InkChemistry

ANSWER BOOK

Oxidation and elimination of alcohols

Alkenes and alcohols · Unit C18

AQA 3.3.5.2, 3.3.5.3 · OCR A 4.2.1

19 questions · 62 marks

NAVY EDITION

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SECTION A · Short, 1 to 2 marks

A1 OE-Q3

B1 correct formulae for propan-1-ol, $CH_3CH_2CH_2OH$, and propanoic acid, CH_3CH_2COOH. **B1** balanced with 2[O] on the left and H_2O on the right: $CH_3CH_2CH_2OH(l) + 2[O] \rightarrow CH_3CH_2COOH(l) + H_2O(l)$. [2]

A2 OE-Q13

B1 warm the distillate with Tollens' reagent, or with Fehling's solution. **B1** an aldehyde gives a silver mirror, or a brick-red precipitate from the blue Fehling's solution, while a ketone gives no change. [2]

A3 OE-Q17

B1 cyclohexene, C_6H_{10}, formed by the elimination of water. **B1** shaking it with bromine water turns the bromine water from orange to colourless. [2]

A4 OE-Q21

B1 a pure liquid boils at one fixed temperature, which can be compared with the data-book value for propanal, 49 °C. **B1** a sample that boils over a range of temperatures, or well above 49 °C, contains impurities such as propan-1-ol or water. [2]

SECTION B · Standard, 3 to 5 marks

B1 OE-Q8

B1 a curly arrow from a lone pair on the oxygen of the OH group to an H^+ ion. **B1** the protonated alcohol, with the positive charge on the oxygen, and a curly arrow from the C–O bond to the oxygen as water leaves. **B1** the carbocation $CH_3C^+HCH_3$, with the positive charge on the middle carbon. **B1** a curly arrow from a C–H bond on an adjacent carbon to the C–C bond, forming C=C and releasing H^+. [4]

B2 OE-Q10

B1 pentan-2-ol gives a carbocation on carbon 2, which can lose H^+ from carbon 1 or from carbon 3. **B1** loss from carbon 1 gives pent-1-ene, and loss from carbon 3 gives pent-2-ene, which forms as E and Z isomers: three alkenes. **B1** pentan-3-ol gives a carbocation on carbon 3, whose two neighbours, carbons 2 and 4, are equivalent, so only pent-2-ene forms. **B1** pent-2-ene has E and Z isomers, so pentan-3-ol gives two alkenes; ignore mechanisms if not asked for. [4]

B3 OE-Q18

B1 potassium bromide, or sodium bromide, with 50% concentrated sulfuric acid. **B1** the mixture is heated under reflux. **B1** $CH_3CH_2CH_2CH_2OH(l) + HBr(aq) \rightarrow CH_3CH_2CH_2CH_2Br(l) + H_2O(l)$; ignore state symbols. **B1** fully concentrated acid oxidises some of the bromide ions to bromine, wasting bromide and colouring the product orange. [4]

B4 OE-Q1

B1 potassium dichromate(VI) acidified with dilute sulfuric acid; accept sodium dichromate(VI). **B1** the solution changes from orange to green; both colours are needed for the mark. **B1** the product is propanone, CH_3COCH_3, a ketone. [3]

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B5 OE-Q4 **B1** propanal can be oxidised further, to propanoic acid, by the acidified dichromate. **B1** propanal has a lower boiling point, 49 °C, than propan-1-ol or propanoic acid, because its molecules do not hydrogen bond to each other. **B1** so it vaporises and leaves the flask before it can be oxidised further. [3]

B6 OE-Q5 **B1** it is a tertiary alcohol: the carbon bonded to the OH is bonded to three other carbons. **B1** oxidation removes a hydrogen from the carbon bonded to the OH as well as the H of the OH, and this carbon has no hydrogen. **B1** oxidation would need a C–C bond to break, which acidified dichromate cannot do, so the solution stays orange. [3]

B7 OE-Q6 **B1** a flask holding the mixture and anti-bumping granules, with a condenser fitted vertically above it, open at the top, water in at the bottom and out at the top. **B1** vapour from the boiling mixture condenses and runs back into the flask, so no volatile substance escapes. **B1** the aldehyde formed first stays in contact with the excess oxidising agent for as long as the mixture is heated, so it is oxidised to the carboxylic acid. [3]

B8 OE-Q9 **B1** but-1-ene, $CH_2{=}CHCH_2CH_3$, from the loss of H^+ from carbon 1. **B1** E-but-2-ene, from the loss of H^+ from carbon 3. **B1** Z-but-2-ene, the other stereoisomer, because each carbon of the double bond in but-2-ene carries H and CH_3. [3]

B9 OE-Q11 **M1** amount of propan-1-ol = 6.00 ÷ 60.0 = 0.100 mol, so the maximum amount of propanal is 0.100 mol. **M1** maximum mass of propanal = 0.100 × 58.0 = 5.80 g. **A1** percentage yield = 2.90 ÷ 5.80 × 100 = 50.0%, to three significant figures; allow 50%. [3]

B10 OE-Q12 **M1** amount of ethanol = 1.38 ÷ 46.0 = 0.0300 mol. **M1** one $Cr_2O_7^{2-}$ accepts six electrons and each ethanol gives two, so one dichromate oxidises three ethanol: 0.0300 ÷ 3 = 0.0100 mol. **A1** mass of $K_2Cr_2O_7$ = 0.0100 × 294.2 = 2.94 g, to three significant figures. [3]

B11 OE-Q14 **B1** propan-1-ol is in excess and volatile, so some vaporises and distils over with the propanal, especially if the flask is heated too strongly. **B1** water from the reaction mixture also distils over. **B1** redistil the product and collect only the fraction boiling close to 49 °C, between about 46 and 50 °C. [3]

B12 OE-Q15 **B1** in distillation the condenser slopes down away from the flask and the condensed liquid is collected separately; in reflux the condenser is vertical and the liquid returns to the flask. **B1** distillation removes the aldehyde as it forms, so the product is the aldehyde; reflux keeps it in the flask with the oxidising agent, so the product is the carboxylic acid. **B1** distillation uses the alcohol in excess and reflux uses the oxidising agent in excess, and neither apparatus is sealed. [3]

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B13 OE-Q16

B1 propanal boils at 49 °C and evaporates readily, so cooling the receiver reduces the loss of product. **B1** the thermometer bulb at the side arm measures the temperature of the vapour that is entering the condenser. **B1** so the reading shows which substance is distilling, and only the right fraction is collected. [3]

SECTION C · Long, 6 marks or more

C1 OE-Q7

Indicative content [6]

B1 acidified potassium dichromate(VI) is the oxidising agent, with the propan-1-ol in excess. **B1** the mixture is heated in a flask with anti-bumping granules, using a heating mantle or water bath rather than a flame. **B1** the flask is fitted with a still head, a thermometer with its bulb level with the side arm, and a sloping condenser with water in at the bottom and out at the top. **B1** the alcohol is added slowly so that propanal distils off as soon as it forms, before it can be oxidised further. **B1** the distillate is collected while the thermometer reads below about 60 °C, near propanal's boiling point of 49 °C. **B1** the receiver is cooled in ice and water to reduce evaporation, and the apparatus is left open to the air, not sealed.

Levels

Level 3 (5–6 marks) the oxidising agent, the apparatus for distillation and all the conditions that keep the yield high are given: excess alcohol added slowly, propanal distilled off as it forms, collection below about 60 °C and a cooled receiver.

Level 2 (3–4 marks) acidified dichromate(VI) and distillation are described with the thermometer or condenser placed correctly; one condition for a high yield, such as adding the alcohol slowly or collecting at the right temperature, is not given.

Level 1 (1–2 marks) acidified dichromate(VI) is named, usually with heating under reflux, which turns the propanal into propanoic acid; no condition for keeping the aldehyde is given.

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C2 OE-Q19 **Indicative content** [6]

B1 the alcohol is shaken with excess concentrated hydrochloric acid in a stoppered separating funnel, in a fume cupboard, at room temperature. **B1** the funnel is inverted and the tap opened often to release the pressure of hydrogen chloride gas as the mixture is shaken. **B1** the layers are allowed to separate and the lower aqueous layer is run off and discarded, the product being the upper layer. **B1** the product is shaken with sodium hydrogencarbonate solution to neutralise the remaining acid, releasing the pressure of carbon dioxide, then washed with water. **B1** the organic layer is run into a dry flask and swirled with anhydrous sodium sulfate until the cloudy liquid turns clear. **B1** the dried liquid is decanted and distilled, and the fraction boiling between about 49 and 53 °C is collected, near the boiling point of 51 °C.

Levels

Level 3 (5–6 marks) every stage is in order and justified: shaking with the acid while releasing pressure, discarding the aqueous layer, neutralising with hydrogencarbonate and releasing carbon dioxide, drying with an anhydrous salt until clear, and distilling to collect the fraction near 51 °C; the product layer is identified correctly throughout.

Level 2 (3–4 marks) the separating funnel, removing the aqueous layer and drying are described; the hydrogencarbonate wash, venting the pressure, or the final distillation with its collection range does not appear.

Level 1 (1–2 marks) the alcohol and acid are shaken together or a separating funnel is named; the product is often placed in the lower layer, and the purification is largely missing.

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