

Stereoisomerism

Answer key with explanations

A. Types of isomer

1. Isomer types.

(a) **structural** (chain) isomers (b) **cis-trans** isomers (c) **structural** (position) isomers (d) the **same compound**: rotation about a C-C single bond is free.

B. Cis-trans and E/Z

2. Cis-trans?

(a) **Yes**: one C has H and CH₃, the other H and C₂H₅. (b) **No**: one carbon has two CH₃ groups and the other two H atoms. (c) **Yes**: each carbon has H and Br.

3. 1,2-Dichloroethene.

Cis: both Cl on the same side; trans: Cl on opposite sides. **Cis boils higher (60 °C)**: its two C-Cl dipoles add up, so the molecule is **polar** with dipole-dipole forces. In the trans isomer the dipoles cancel, so it is non-polar (48 °C).

4. E or Z.

(a) Cl beats H and Br beats H; Cl and Br on the same side: **Z**. (b) On one carbon CH₃ (C, 6) beats H; on the other Cl (17) beats H; they are on opposite sides: **E**.

C. Optical isomerism

5. Chiral centres.

(a) **C2** (H, Cl, CH₃, C₂H₅) (b) **none**: the central C has two CH₃ groups (c) **C2** (H, OH, CH₃, COOH) (d) **none**: every carbon has at least two H atoms.

6. Lactic acid enantiomers.

(a) Same: formula, structure (connections), boiling point, melting point, density and most reactions. (b) Different: they rotate **plane-polarized light in opposite directions**, and they can react differently with other chiral molecules such as enzymes. A **racemic mixture** is a 50 : 50 mixture of the two enantiomers; it shows no overall rotation.

D. Applications

7. Single-enantiomer drugs.

Drug targets (enzymes and receptors) are themselves chiral, so usually only one enantiomer **fits** the target. In a racemic mixture half the dose may be inactive, or may cause side effects. A single enantiomer can give the same effect at a lower dose with fewer side effects.

E. Challenge

8. Butanols.

In **butan-2-ol** carbon 2 carries four different groups (H, OH, CH₃, C₂H₅), so it is a **chiral centre** and there are two enantiomers. In **butan-1-ol** no carbon has four different groups (C1 carries two H atoms), so there are no stereoisomers. Butan-1-ol and butan-2-ol differ in the position of the OH group: they are **structural (position) isomers**.

F. CIP rules and R/S

9. Ranking groups.

(a) **-Cl > -OH > -CH₃ > -H** (Cl 17, O 8, C 6, H 1). (b) **-COOH (O,O,O) > -CHO (O,O,H) > -CH₂OH (O,H,H) > -CH₃ (H,H,H)**: all start with C, so compare the attached atoms; C=O counts as two O. (c) **-CH₂OH (O,H,H) > -CH(CH₃)₂ (C,C,H) > -CH₂CH₃ (C,H,H)**: O beats C at the first point of difference; then (C,C,H) beats (C,H,H) at the second.

10. Lactic acid.

(a) **-OH (1) > -COOH (2) > -CH₃ (3) > -H (4)**: O beats C; between the two carbons, (O,O,O) beats (H,H,H). (b) With H at the back, the path OH → COOH → CH₃ is 1 → 2 → 3 **clockwise: R**. (c) With H towards you, the clockwise path must be reversed: **S**.