

STEREOISOMERISM

↳ Different compounds with the same molecular formula but a different spatial arrangement of atoms

↳ Atoms are arranged in space differently

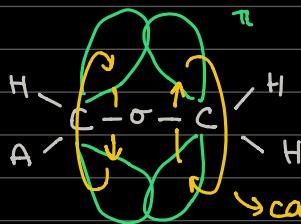
GEOMETRICAL ISOMERISM

Two types of stereoisomers :

- The "directions of the bonds" are different

1. Geometrical Isomers

- Also known as cis-trans isomerism
- Occurs when there is no rotation around at least one carbon of the molecule
- Lack of rotation is seen in alkenes where the π bond restricts rotation

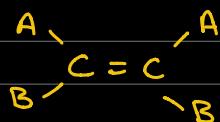


↳ can't do this "twisting" rotation (at least, at room temp) because it will require the C=C bond to be broken, which requires a great amount of energy

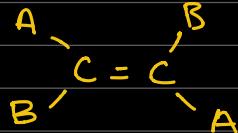
- This lack of rotation leads to cis-trans isomerism

↳ + important: cis-trans isomerism occurs when each of the C=C carbons have different groups attached to them

1.



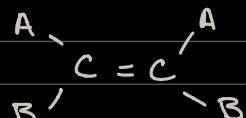
2.



we can't just rotate to go from 1 to 2.
Hence, 1 and 2 are isomers

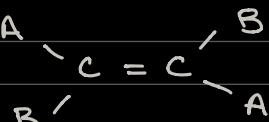
- A cis isomer has two similar groups on the same side of the double bond (vertically)

Example



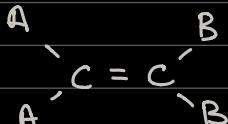
- A trans isomer has two similar groups diagonal to each other, across the double bond

Example



- These is a third isomer, but it is only a structural isomer and NOT a cis or a trans isomer, as both the C atoms have the same groups attached to them

Example

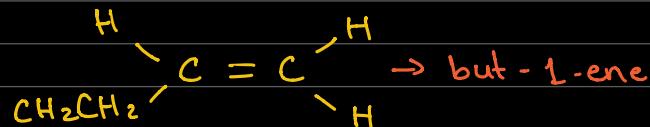


Examples

i.e. Butene \rightarrow C_4H_8

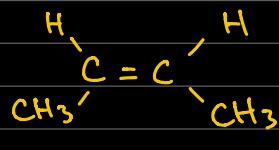
Important Note: cis-trans isomerism is not possible in cyclic alkenes due to "ring strain"

1. $\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2 \rightarrow$ only structural, not cis-trans.



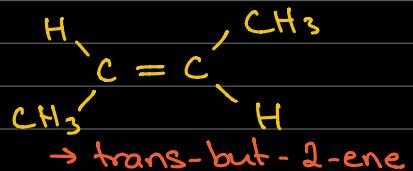
2. But-2-ene \rightarrow $\text{CH}_3-\text{CH}=\text{CH}-\text{CH}_3$

Cis Isomer :



\rightarrow cis-but-2-ene
B.P = 1°C

Trans isomer :



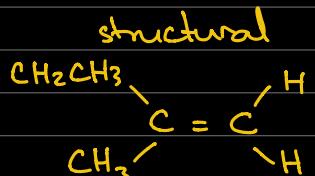
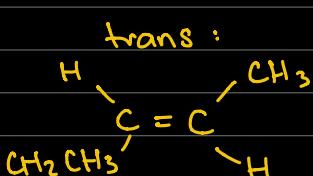
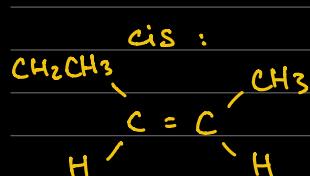
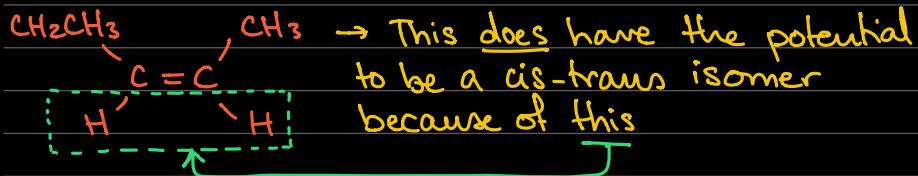
B.P = 2.5°C \rightarrow Higher BP because stronger intermolecular forces

\hookrightarrow packing closer together

Properties:

- cis/trans-isomers have the same chemical properties (because the functional group is the same)
- . But they have different physical properties (i.e. melting/boiling point, polarity, solubility, etc.)

More complicated examples :



when all four groups are different: have to assign priority

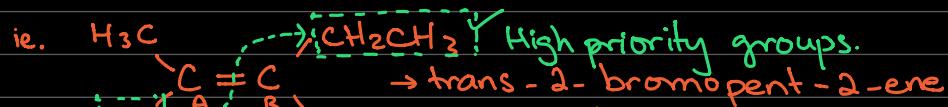
Rules for assigning priority:

1. Priority depends on the atomic number of the atom attached to the C=C carbon atoms.

2. The higher the atomic number, the higher the priority of the atom or the group

3. If two atoms have the same atomic number (same priority), then look at the next atom "in line" (the C-C chain) until a difference is found and priority is assigned based on that difference.

Example



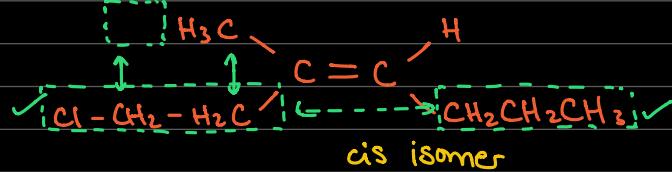
$\text{Br} \quad \text{K}$ H - If high priority groups are diagonal to each other \rightarrow trans isomer

High priority
trans isomer

cuz
higher atomic
number

- If high priority groups are on the same side of C=C bond \rightarrow cis isomer

Hence, Cl - CH₂ - CH₂ is the higher priority group?



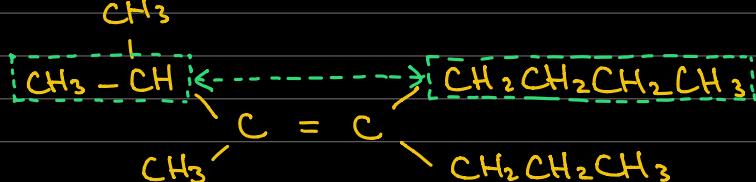
\rightarrow cis - 1 - chloro - 3 - methyl - hept - 3 - ene



\hookrightarrow Hence, a trans isomer

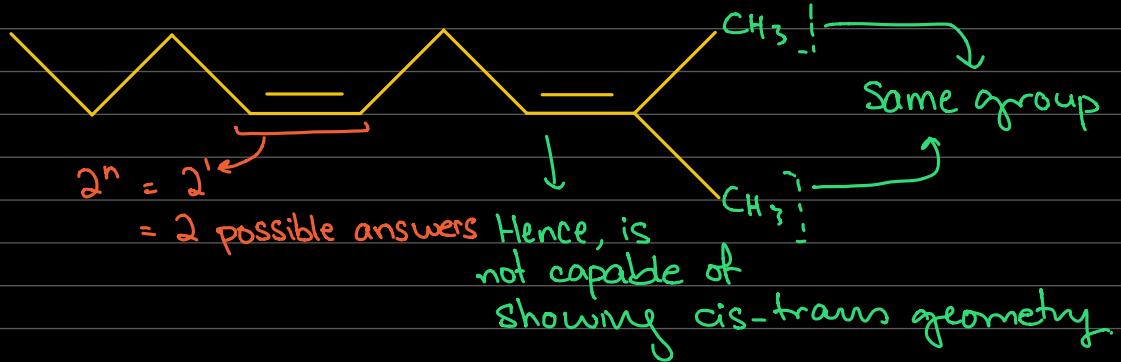
\rightarrow trans - 2, 3 - dimethyl - 4 - propyl oct - 3 - ene

\hookrightarrow The corresponding cis isomer would be :



Total no. of geometrical isomers = 2^n → Use this formula for stereoisomers only
where n is the number of C=C bonds capable of showing cis-trans geometry.

Example:



→ Re-listen to the questions/answers at 54:00

OPTICAL ISOMERS : A type of stereoisomer

Optical isomerism arises due to :

1. the chirality of the compound : the molecule must have at least one chiral carbon
2. Optical isomers are non-superimposable mirror images of each other

3. Optical isomers have no plane of symmetry

4. Optical isomers show optical activity → is the ability of optical isomers to rotate plane polarised light in equal but opposite directions

- Optical isomers have the same molecular and the same structural formula, hence the same chemical and physical properties
- But they show different "optical activity"
- Optical activity is measured using an instrument called a polarimeter

Explaining point 1 from "Optical isomerism arises due to:"

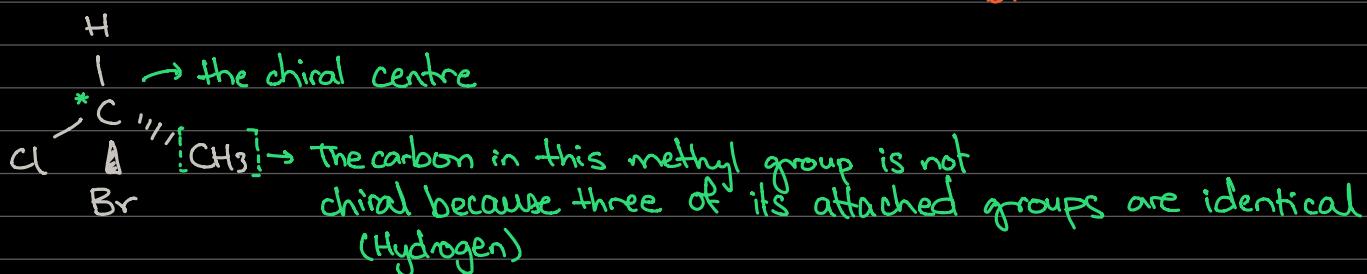
Q. What is a chiral carbon?

A chiral atom is atom with 4 different groups or atoms attached to it

It is also known as an "asymmetric carbon"

Note: Always draw optical isomers using 3D bond rotation

Example:



Verifying a chiral carbon:

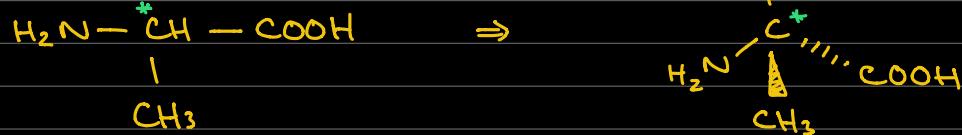
- Draw 3D bonds to the (potentially) chiral carbon.
- If any C=C, C≡C, C=O, C≡N bonds are present, the carbon is not chiral.
↳ This is because if the carbon has a double or a triple bond, it means that it is not bonded to four different groups.
- Similarly, if two or more of the groups attached to the carbon are identical, then the carbon is not chiral.
↳ For the carbon to be chiral, it is necessary that each of the four attached groups are unique

Example:

Amino Acids → building blocks of protein

19 out of 20 essential amino acids are chiral → As m they contain a chiral carbon

i.e. Alanine :

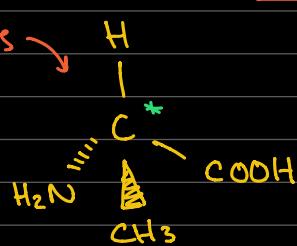
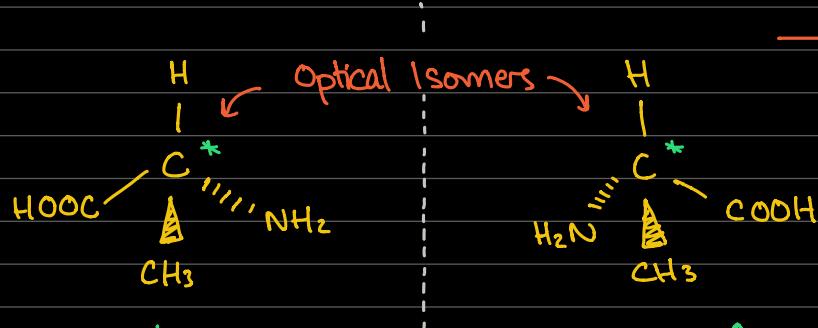


- One chiral carbon in a molecule means that the molecule has two optical isomers

Explaining point 2 from "Optical isomerism arises due to : "

↳ optical isomers are non-superimposable mirror images of each other

Taking alanine as an example again :



→ To verify that they are optical isomers, we can try and rotate either of them so that both the "group position" and "group bond notation" is the same.

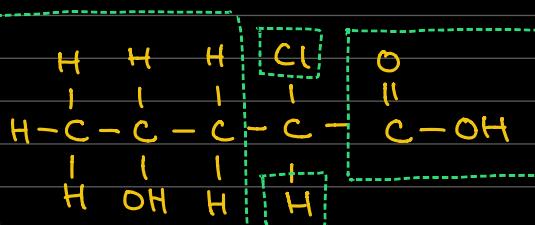
↳ (without flipping)
↳ If we are unable to do so (like in this case), that means that the two molecules are optical isomers.

These are mirrored images of each other.

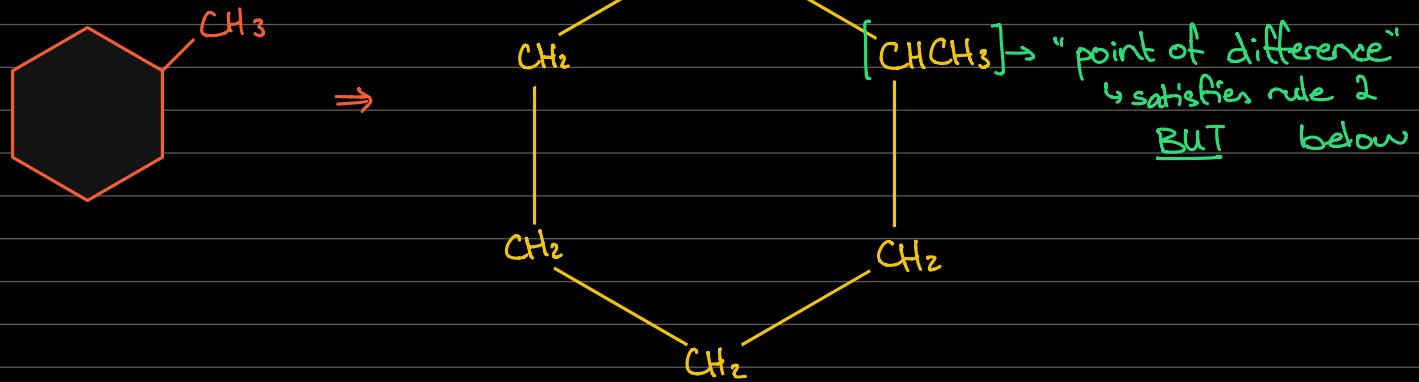
As such, they are not super-imposable

□ = unique groups around a carbon

Identifying chiral carbons :



2. methylcyclohexane



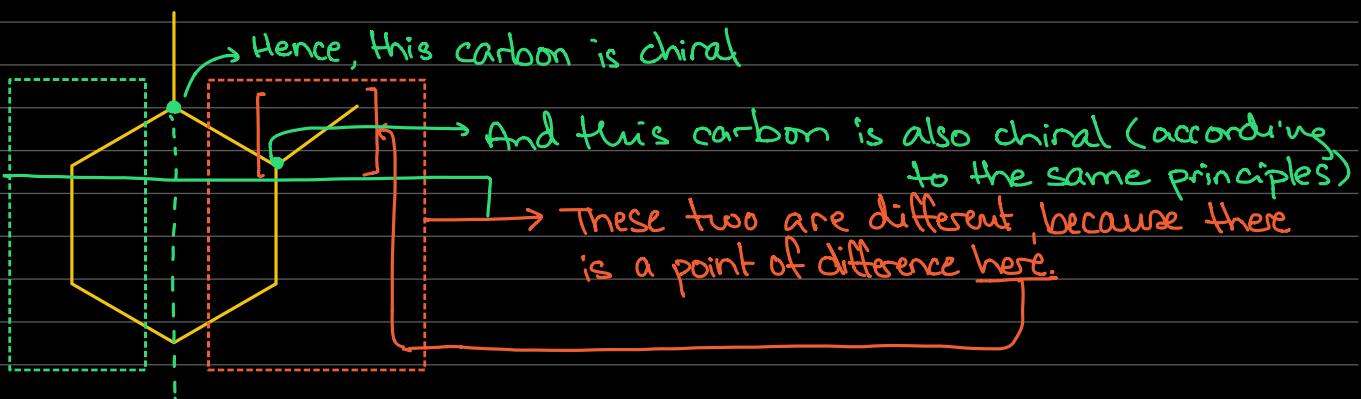
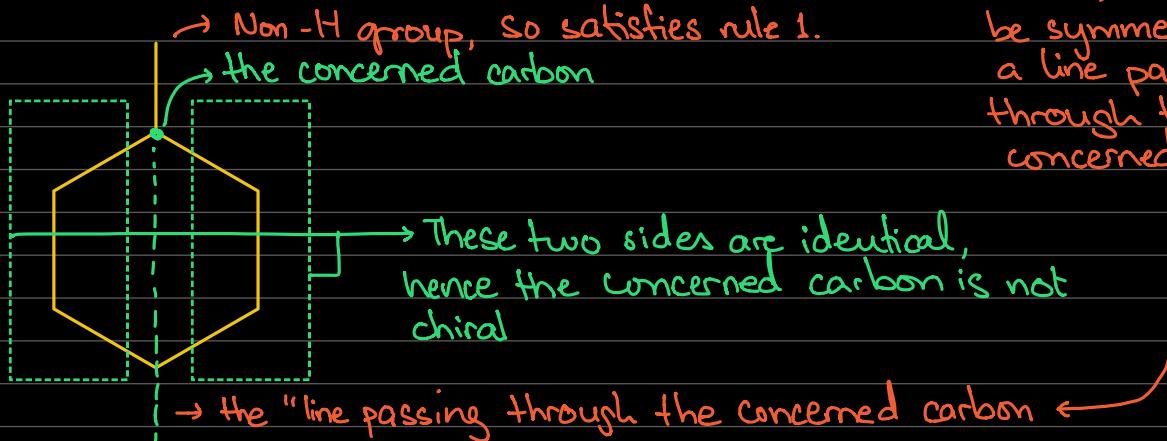
• For a carbon in a cyclic compound to be chiral, it must satisfy both of the following conditions :

1. It must have at least one non-hydrogen group attached to it.
 ↳ If it has two non-hydrogen groups attached, then those two groups must be different.

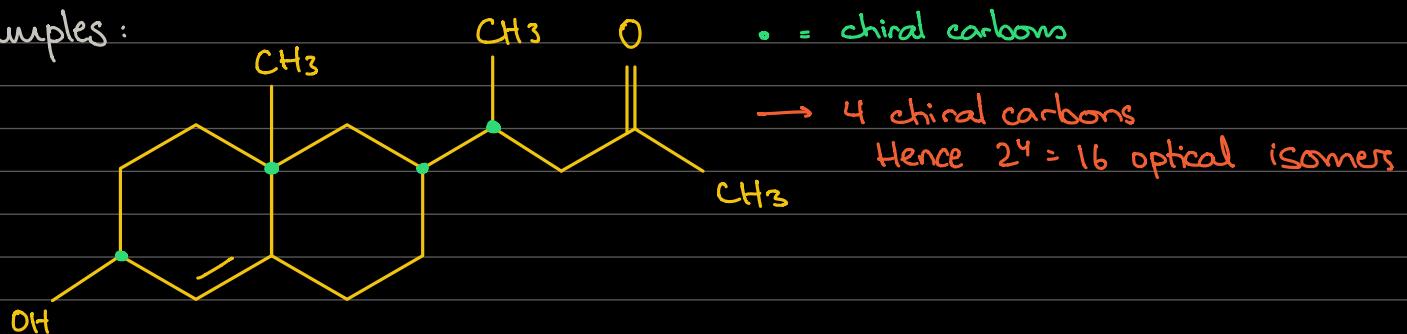
2. Going in either direction of the concerned carbon, there must be a "point of difference".

↳ that is, there must be a certain point in the chain where the one side becomes different from the other side.

↳ that is, there mustn't be symmetry about a line passing through the concerned carbon



Examples :



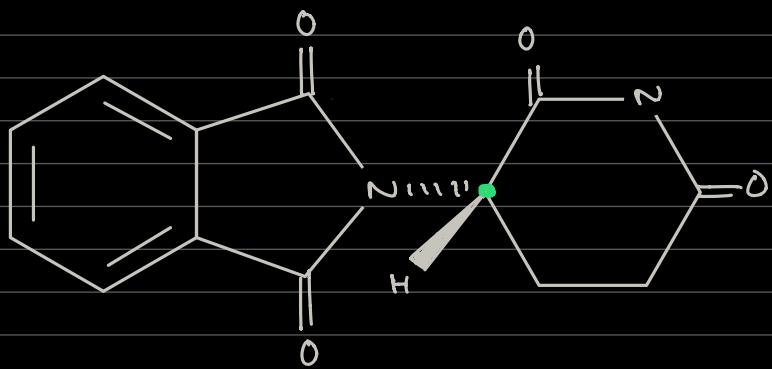
[Number of optical isomers = 2^n]

where "n" is the number
of chiral carbons

Example → Draw the optical isomers of butan-2-ol as mirror images:



Example → Thalidomide : A drug introduced in 1960 meant reduce "morning sickness" in pregnant women, which it, but it also resulted in fetal deformities and hence, was recalled



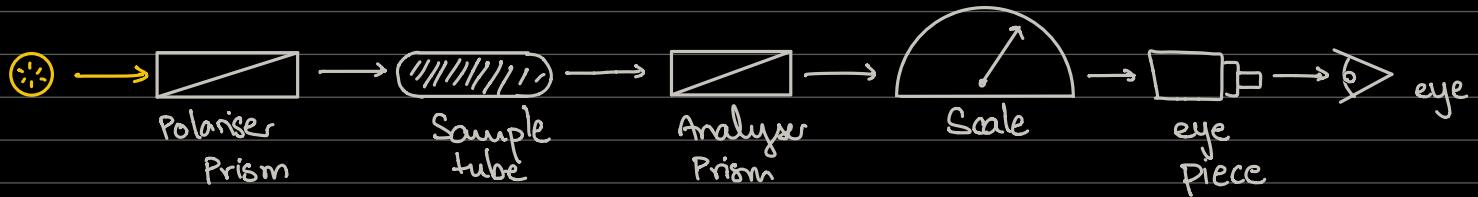
Optical Activity

↳ is measured with an instrument called a "polarimeter"

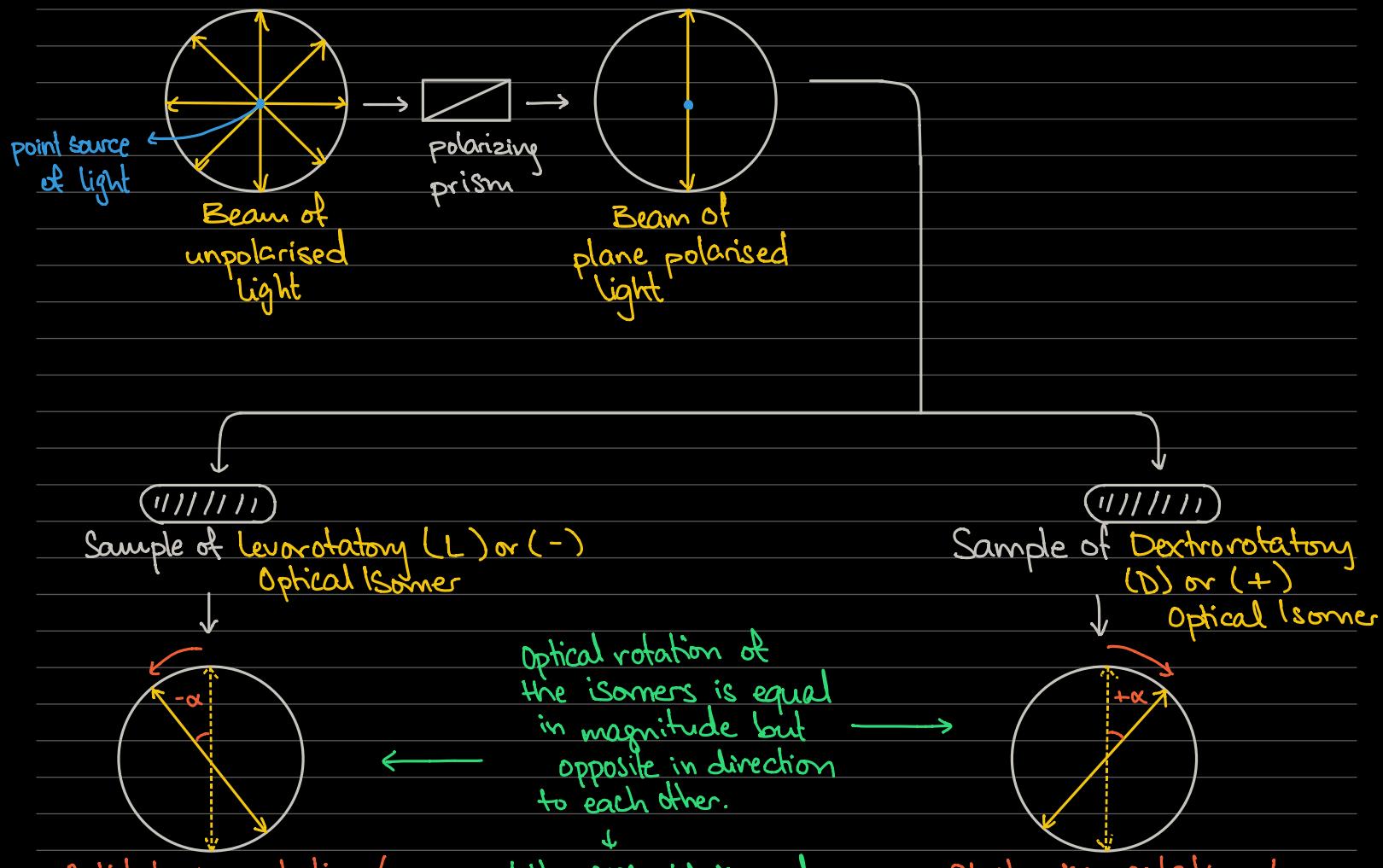
- Optical activity is the ability of optical isomers to rotate plane polarised light in opposite directions

(Simplified) Polarimeter Schematic

→ Shows angle of rotation



- Ordinary light has a great number of electromagnetic waves, the planes of which are randomly oriented.
↳ Such light is unpolarised
- Certain crystals / lenses (e.g. a polaroid lens) allows the passage of light in one single plane only.
↳ This light is plane polarised.
- If a compound has a chiral carbon, it can rotate plane polarised light, the angle of which can be measured using a polarimeter



LEVOROTATORY

concentrations of the optical isomers in the sample is the same,
ie. they are equi-molar)

DEXTROROTATORY

* Levo- and Dextro- are Latin prefixes for "left" and "right", respectively

Important

↪ Equimolar mixture of the two optical isomers will NOT show any optical activity as they cancel each other out.

↳ This mixture is known as a "Racemic Mixture" or a "Racemate"

Q. What if there is an excess of one isomer present?

Excess of one isomer over the other will show optical activity corresponding to the percentage of the species (isomer) that is in excess.

i.e. Mixture:

75%. D-butan -2-ol

25%. L-butan -2-ol

The rotation in degrees that would've been displayed if the isomer in excess was the only

Overall rotation will be $75 - 25 = 50\%$ of the "original" rotation

species present

i.e. 50% of 13.9° to the right = $+ 6.95^\circ$

↳ to the right

→ Hence, this mixture would be a dextrorotatory one

x — End of : Isomerism — x