InkChemistry

ANSWER BOOK

Structural isomerism and E/Z isomerism

Introduction to organic chemistry · Unit C16

AQA 3.3.1.3 · OCR A 4.1.1, 4.1.3

20 questions · 64 marks

NAVY EDITION

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SECTION A · Short, 1 to 2 marks

A1 SIE-Q3

B1 butane, $CH_3CH_2CH_2CH_3$, the unbranched isomer. **B1** 2-methylpropane, $CH_3CH(CH_3)CH_3$, the branched isomer. [2]

A2 SIE-Q5

B1 propanal and propanone are functional group isomers, an aldehyde and a ketone. **B1** 1-chloropropane and 2-chloropropane are position isomers, with the Cl on a different carbon. [2]

A3 SIE-Q7

B1 carbon 1 of the C=C carries two hydrogen atoms, which are identical groups. **B1** swapping two identical groups gives the same molecule, so only one compound exists. [2]

A4 SIE-Q15

B1 both groups are joined through a carbon atom, so the first atoms tie and the next atoms out are compared. **B1** CH_2OH carries (O, H, H) and CH_3 carries (H, H, H); O has the higher atomic number, so CH_2OH has the higher priority. [2]

SECTION B · Standard, 3 to 5 marks

B1 SIE-Q20

B1 hexane, $CH_3CH_2CH_2CH_2CH_2CH_3$, the unbranched chain. **B1** 2-methylpentane, $(CH_3)_2CHCH_2CH_2CH_3$, a chain of five with a methyl branch on carbon 2. **B1** 3-methylpentane, $CH_3CH_2CH(CH_3)CH_2CH_3$, a chain of five with a methyl branch on the middle carbon. **B1** 2,2-dimethylbutane, $(CH_3)_3CCH_2CH_3$, a chain of four with two methyl branches on carbon 2. **B1** 2,3-dimethylbutane, $(CH_3)_2CHCH(CH_3)_2$, a chain of four with one methyl branch on each inner carbon. [5]

B2 SIE-Q2

B1 structural isomers have the same molecular formula but a different structural formula. **B1** stereoisomers have the same structural formula but a different arrangement of the atoms in space; reject 'same molecular formula' alone. **B1** butan-1-ol and butan-2-ol are structural isomers, position isomers with the OH on a different carbon. **B1** E- and Z-but-2-ene are stereoisomers, E/Z isomers about the C=C, with the same structural formula. [4]

B3 SIE-Q4

B1 1-bromobutane, $CH_3CH_2CH_2CH_2Br$, with Br at the end of the unbranched chain. **B1** 2-bromobutane, $CH_3CH_2CHBrCH_3$, with Br on an inner carbon of the unbranched chain. **B1** 1-bromo-2-methylpropane, $(CH_3)_2CHCH_2Br$, with Br at an end of the branched chain. **B1** 2-bromo-2-methylpropane, $(CH_3)_3CBr$, with Br on the branching carbon. [4]

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B4 SIE-Q21

B1 the longest chain through the C=C has five carbons, numbered from the end that gives the double bond the lower locant, so the stem is pent-2-ene with the methyl branch on carbon 3. **B1** on carbon 2 the groups are CH_3 and H, and CH_3 has the higher priority because carbon's atomic number, 6, exceeds hydrogen's, 1. **B1** on carbon 3 the groups are CH_3 and C_2H_5; the first atoms tie, so the next atoms out are compared, (C, H, H) for ethyl against (H, H, H) for methyl, and C_2H_5 has the higher priority. **B1** with the two methyls opposite, the CH_3 on carbon 2 lies on the same side as the C_2H_5 on carbon 3, so the two higher-priority groups are together and the isomer is Z; reject E from treating the methyls as the groups compared. [4]

B5 SIE-Q6

B1 there is restricted rotation about the C=C double bond; reject 'no rotation about the molecule'. **B1** each carbon of the C=C carries two different groups, a CH_3 and an H. **B1** so the two CH_3 groups can be on the same side (Z) or on opposite sides (E), and the two cannot interconvert. [3]

B6 SIE-Q8

B1 the double bond consists of a σ bond and a π bond. **B1** the π bond forms by the sideways overlap of a p orbital on each carbon, above and below the plane of the molecule. **B1** rotation would twist the p orbitals out of line and break the π bond, which needs far more energy than is available at room temperature. [3]

B7 SIE-Q9

B1 2-methylpropane is branched and more compact, so its molecules have a smaller area of contact with each other. **B1** the van der Waals forces between its molecules are therefore weaker. **B1** less energy is needed to overcome these forces, so its boiling point is lower; reject any answer that breaks covalent bonds on boiling. [3]

B8 SIE-Q10

B1 on carbon 2, Cl has a higher priority than CH_3, because Cl has the higher atomic number, 17 against 6. **B1** on carbon 3, C_2H_5 has a higher priority than H, atomic number 6 against 1. **B1** the two higher-priority groups are on opposite sides, so the isomer is E-2-chloropent-2-ene; accept (E)-2-chloropent-2-ene. [3]

B9 SIE-Q11

B1 in the Z isomer both COOH groups are on the same side of the C=C, close to each other. **B1** they can react with each other, losing a molecule of H_2O and closing a ring. **B1** in the E isomer the COOH groups are on opposite sides, too far apart, and restricted rotation stops them being brought together. [3]

B10 SIE-Q12

B1 a Z double bond puts a kink in the hydrocarbon chain, whereas an E chain is nearly straight. **B1** straight chains pack more closely together, as saturated chains do, with a larger area of contact. **B1** the van der Waals forces between the E chains are stronger, so more energy is needed to melt the fat. [3]

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B11 SIE-Q13

B1 both systems describe the arrangement of groups about a C=C that cannot rotate. **B1** cis/trans compares the positions of the carbon chain, so this isomer, with both CH_3 groups on one side, is cis. **B1** E/Z compares the CIP highest-priority groups; Cl outranks CH_3 on carbon 2, so the priority groups are opposite and the isomer is E. [3]

B12 SIE-Q14

B1 pentane, $CH_3CH_2CH_2CH_2CH_3$, the unbranched chain of five. **B1** 2-methylbutane, $CH_3CH(CH_3)CH_2CH_3$, a chain of four with one branch. **B1** 2,2-dimethylpropane, $C(CH_3)_4$, a chain of three with two branches on the middle carbon. [3]

B13 SIE-Q16

B1 both are $C_2H_2Cl_2$, so they are isomers. **B1** the Cl atoms are on different carbons, so the structural formulae differ and they are structural (position) isomers, not stereoisomers. **B1** 1,2-dichloroethene does have stereoisomers of its own, the E and Z forms, whereas 1,1-dichloroethene has none because one carbon carries two hydrogens. [3]

B14 SIE-Q18

B1 both have a C=C, about which rotation is restricted. **B1** in 1-chloroprop-1-ene carbon 1 carries Cl and H and carbon 2 carries CH_3 and H, so each carbon of the C=C has two different groups. **B1** in 3-chloroprop-1-ene carbon 1 carries two hydrogen atoms, and swapping identical groups gives the same molecule, so there are no E/Z isomers. [3]

B15 SIE-Q19

B1 with Br and Cl on the same carbon there is one compound, 1-bromo-1-chloroethene, $CH_2=CBrCl$, which has no E/Z isomers because the other carbon carries two hydrogens. **B1** with Br and Cl on different carbons the compound is 1-bromo-2-chloroethene, CHBr=CHCl, in which each carbon carries two different groups, so it has E and Z isomers. **B1** there are three isomers in all: 1-bromo-1-chloroethene, E-1-bromo-2-chloroethene and Z-1-bromo-2-chloroethene. [3]

SECTION C · Long, 6 marks or more

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C1 SIE-Q17

Indicative content [6]

B1 but-1-ene and but-2-ene are position isomers, the C=C starting on a different carbon of the same unbranched chain. **B1** 2-methylpropene has a branched skeleton, so it is a chain isomer of both butenes. **B1** but-2-ene is the only one of the three to show E/Z isomerism, existing as E-but-2-ene and Z-but-2-ene. **B1** this is because rotation about the C=C is restricted and each carbon of the C=C carries two different groups, CH_3 and H. **B1** but-1-ene and 2-methylpropene show no E/Z isomerism, because one carbon of the C=C carries two identical groups. **B1** the cycloalkanes cyclobutane and methylcyclopropane are also C_4H_8 and are functional group isomers of these alkenes.

Levels

Level 3 (5–6 marks) all three kinds of structural isomerism in the set are identified with the pairs that show them, E/Z isomerism is explained for but-2-ene through restricted rotation and two different groups on each carbon, and the answer says why the other two alkenes show no E/Z isomerism.

Level 2 (3–4 marks) position and chain isomerism are identified and but-2-ene is said to show E/Z isomerism; restricted rotation and two different groups on each carbon, or why the other two alkenes do not show it, are not explained.

Level 1 (1–2 marks) one kind of isomerism is named; but-1-ene is often said to show E/Z isomerism too because it has a C=C bond.

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