Exercise walk-through

Isomerism: optical ▪ 29.4

eXercise

You must be able to

- identify a chiral centre (4 different groups on one carbon)
- describe how enantiomers differ (rotation of plane-polarised light; biological activity)
- explain why a racemic mixture is optically inactive

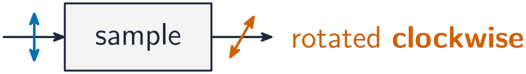
Method — Chirality and optical activity

- a **chiral centre** is a carbon with **four different** groups → two non-superimposable mirror images (enantiomers).
- enantiomers are identical in all properties **except**: they rotate plane-polarised light in **opposite** directions, and may have different biological effects.
- a **racemic mixture** (50:50) shows **no** net rotation — the two opposite rotations cancel.

Drugs: one enantiomer may cure while the other harms — so makers use a chiral catalyst or separate the enantiomers.

Method — Chirality and optical activity

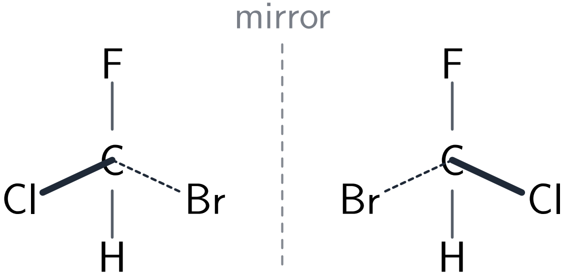
enantiomer 1



enantiomer 2 (mirror image)

a 50:50 **racemic mixture** gives no net rotation (the two cancel)

Method — Chirality and optical activity



enantiomers: mirror images that cannot be superimposed
(the central carbon has 4 different groups)

Optical isomers are non-superimposable mirror images

Practice 2.1 ▪ 1 mark

State what feature a molecule must have to show optical isomerism.

Solution 2.1

Method: Chirality and optical activity

Worked steps

a chiral centre — a carbon atom bonded to four different groups B1.

Practice 2.2 ▪ 1 mark

State why a racemic mixture does not rotate plane-polarised light.

Solution 2.2

Method: Chirality and optical activity

Worked steps

the two enantiomers are present in equal amounts, so their equal and opposite rotations cancel **B1**.

Exam-style 3.1 ▪ 1 mark

A chiral carbon atom is bonded to:

A four identical groups

B two identical and two different groups

C four different groups

D three different groups and one H, with a double bond

Solution 3.1

Method: Chirality and optical activity

A four identical groups

B two identical and two different groups

C four different groups ✓

D three different groups and one H, with a double bond

Worked steps

C. A chiral carbon has four different groups attached.

Exam-style 3.2 ▪ 1 mark

Two enantiomers of a molecule always have the **same**:

A rotation of plane-polarised light

B boiling point

C effect in the body

D direction of optical rotation

Solution 3.2

- **A** rotation of plane-polarised light
- **B** boiling point ✓
- **C** effect in the body
- **D** direction of optical rotation

Worked steps

B. Enantiomers share all physical properties such as boiling point; only the direction of optical rotation and biological activity differ.

Exam-style 3.3 ▪ 2 marks

The molecule $CH_3CH(OH)COOH$ (lactic acid) is optically active.
(a) Mark the chiral centre and state how many enantiomers it has.
(b) State the two ways in which the enantiomers differ.

Solution 3.3

Method: Chirality and optical activity

Worked steps

(a) the central carbon (bonded to –OH, –COOH, $-CH_3$ and –H) is the chiral centre **M1**; it has 2 enantiomers **A1**.

(b) they rotate plane-polarised light in opposite directions **M1**; they may have different biological effects **A1**.

Exam-style 3.4 ▪ 2 marks

Explain why drug manufacturers often want a single enantiomer rather than a racemic mixture.

Solution 3.4

Method: Chirality and optical activity

Worked steps

the two enantiomers can behave very differently in the body — one may be effective or safe while the other is inactive or harmful **M1**; so the maker wants only the beneficial single enantiomer **A1**.