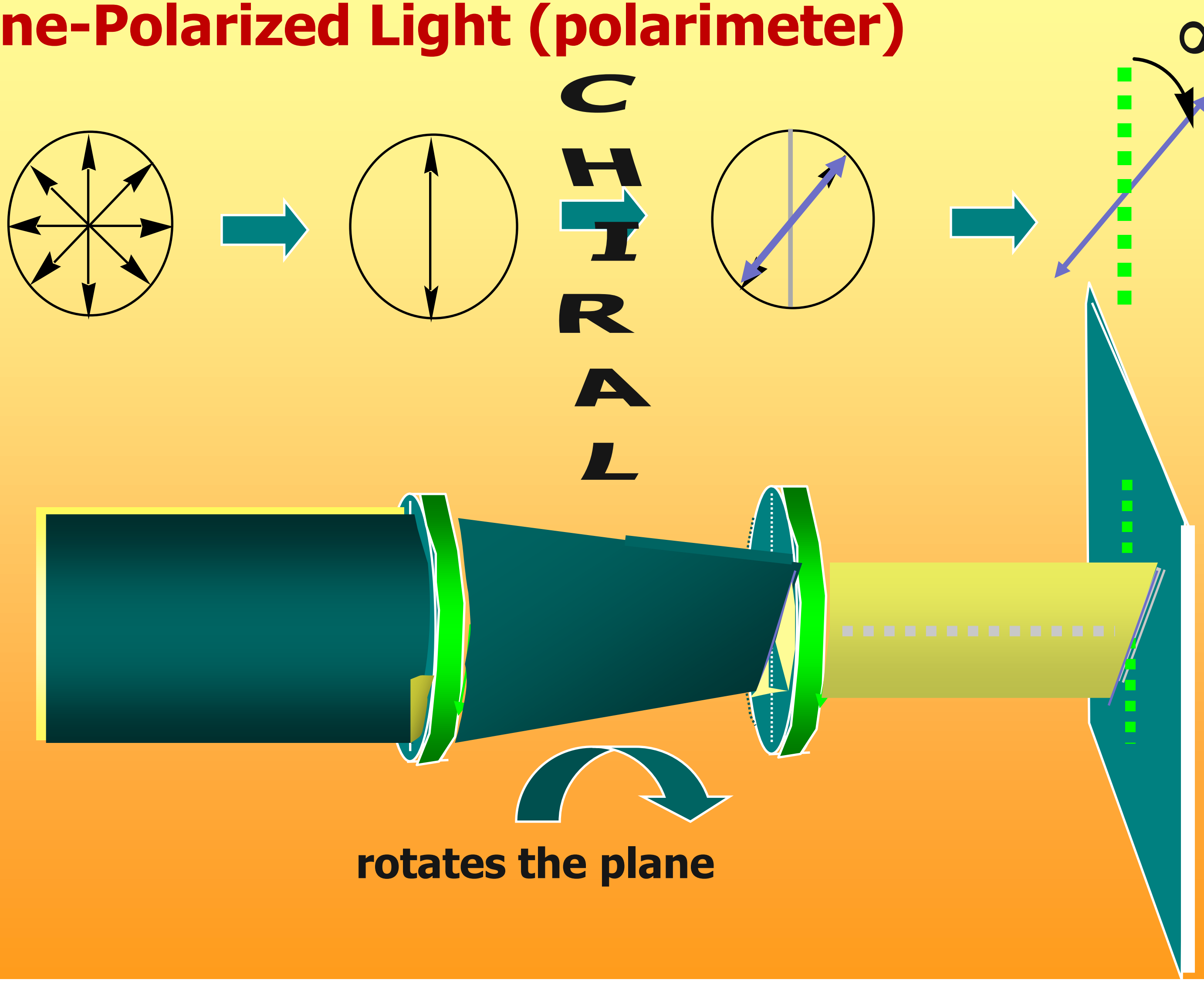
Rotation of plane-polarized light clockwise (+) or counterclockwise (-).

Plane-Polarized Light (polarimeter)



no change in the plane of polarised light.

Plane-Polarized Light (polarimeter)



Specific rotation

$$[\alpha]_D^{t^\circ C} = \frac{\alpha_{obs}}{l \times C}$$

where $\alpha \rightarrow$ **Specific rotation,**

$\alpha_{obs} \rightarrow$ **Observed angle of rotation,**

$l \rightarrow$ **Length of the solution in decimetre,**

$C \rightarrow$ **Concentration of the active compound in grams per millilitre.**

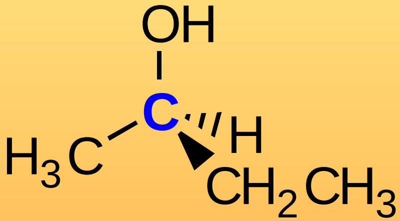
The observed rotation of the plane of polarised light produced by a solution depends on the following.

1. **The amount of substance in tube.**
2. **Length of solution examined.**
3. **Temperature of the experiment.**
4. **Wavelength of light used.**

Chiral Center

Common source of chirality - tetrahedral (sp^3) carbon (atom) – bonded to 4 different groups.

Chiral center - carbon (atom) with 4 different groups, e.g., 2-Butanol - 1 chiral center.



(1)

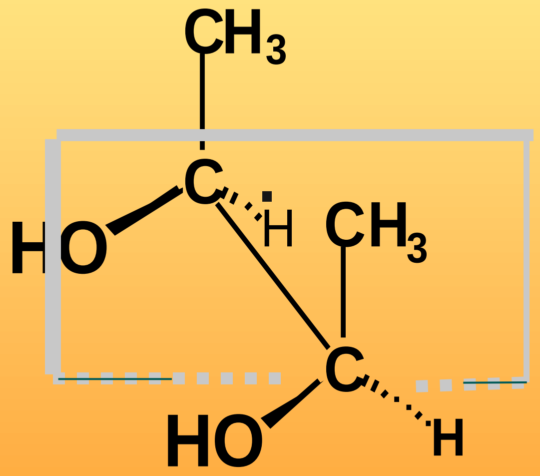
Enantiomers: stereoisomers are nonsuperposable mirror images.

All chiral centers are stereocenters.
Not all stereocenters are chiral centers.

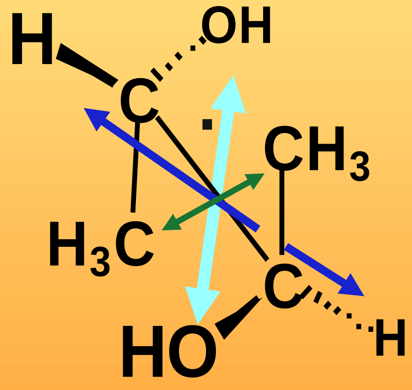
Elements of Symmetry

Conformations of 2,3-butanediol*

syn - plane of symmetry



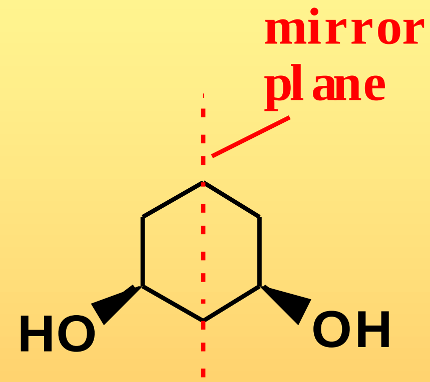
anti - point of symmetry

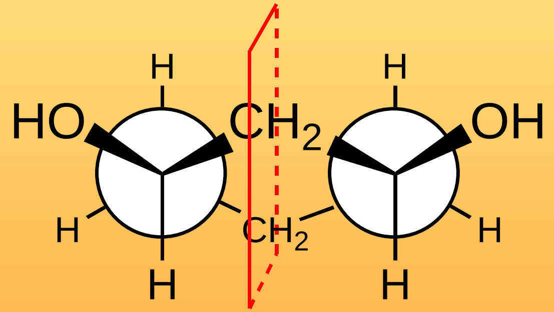


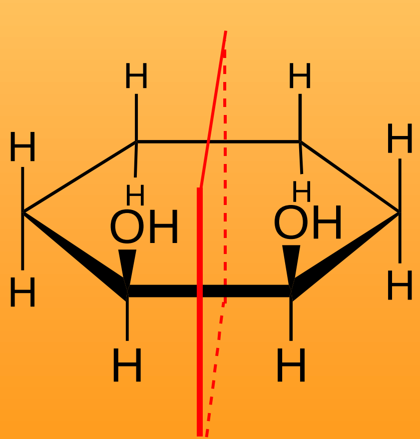
If symmetry is present, the substance is achiral.

Elements of Symmetry

(a) Plane of symmetry







Fischer projection formula

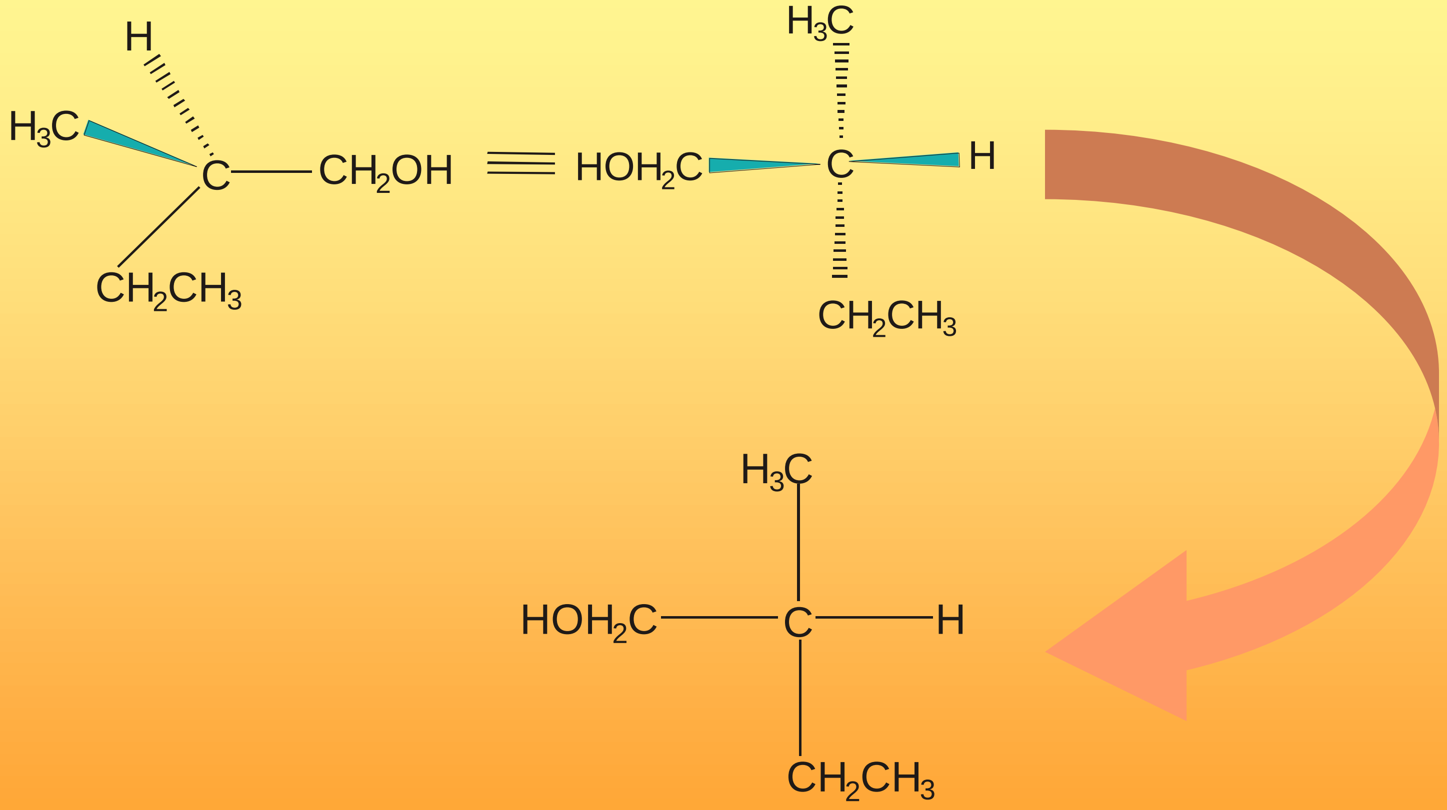
Convenient way to represent the three dimensional structures in two dimensions.

Molecule is drawn in the form of a cross with the chiral carbon at the intersection of the horizontal and vertical lines.

First we orient the molecule in such a way so that the carbon chain is vertical.

The horizontal lines represent the bonds directed towards the viewer, and the vertical lines away from the viewer.

Drawing of Fischer formula



In Fischer projection formula rotation by 180^o in plane of paper is allowed.

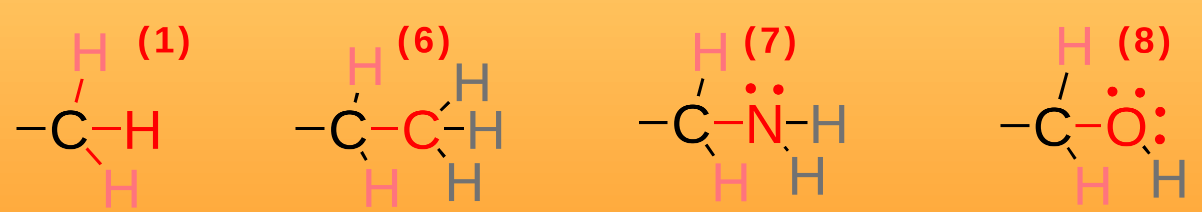
R,S Convention

Each atom bonded to the chiral center assigned a priority by atomic number; higher atomic number, higher the priority.

(1)	(6)	(7)	(8)	(16)	(17)	(35)	(53)
-H	$-CH_3$	$-NH_2$	-OH	-SH	-Cl	-Br	-I

increasing priority →

Same atoms bonded to the chiral center look to the next set of atoms priority assigned to 1st point of difference.

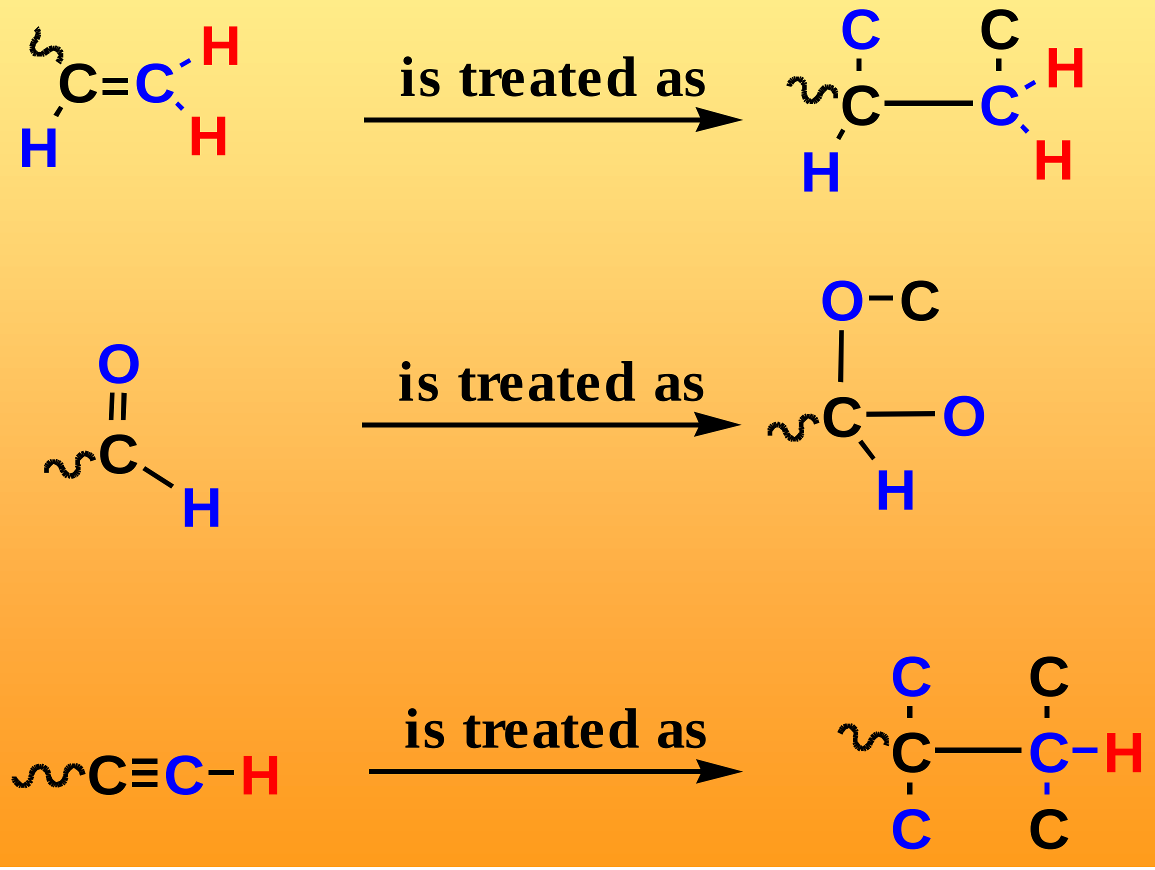


increasing priority →

The isotope with higher mass number is given higher order of precedence.

R,S Convention

Double (triple) bond atoms viewed as bonded to an equivalent number of atoms by single bonds

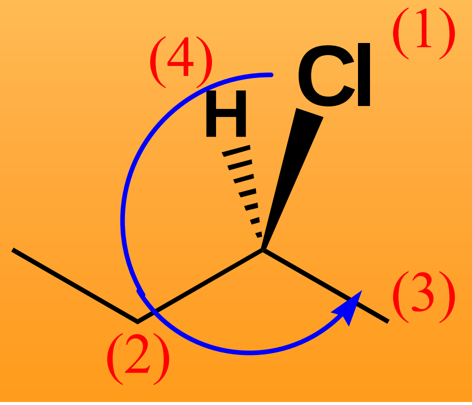


Naming Chiral Centers

1. Locate the chiral center, prioritize four substituents 1 (highest) to 4 (lowest)

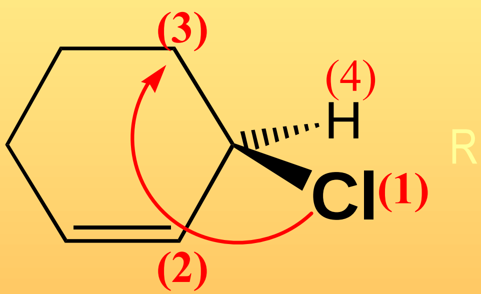
2. Orient molecule so that lowest priority (4) group is directed away (behind)

3. Read three groups toward you (in front) (1) to (3) Clockwise *R* configuration; counterclockwise *S*

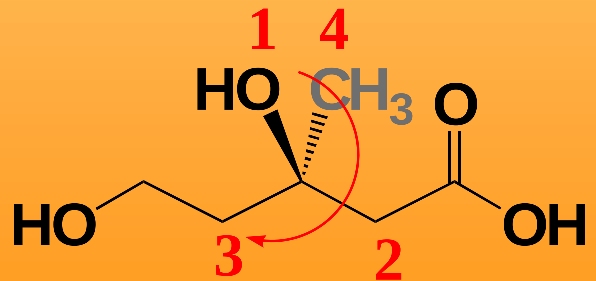


Naming Chiral Centers

(R) -3-Chlorocyclohexene

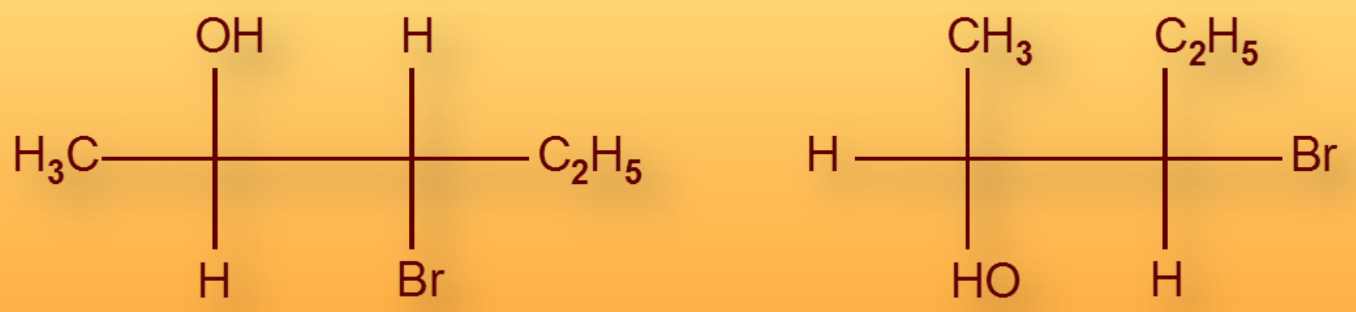


(R)-mevalonic acid



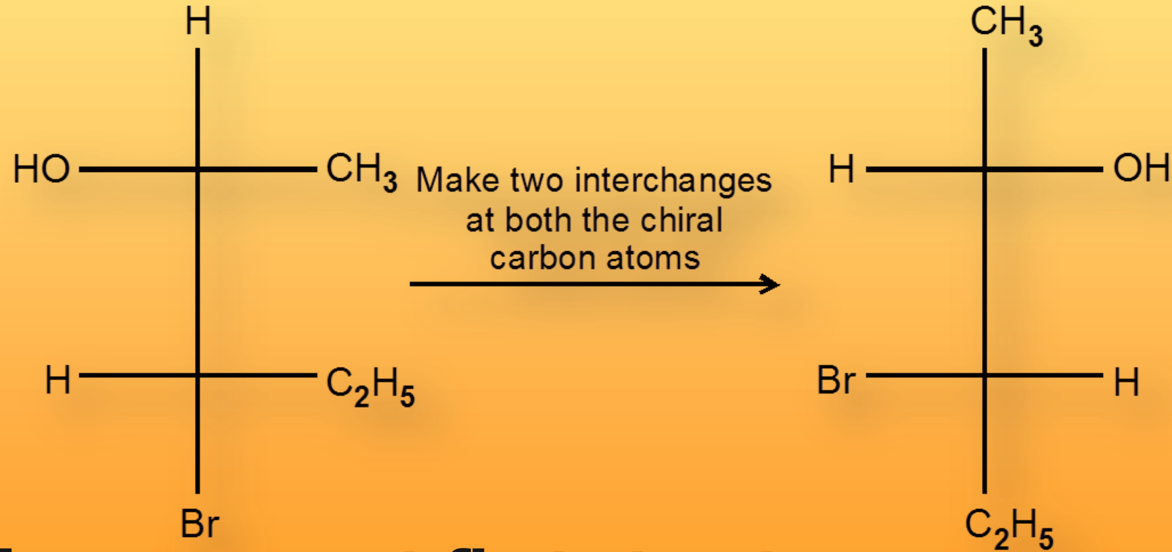
Illustrative Example

What is the relation between the molecules represented by the following two structures?



Solution

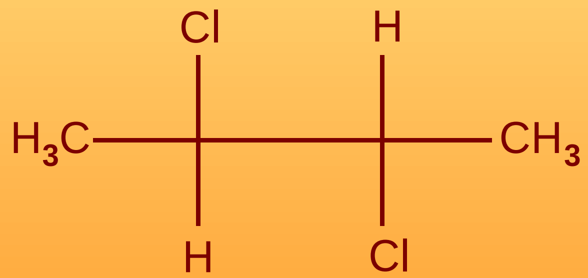
Make two interchanges at each of the two chiral carbon atoms in second structure in such a way that CH_3 — group is held vertically upward and C_2H_5 — group vertically downward.



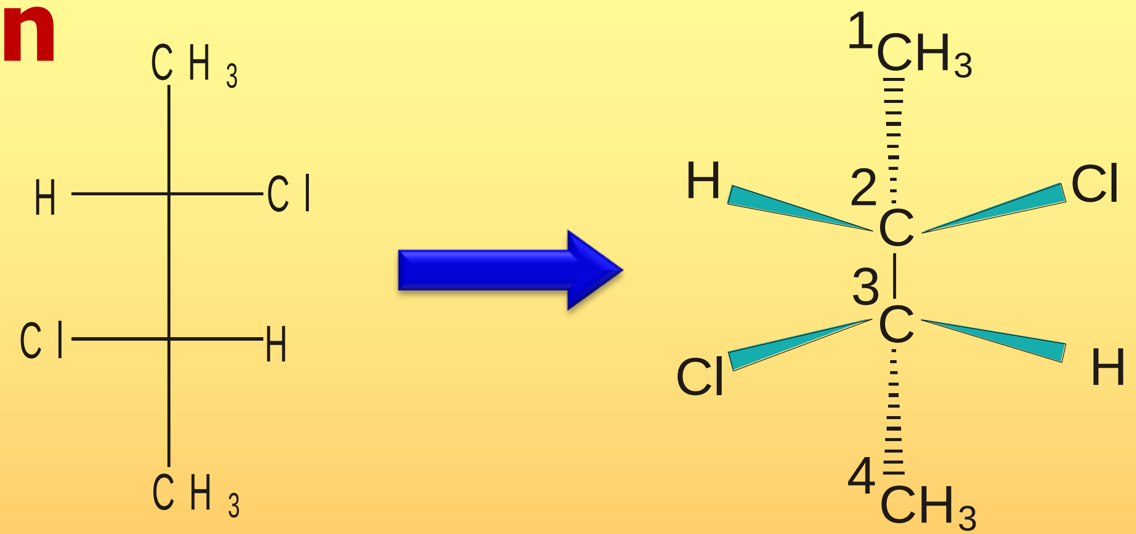
By doing so we get first structure.
Thus, the two structures are identical.

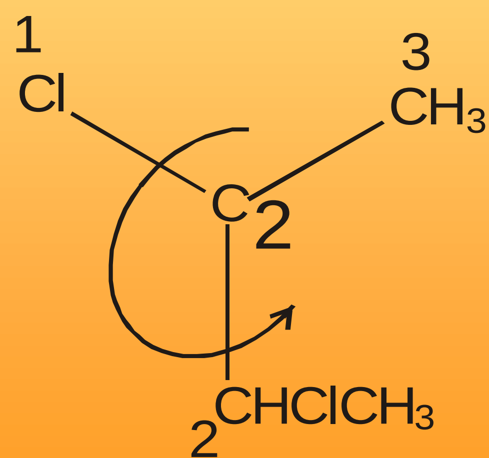
Illustrative Example

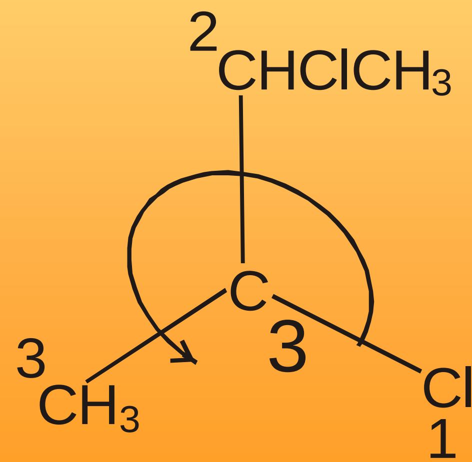
Write the R, S configuration of the following compound.



Solution





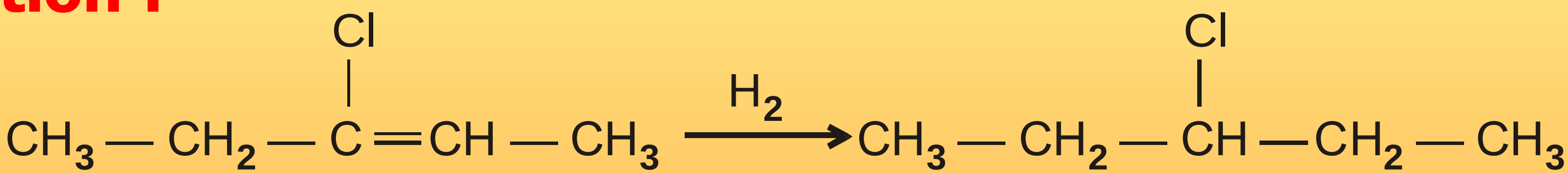


So configuration is 2S, 3S.

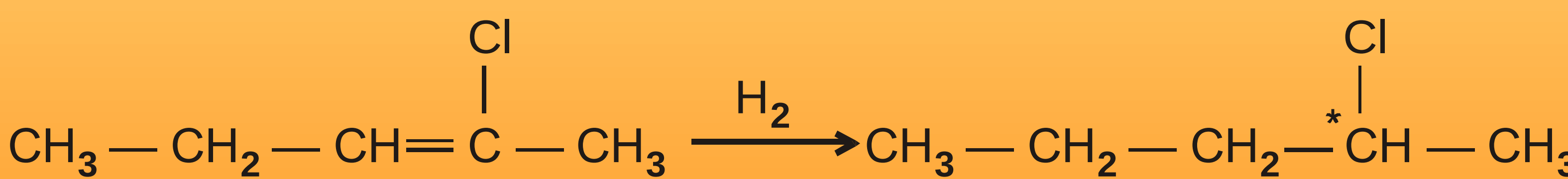
Illustrative Example

Two isomeric alkenes A and B having molecular formula C_5H_9Cl on adding H_2, A gives optically inactive compound, while B gives a chiral compound. What are the two isomers?

Solution :



3-chloro-2-pentene (A) Optically inactive

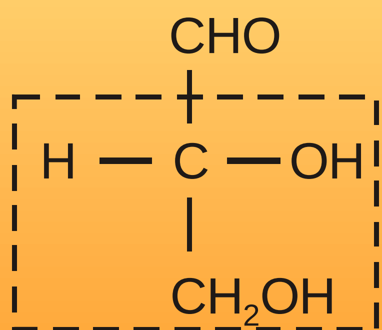


2-chloro-2-pentene (B) Optically active

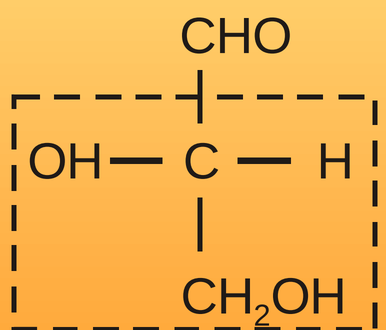
Therefore A is 3-chloro-2-pentene, B is 2-chloro-2-pentene.

D and L system

This system has been used to specify the configuration at the asymmetric carbon atom. In this system, the configuration of an enantiomer is related to the two forms of glyceraldehyde were arbitrarily assigned the absolute configuration.

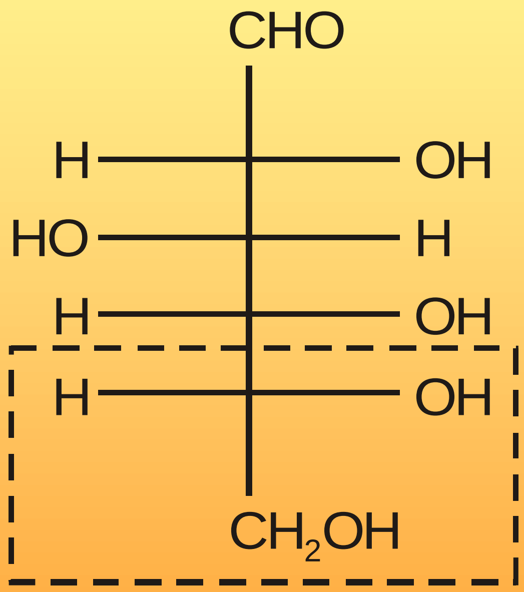


(+) - glyceralodehyde
D Configuration

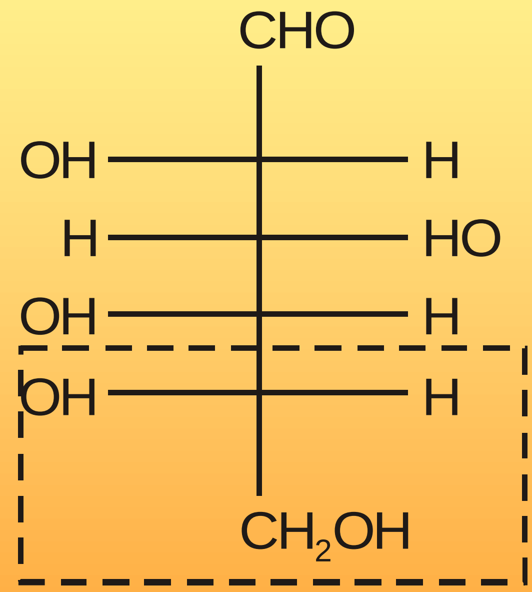


(–) - glyceralodehyde
L Configuration

D and L system

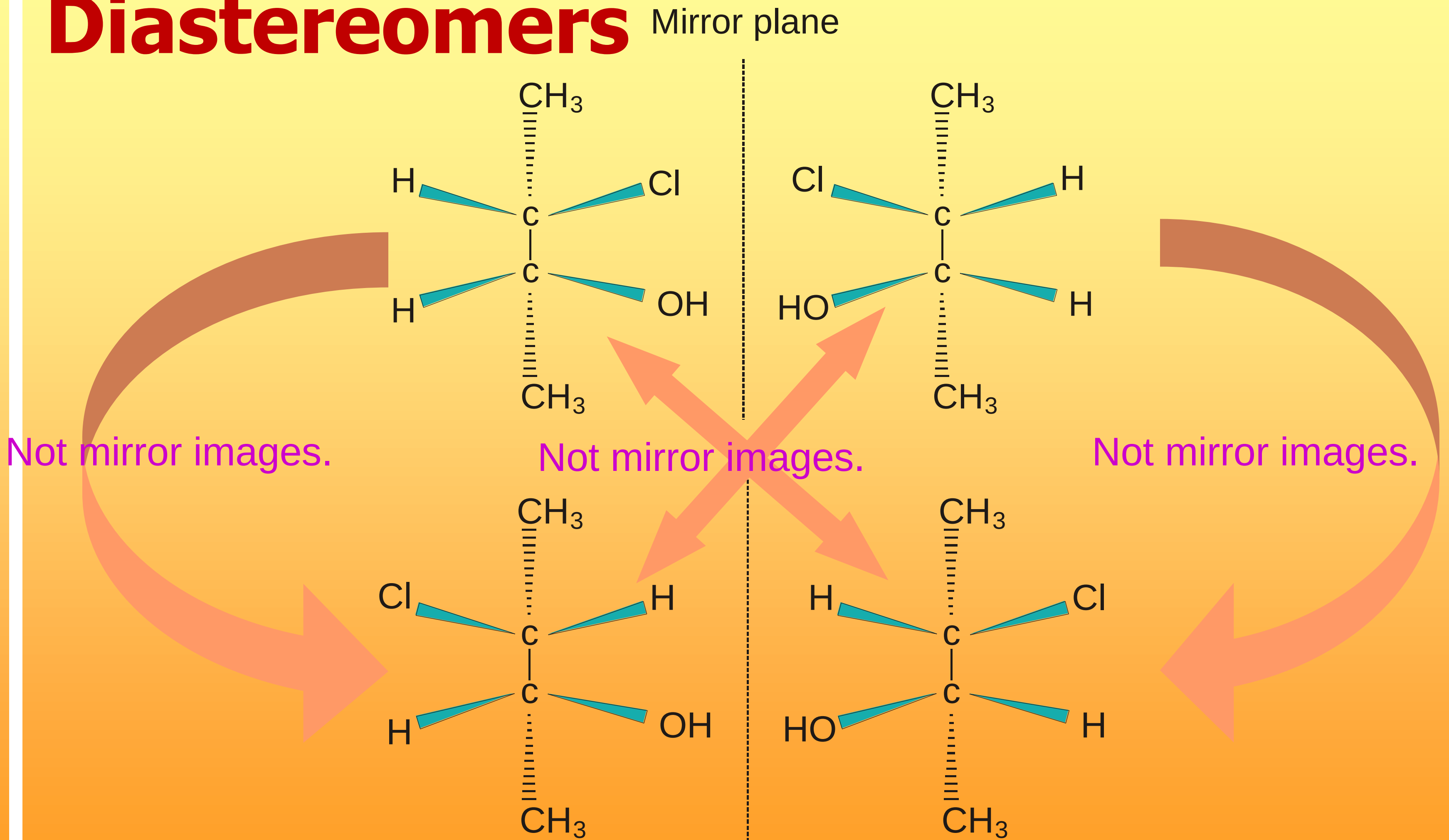


D - (+) - glucose



L - (–) - glucose

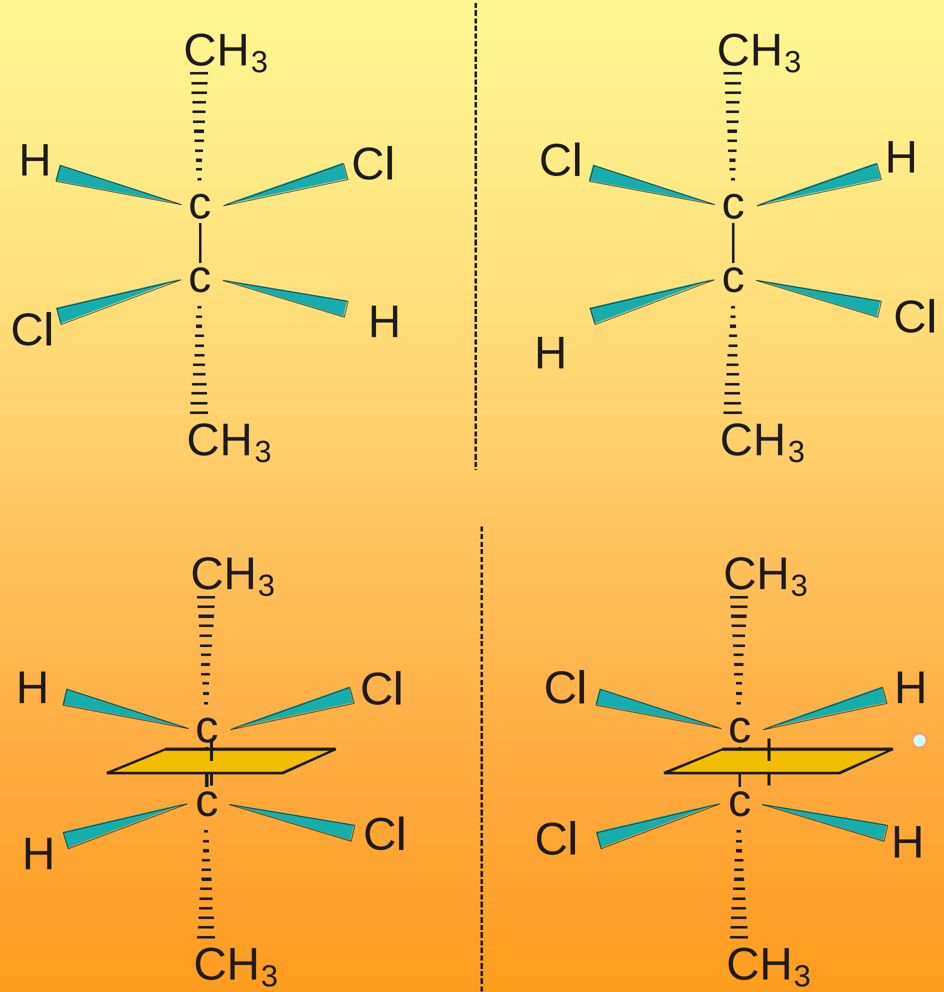
Diastereomers



Diastereomers: different physical properties

Meso-compounds

Mirror plane



Plane of symmetry

Same molecule,
Optically inactive.

Illustrative Example

What is the relationship between the molecule given below?

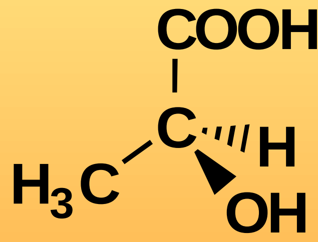
Solution :

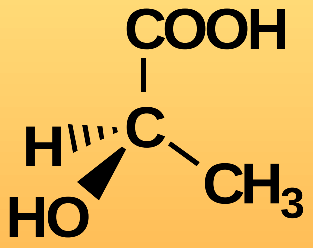
The two compounds are identical since they have a plane of symmetry.

Racemic mixture

equal amounts of (+) and (-) enantiomers - rotation is 0

$[\alpha]_D^{21} = +2.6°$





$[\alpha]_D^{21} = -2.6°$

Net rotation is zero.

Composition of a mixture of Enantiomers

$$\text{optical purity \%} = \frac{[\alpha]_{sample}}{[\alpha]_{pure\ enantiomer}} \text{ x } 100$$

enantiomeric excess (ee):

Difference between the percent of 2 enantiomers in a mixture.

$$\text{Enantiomeric excess} = \frac{[R]-[S]}{[R]+[S]} \times 100$$

Illustrative Example

(+)-Mandelic acid has a specific rotation of +158°. What would be the observed specific rotation of a mixture of 25% (–)-mandelic acid and 75% (+)-mandelic acid?

Solution :

Specific rotation of the mixture

$$=\left(\frac{75}{100}\right)\left(+158^\circ\right)+\left(\frac{25}{100}\right)\left(-158^\circ\right)$$

$$= +79^\circ$$

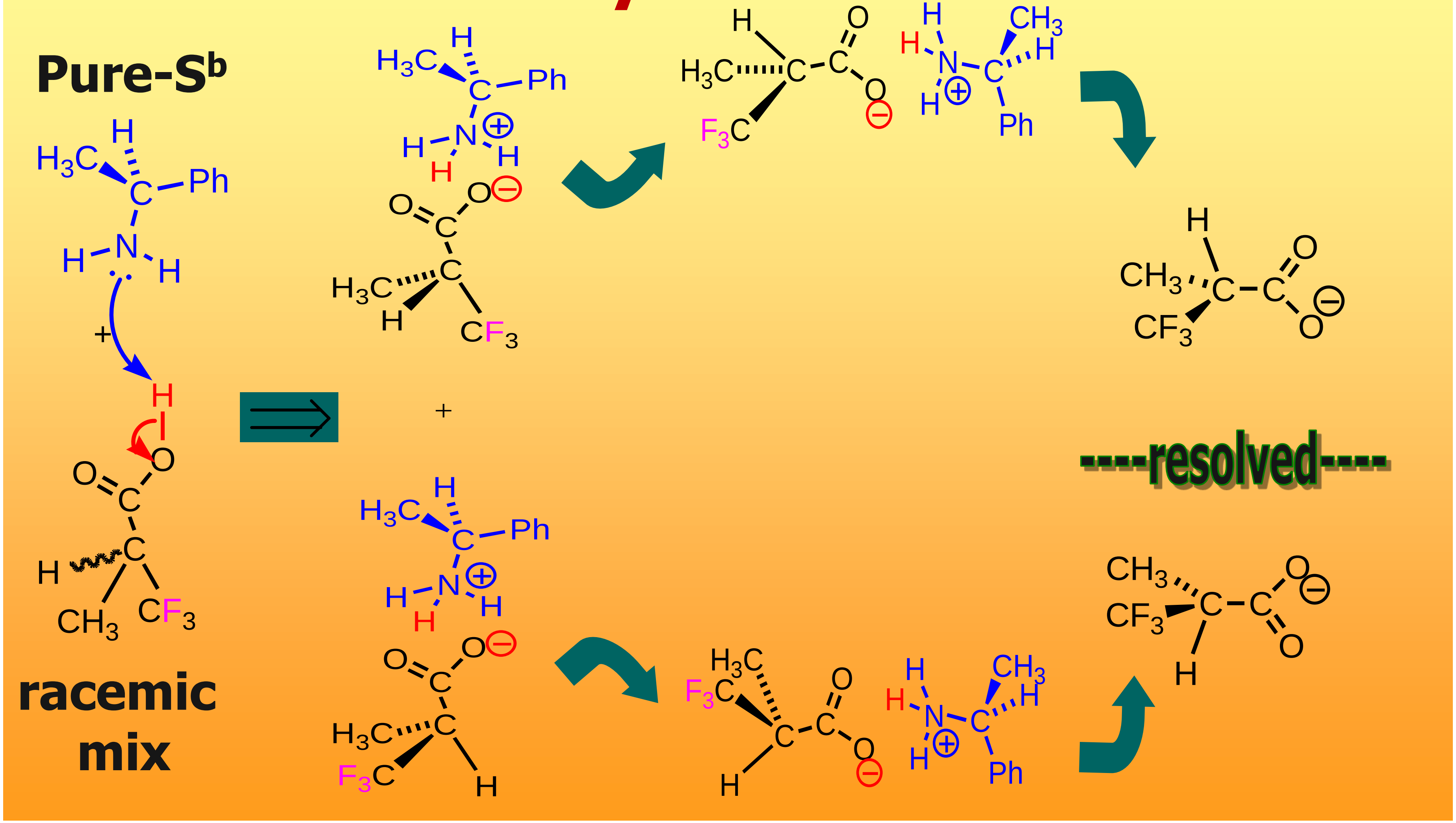
Resolution of racemic mixture

(a)One strategy: convert enantiomeric pair into 2 diastereomers.

diastereomers - different compounds, different physical properties.

- separate <u>diastereomers</u>
- remove reagent
- leaves pure enantiomers

Resolution by acid-base reactions



Illustrative Example

How (+) and (–) lactic acid can be separated?

Solution :

(+) and (–) lactic acid on treatment with an optically active base such as (+) or (–) brucine to form diastereomers which have different-melting /boiling point and solubilities and hence can be separated.

Thanks…