Beckfoot

Subject: Chemistry	Topic: Optical Isomerism 3.3.7	Year Group: 13

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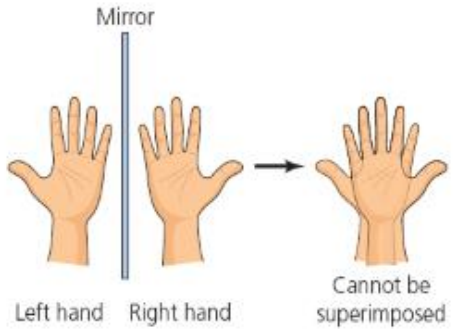
Chiral molecules are non-superimposable

A molecule is **chiral** if, like one of your hands , it **cannot be superimposed on its mirror image**

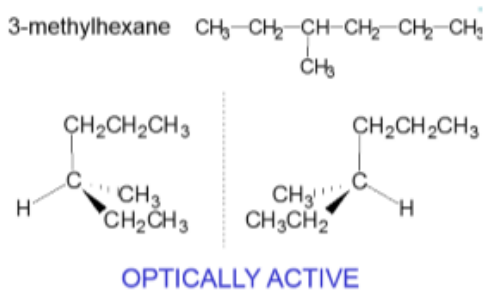


How to spot optical isomers

1	Look for a carbon atom in the molecule that is attached to 4 different atoms or groups. This is a chiral centre.
2	Note that there may be more than 1 chiral centre in the molecule which would mean there would be more than 2 enantiomers of that compound (one chiral centre = 2 enantiomers).
3	The chiral carbon atom in the molecule may be marked with an asterisk to identify it as such.

Examples of optical isomers

Note that the atoms/groups are drawn tetrahedrally around the asymmetric carbon atom / chiral centre. Also the molecules are drawn three dimensionally.



Significance of optical isomers

1	Thalidomide is a sedative drug, which was prescribed as a racemate to treat nausea in pregnant women in the early 1960s.
2	It was later found to cause foetal abnormalities involving limb malformation. Thalidomide is optically active: the (+) isomer was an effective drug but the (-) isomer caused deformation.
3	The drug was banned in 1962. Today, the optical isomers of chiral drugs are separated before testing.
4	Separation is difficult because optical isomers have similar physical properties.
5	Ibuprofen is a drug that targets muscle and bone pain, headaches and back pain. It is a chiral structure and has optical isomers.

Key Vocabulary

1	Optical isomers	Are stereoisomers that occur as a result of chirality in molecules. They exist as non-superimposable mirror images & differ on their effect on plane polarised light
2	Chiral	The structure & its image are non-superimposable
3	Asymmetric carbon atom	A carbon atom attached to 4 different atoms or groups and is chiral
4	Racemic mixture (racemate)	An optically inactive mixture of equal amounts of enantiomers of the same concentration
5	Enantiomers	Each of the non-superimposable mirror images of an optical isomer
6	Plane Polarised light	Light in which all the waves vibrate in the same plane
7	Optically active substance	One that can rotate the plane of plane polarised light
8	Stereoisomerism	A compound with the same structural formula but atoms / groups are arranged differently in space
9	Planar	A flat molecule— a molecule which lies in one plane or all the atoms attached to the molecule lie in the same plane

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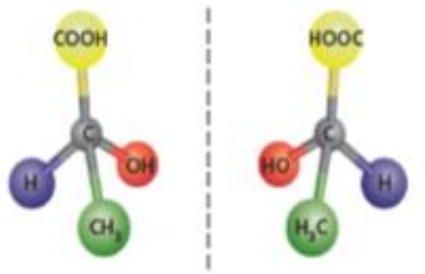
How to draw optical isomers

1	Draw the displayed formula
2	Identify the chiral centre
3	Draw the 3D tetrahedral structure based on the chiral centre and insert the four different groups
4	Draw a dotted line to represent a mirror, and draw the second isomer as a mirror image



How is a racemate formed?

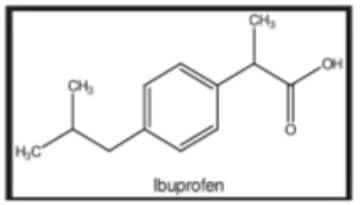
1	In some reactions of aldehydes (RCHO) and ketones (RCO-) a **racemate** is formed. This is because the **carbonyl group is planar (flat)** which means the **nucleophile (e.g. CN^-) can attack from either above or below** (or either side) with **equal probability**.
2	This means equal amounts of each enantiomer are formed i.e. a racemate which has **no effect on plane polarised light**.
3	**All aldehydes (except methanal)** and **unsymmetrical ketones** reacting with the nucleophile **CN^-** will produce a racemate so they will be **optically inactive**. This is due to the nature of the mechanism described above.
4	*See knowledge organiser on aldehydes & ketones for further information on this.*

What is a racemate (racemic mixture)?

1	A racemate or racemic mixture contains **equal amounts of each enantiomer**
2	Hence, its effect on plane polarised light is cancelled out because each enantiomer rotates the plane of plane polarised light by equal amounts and in opposite directions so that there is no overall effect.
3	This means a racemate is **optically inactive**.
4	The reaction of some aldehydes/ketones in nucleophilic addition will produce a racemate due to the mechanism described above.
5	You can tell the difference between a single enantiomer and a racemate because ***only the enantiomer will rotate plane polarised light in one direction but the racemate will have no effect*** on plane polarised light.

Identifying chiral centres

Can you identify the chiral centre (s) in the ibuprofen structure?



Distinguishing between enantiomers

1	Enantiomers have identical physical and chemical properties except for their **effect on plane polarised light** and how they **interact with other chiral molecules** (e.g. enzyme activity with substrate).
2	Each enantiomer will rotate the plane of plane polarised light in opposite directions. Hence, they are optically active and can be distinguished in this way.
3	Must state that the plane polarised light is **rotated** in **opposite directions** (i.e. include the underlined words in your answer).

EXAM BULLET POINTS: Explain how you could distinguish between a racemate of lactic acid and one of the enantiomers of lactic acid? [3]

Plane polarised light will be rotated by the single enantiomer but it will be unaffected by the racemate [1]. The racemate is optically inactive as it contains equal amounts of each isomer [1] and one isomer rotates plane polarised light to the right, the other to the left and the two opposite effects cancel out [1]

EXAM BULLET POINTS: How would you distinguish between a solution of two separate enantiomers? [2 marks]

Pass plane polarised light through each enantiomer [1]

Enantiomers will rotate the plane of plane polarised light in opposite directions [1]