# ORGANIC CHEMISTRY - III

## UNIT 1 NOTES

### STEREOISOMERISM

- STEREOISOMERISM
- OPTICAL ISOMERISM
- DL AND RS SYSTEM
- REACTION OF CHIRAL MOLECULES
- ASYMMETRIC SYNTHETIS

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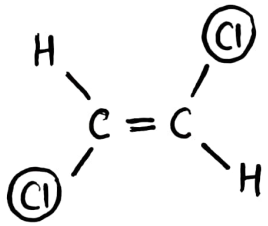
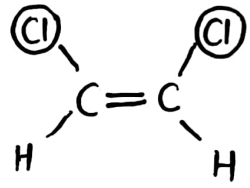
# STEREOISOMERISM

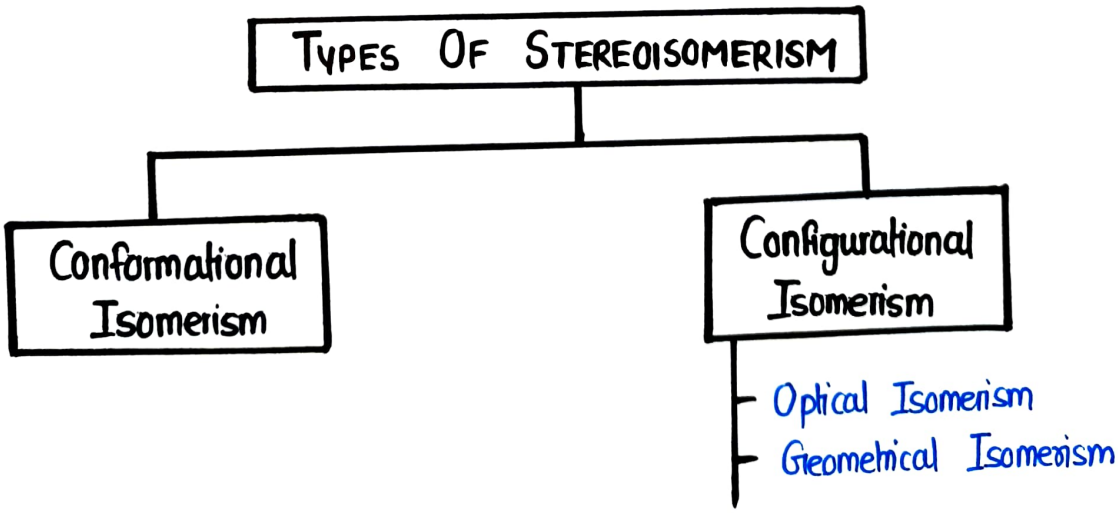
- The Branch of Chemistry dealing with structure of three dimensional molecules is known as **Stereochemistry**.
- The phenomenon of isomerism caused by different arrangement of atoms or groups in space is known as **Stereoisomerism**, and the compounds showing phenomenon is known as **Stereoisomers**.
- These molecules have same structural as well as molecular formulas, but their atomic arrangement is different.




trans 1,2 - dichloroethane




cis - 1,2, dichloroethane

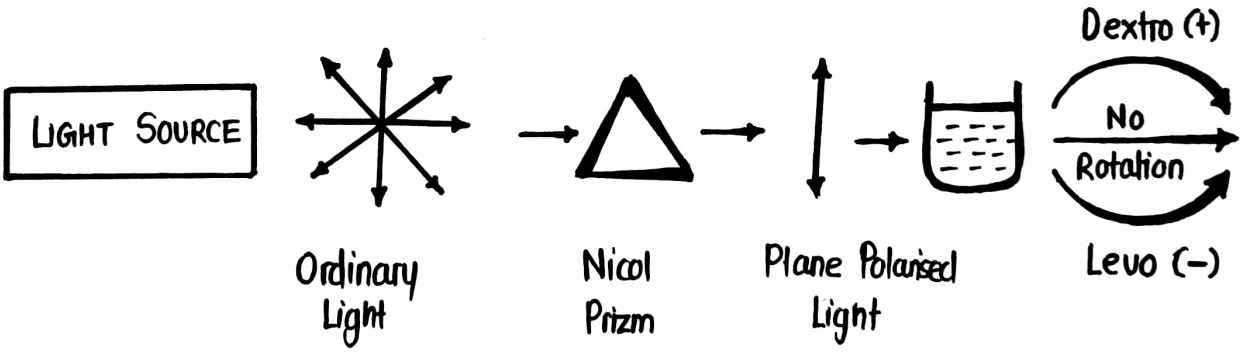


# Optical Isomerism

- Optical Isomerism is a type of stereoisomerism in which molecules have the same molecular and structural formula but differ in the way they interact with plane-polarised light.
- They are also known as Enantiomers.

## Optical Activity

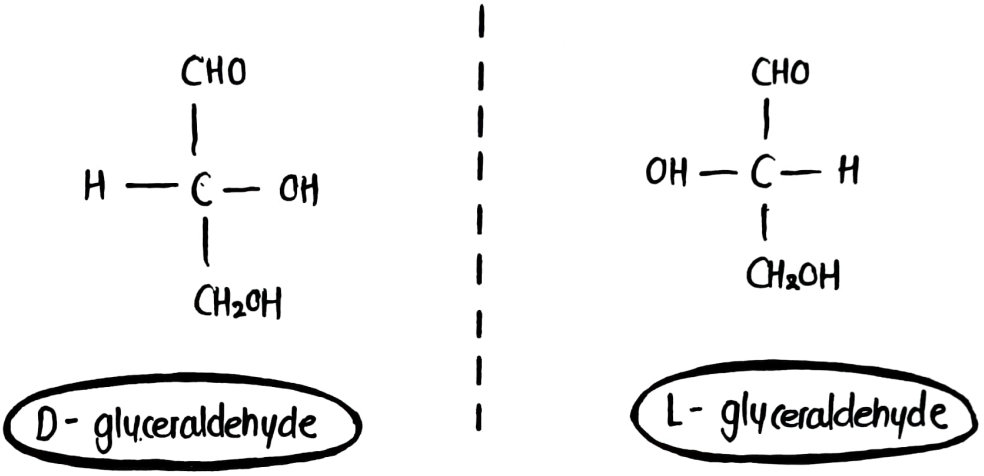
- When a plane polarised light is passed through an Optically Active substance then it rotates the light in Clockwise or Anticlockwise direction and this phenomenon is known as Optical Rotation.
- The compounds showing Optical Activity are known as Optically Active Compounds.




- Now, if the compound rotates the light in Clockwise direction, then it is said to be Dextrorotatory (+)
- If the compound rotates the light in Anticlockwise direction, then it is said to be Levorotatory (−)
- If the light passes undeviatedly, then compound is Optically Inactive.

# ENANTIOMERISM

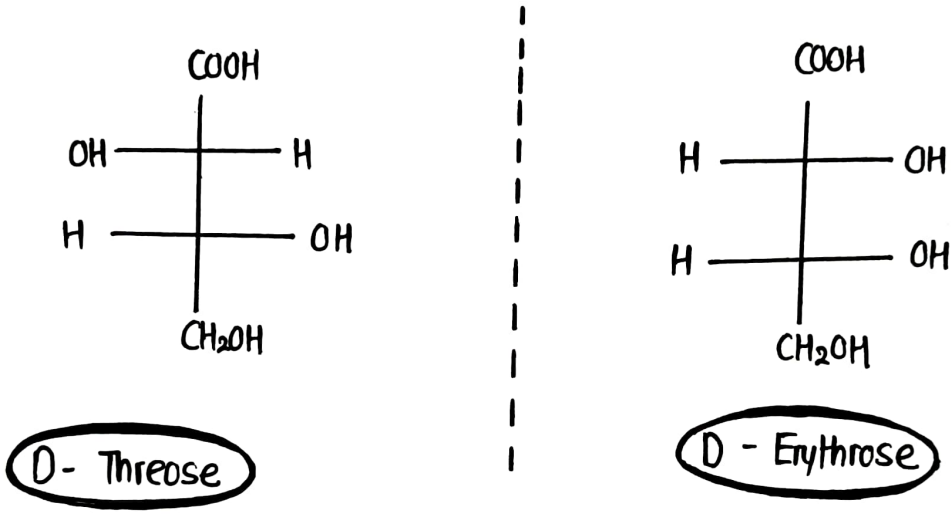
- Enantiomerism is nothing but Optical Isomerism
- Enantioisomerism is a form of Stereoisomerism in which molecules exist as non- superimposable mirror images of each other.
- These mirror image isomers are called Enantiomers.




- Now, If the compound showing enantiomerism rotates the plane polarised light in clockwise direction, then it is said to be Dextrorotatory (+).
- And if in anticlockwise direction, then it is said to be Levorotatory (-).

# DIASTEREOISOMERISM

- Diastereoisomerism is a type of Stereoisomerism where isomers have same molecular formula and connectivity of atoms but are not mirror images of each other and not superimposable.
- Unlike, Enantiomers, diastereoisomers do not have identical physical or chemical properties and often exhibit different melting points, boiling points and reactivity.

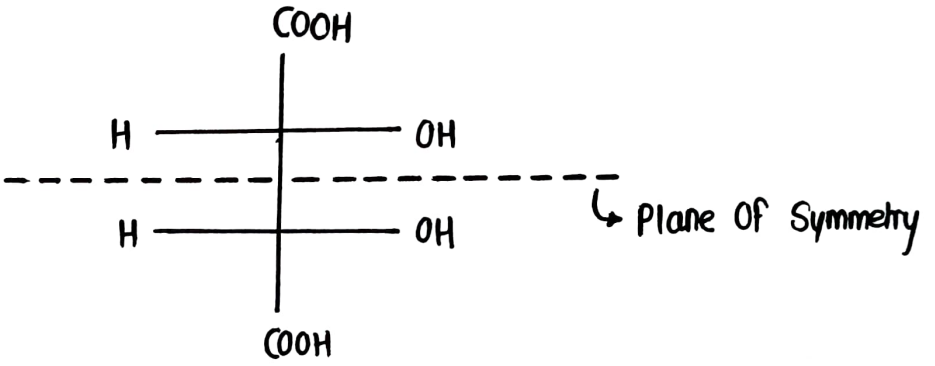



## DIFFERENCE BETWEEN ENANTIOMERS & DIASTEREOISOMERS

| PARAMETER | ENANTIOMER | DIASTEREOMER |
|---|---|---|
| • Number of Chiral Centres | One | Two or More |
| • Mirror Images | Yes | No |
| • Superimposition | No | No |
| • Physical Properties | Same | Different |
| • Chemical Properties | Same | Different |

# Meso Compound

- A Meso compound is a stereoisomer that contains two or more chiral centers but is optically inactive due to an internal plane of symmetry.
- A meso compound can be divided into two symmetrical halves, making one half a mirror image of other.
- This symmetry causes the molecule to exhibit internal compensation, meaning that the optical rotation of chiral centres cancel each other out.




Tartaric Acid (Meso Form)

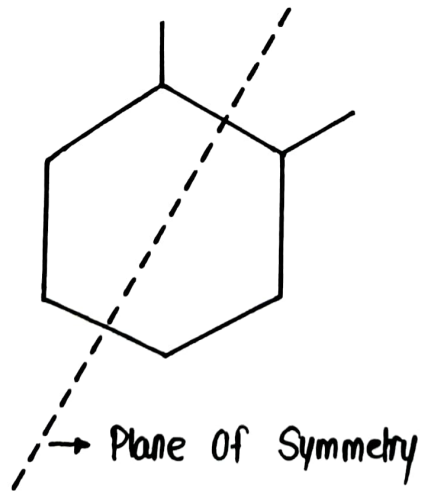
# Elements Of Symmetry

- Elements of symmetry refers to the geometric transformations in which you can move or change the position or shape of of an object so that it still look the same.
- If certain symmetry elements are present, the molecule cannot show Optical Isomerism.
- The ~~th~~ key symmetry elements are:

① Plane of Symmetry
② Centre of Symmetry
③ Axis of Symmetry

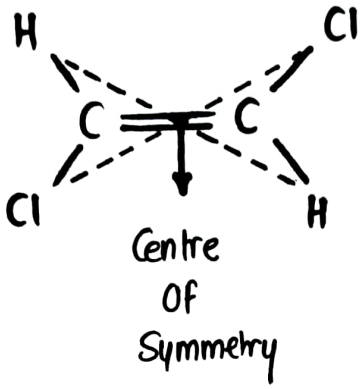
## ① Plane Of Symmetry

- A Plane of symmetry is an imaginary flat line that divides a molecule or object into two mirror-images halves.
- If you fold the object along this plane, both sides would match perfectly.
- In optical Isomerism, if a molecule has a plane of symmetry. it means the molecule is achiral.



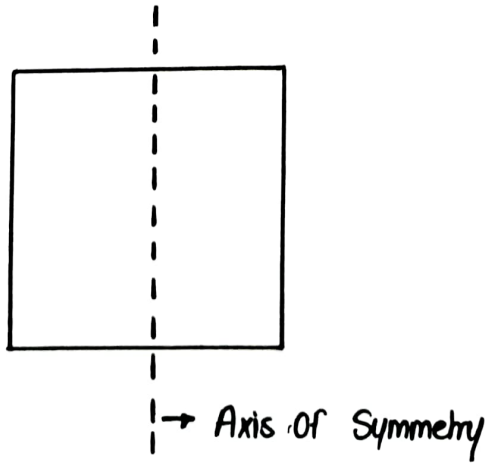
## ② Centre Of Symmetry

- A Centre of Symmetry (also known as Point of Symmetry) is a point in a molecule or object where every part has an identical counterpart in the opposite direction at the same distance.
- If a molecule has centre of symmetry it cannot be chiral.




## ③ Axis Of Symmetry

An Axis of symmetry is an imaginary line around which an object or molecule can be rotated by a certain angle and it still looks the same.



## Chiral Molecules

- A molecule is Chiral if it cannot be superimposed on its mirror image - just like left and right hands.
- These molecules lack a plane of symmetry and usually have a Chiral Centre (a carbon atom bonded to 4 ~~carbon~~ different groups)
- These molecules are Optically Active

## Achiral Molecules

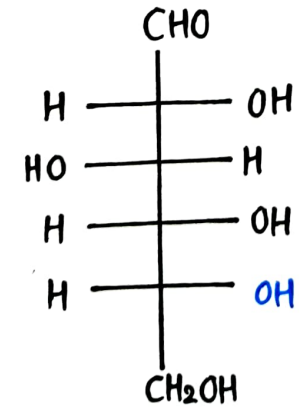
- A molecule is achiral if it can be superimposed on its mirror image.
- These molecules have a plane of symmetry or centre of symmetry making them Optically Inactive.

# DL System Of Nomenclature

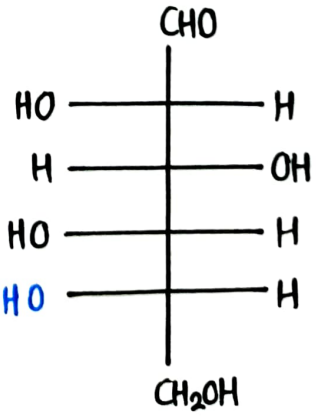
The DL System of Nomenclature is a way to designate the configuration of chiral molecules, particularly amino acids and sugars. based on their similarity to the reference molecule glyceraldehyde.

## Rules For DL System

- Draw the Fischer Projection for the given molecule.
- Arrange the molecules so that the most oxidised group is at the top.
- Now look at the last chiral (asymmetric) carbon in the chain.
- Now check the position of OH, $NH_2$ groups
- If the -OH group on the last chiral carbon is on the RIGHT, the molecule is in the D- configuration.
- If the -OH group is on the LEFT, the molecule is in the L- configuration.




D - Glucose




L- Glucose

## Example

- D- Glucose : The -OH on the last chiral carbon is on right.
- L- Glucose : The -OH on the last chiral carbon is on left.

## Key Features

- It does not correspond to optical activity (+ or -)
- Some D compounds are dextrorotatory (+) & some are levorotatory (-).
- Example : D-glucose is (+) but D- fructose is (-)

## Important Note

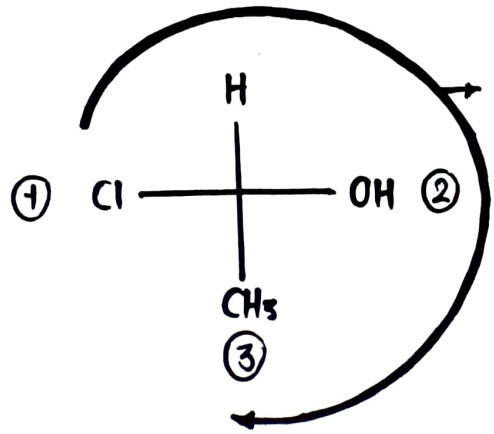
- DL System basically a Relative Configuration.
- The D/L system is an important convention in Organic Chemistry, especially for naming sugars and amino acids, but it is now often replaced by R/S system in modern chemistry.

# RS System Of Nomenclature

- The R/S system is a modern and systematic way of naming chiral molecules based on spatial arrangement of atoms around a chiral centre.
- It was developed by Cahn, Ingold and Prelog and is used to determine the absolute configuration of Chiral Molecules.
- Unlike the D/L system, which is specific to sugars & amino acids, the R/S system can be applied to all chiral compounds.

## Rules For R/S System

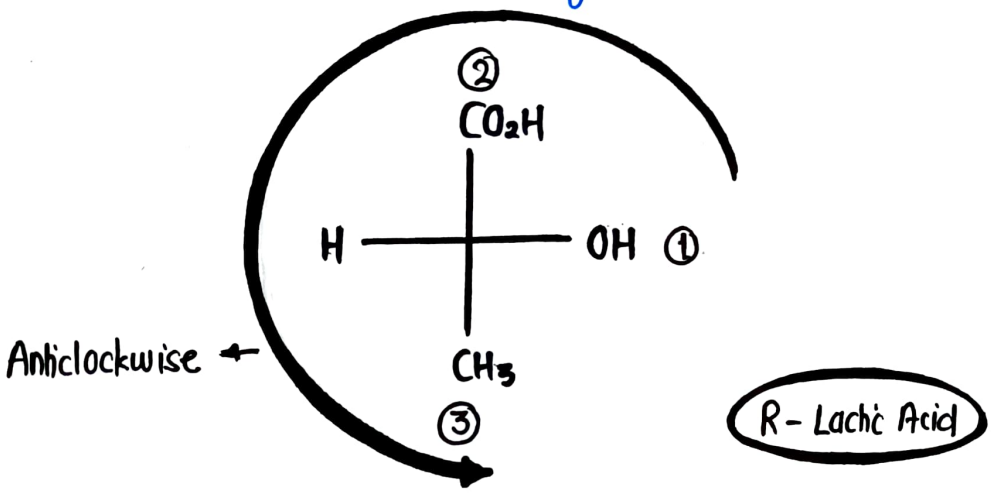
- Identify the Chiral Center.
- Assigned priorities based on atomic number.
- The higher the atomic number, the higher the priority.
- Example: Br > Cl > O > N > C > H.
- If the first atom in the two groups is the same, look at the next atom in the chain until a difference is found.
- Double bond or triple bond is treated as if the atom is duplicated or triplicated.
- The lowest priority group should be on vertical line.
- Draw a curved arrow from priority 1 → 2 → 3.
- If the arrow moves clockwise, the configuration is R (Rectus).
- If the arrow moves anticlockwise, the configuration is S (Sinister).




(R)- 2-Chlorobutanol

## Special Cases

- If the lowest priority group lies on horizontal plane instead of Vertical then whatever configuration comes, just reverse it.
  - If rotation appears R, assign S
  - If rotation appears S, assign R




## Importance Of RS System

- It is a universal system that applies to all chiral molecules not just biomolecules.
- It provides an absolute configuration rather than a relative one.

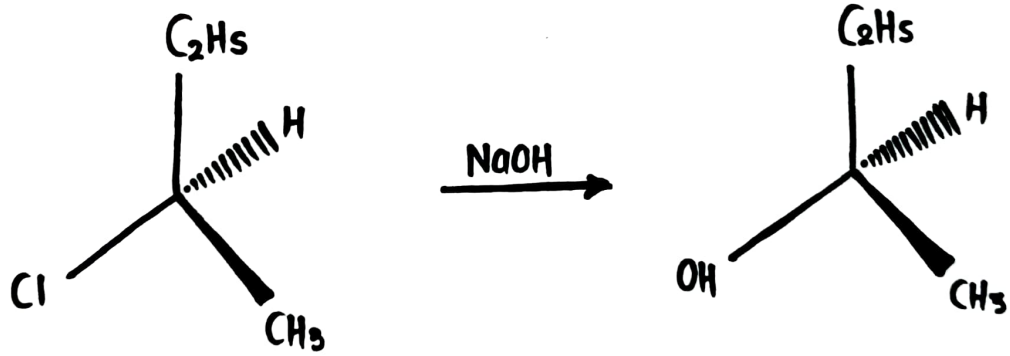
# REACTIONS OF CHIRAL MOLECULES

- Chiral molecules can undergo various chemical reactions, often leading to products with specific stereochemistry.
- Chiral Molecules generally give 3 types of chemical reactions.

① Retention
② Inversion
③ Racemization

## ① RETENTION

Retention reaction refers to a reaction where the configuration (R or S) of chiral centre remains the same after the reaction. means stereochemistry of chiral molecule is retained.

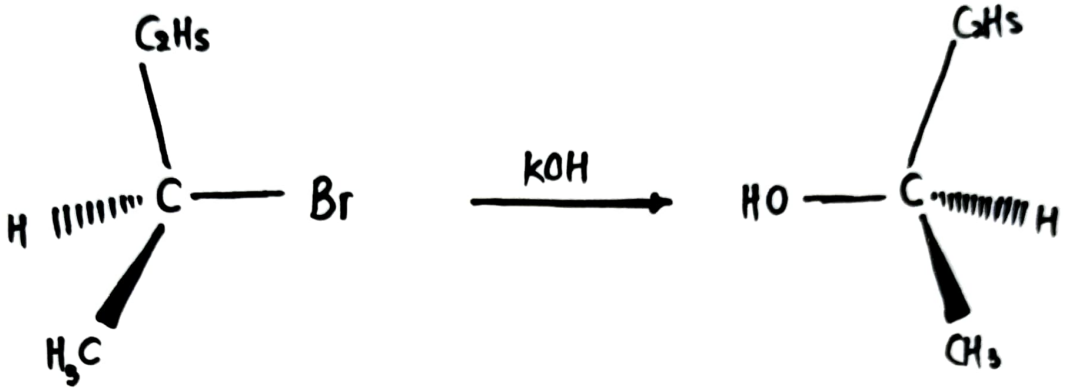


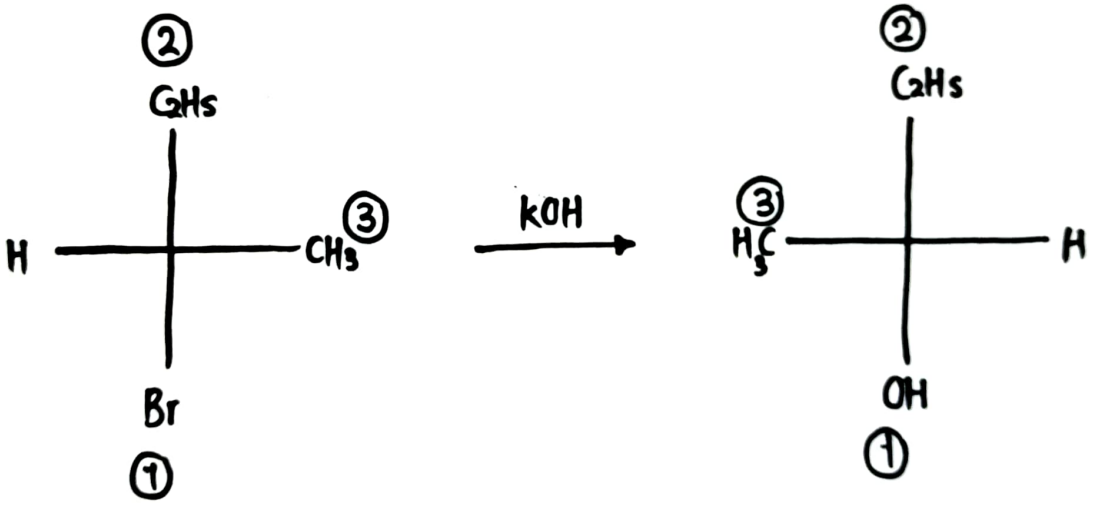

(R) 2 - Chlorobutane

(R) 2 - Butanol

## ② INVERSION

An Inversion reaction in a chiral molecules refers to the process where the configuration (R or S) of a chiral centre is reversed after the reaction.



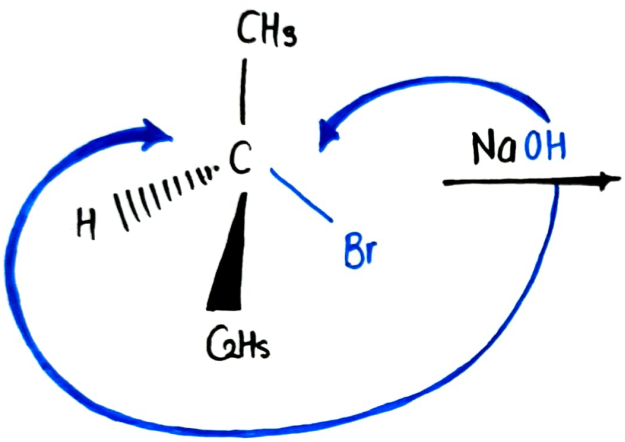




Ⓡ - 2- Bromobutane

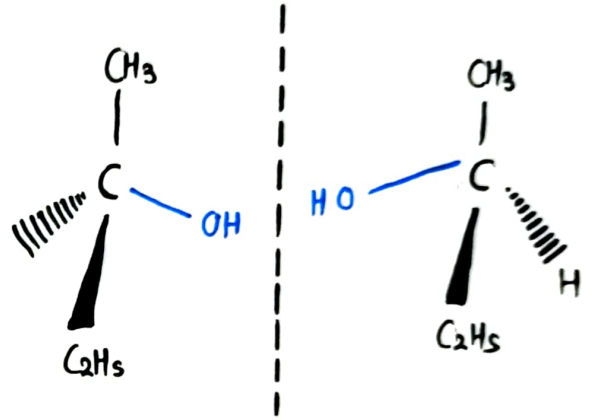
Ⓢ - 2- Butanal

## ③ RECEMIZATION / RECEMIC MODIFICATION

- Recemization is a process in which an optically active compound converts into a recemic mixture, which contains equal amount of both enantiomers (R & S form).
- Since the two enantiomers rotate light in opposite directions, the net optical activity becomes zero.




Ⓡ 2-Bromobutane




Ⓡ - 2- Butanol

Ⓢ - 2 - Butanol

# Resolution Of Recemic Mixture

- The Resolution of recemic mixture refers to the process of separating a recemic (50:50) mixture of enantiomers into its individual optically active components.
- It involves following techniques:

## ① Mechanical Separation

- Mechanical separation is one of the earliest methods used to resolve recemic mixtures.
- This technique relies on physically separating the crystals of individual enantiomers based on different shapes.

### Process

- The mixture is allowed to crystallize slowly under controlled conditions.
- The crystals are examined under microscope.
- The individual enantiomeric crystals are picked out using a fine needle or tweezers.

## ② Chemical Separation

- Chemical Separation is one of the most commonly used methods to separate a recemic mixture.
- In this a chiral resolving agent is used to convert enantiomers into diastereomers.
- Diastereomers have different physical properties, allowing separation via crystallization or Chromatography.
- The resolving agent is then removed to obtain pure enantiomers.

## ③ Enzymatic Separation

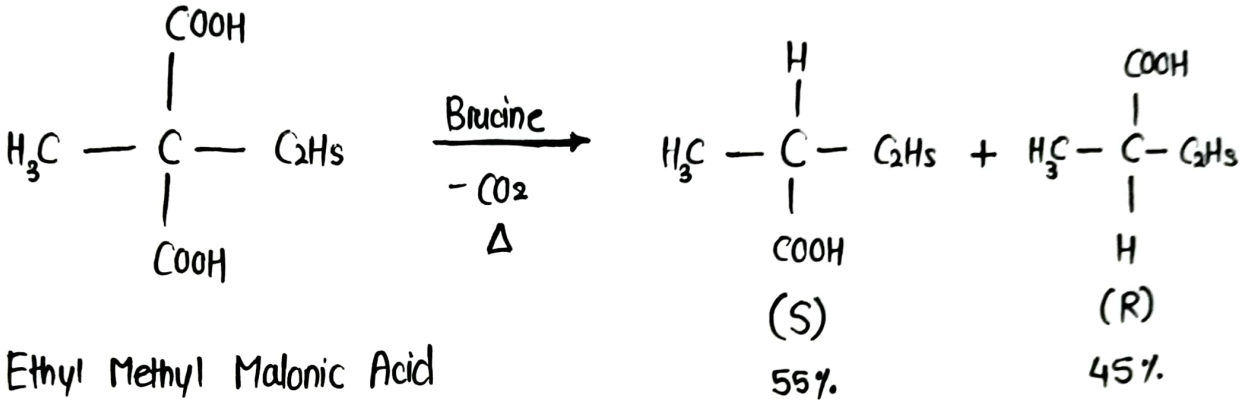
- Enzymatic Separation is a highly selective method for separating a recemic mixture into its individual enantiomers using enzymes.
- Enzymes are biological catalysts that often exhibit stereoselectivity, meaning they react preferentially with only one enantiomer while leaving the other unchanged.

## ④ Chromatographic Separation

- Chromatographic separation is a powerful method for separating enantiomers from a recemic mixture using Chiral Stationary Phases in HPLC, TLC or Gas Chromatography.
- One enantiomer binds more strongly to CSP, while the other elutes faster.

# Asymmetric Synthesis

- Asymmetric Synthesis is defined as conversion of an achiral (symmetric) compound into a chiral (asymmetric) compound in such a way that one enantiomer predominates over the other.




Ethyl Methyl Malonic Acid

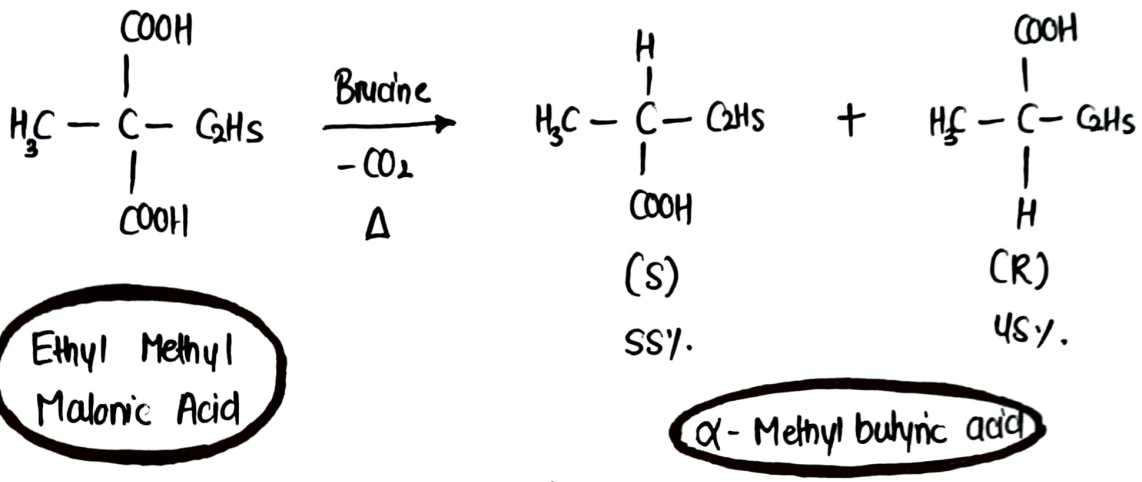
## Types Of Assymmetric Synthesis

They are of two types :

① Partial Asymmetric Synthesis
② Absolute Asymmetric Synthesis

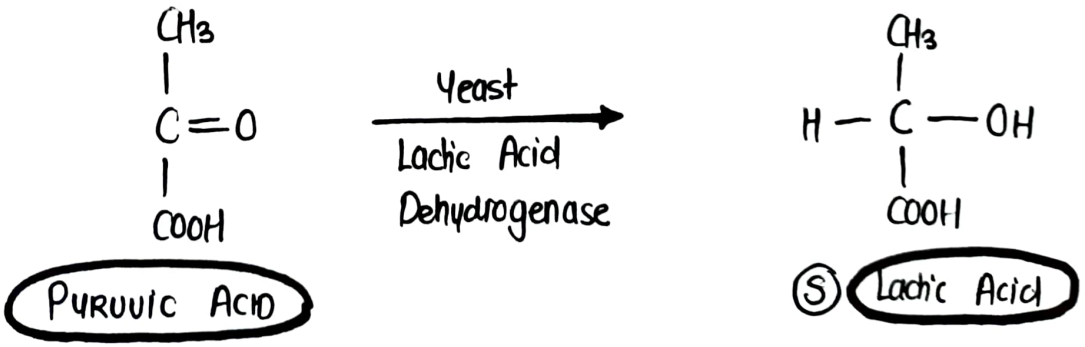
## ① Partial Asymmetric Synthesis

- Partial asymmetric synthesis produces a chiral product with an excess of one enantiomer, but not exclusively.
- A mixture of enantiomer is formed with one being more abundant.




## ② Absolute Assymetric Synthesis

Absolute Asymmetric synthesis creates only 1 specific enantiomer directly from an achiral material.



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