InkChemistry

ANSWER BOOK

Alcohols: hydration, fermentation and classification

Alkenes and alcohols · Unit C18

AQA 3.3.5.1, 3.3.5.2 · OCR A 4.2.1

21 questions · 61 marks

NAVY EDITION

Every question in this book has a code beside its number.
Type inklearning.co.uk/q/ followed by the code to open that question online.
© 2026 Ink Learning Ltd. All rights reserved.
inklearning.co.uk/chemistry/

SECTION A · Short, 1 to 2 marks

A1 AHF-Q1

B1 an alcohol in which the carbon atom bonded to the OH group is bonded to two other carbon atoms. **B1** the three-carbon secondary alcohol is propan-2-ol, $CH_3CH(OH)CH_3$. [2]

A2 AHF-Q5

B1 with oxygen present, yeast respires aerobically, converting glucose to carbon dioxide and water instead of ethanol. **B1** oxygen also lets bacteria oxidise the ethanol to ethanoic acid, which lowers the yield. [2]

A3 AHF-Q13

B1 the OH group forms hydrogen bonds with water molecules, but the hydrocarbon chain cannot. **B1** a longer chain disrupts more of the hydrogen bonding between water molecules while forming only weak van der Waals forces with water, so less alcohol dissolves. [2]

A4 AHF-Q14

B1 Brazil has the land and climate to grow sugar cane, a cheap and renewable source of sugar. **B1** fermentation does not use crude oil, so the fuel supply does not depend on oil prices or imports. [2]

A5 AHF-Q20

B1 ethanol is a weaker acid than water, so it reacts with sodium more slowly and steadily. **B1** heat is released more slowly, so the sodium does not melt and the hydrogen does not ignite. [2]

A6 AHF-Q17

B1 a fuel produced from renewable biological material, such as crops. [1]

SECTION B · Standard, 3 to 5 marks

B1 AHF-Q10

B1 fermentation uses a renewable raw material, sugar from crops, while hydration uses ethene from crude oil, which is finite. **B1** fermentation is a slow batch process, while hydration is fast and continuous. **B1** fermentation gives dilute ethanol, about 15%, that must be concentrated by fractional distillation, while hydration gives nearly pure ethanol. **B1** fermentation needs only a low temperature and cheap equipment but has an atom economy of 51.1%, while hydration needs high temperature and pressure in costly plant but has an atom economy of 100%. [4]

B2 AHF-Q16

B1 a curly arrow from the C=C double bond to an H^+ ion, giving the carbocation $CH_3C^+H_2$. **B1** a curly arrow from a lone pair on the oxygen of a water molecule to the positively charged carbon. **B1** the protonated alcohol, $CH_3CH_2OH_2^+$, with the positive charge on the oxygen. **B1** a curly arrow from an O–H bond to the oxygen, releasing H^+ and regenerating the catalyst. [4]

© 2026 Ink Learning Ltd. All rights reserved.

B3 AHF-Q2 — **B1** 2-methylpropan-1-ol is primary: the carbon bonded to the OH is bonded to one other carbon. **B1** pentan-3-ol is secondary: the carbon bonded to the OH is bonded to two other carbons. **B1** 2-methylbutan-2-ol is tertiary: the carbon bonded to the OH is bonded to three other carbons. [3]

B4 AHF-Q3 — **B1** yeast, whose enzymes catalyse the reaction, with glucose in aqueous solution. **B1** a temperature of 30 to 40 °C, typically about 35 °C. **B1** anaerobic conditions, with air excluded. [3]

B5 AHF-Q4 — **B1** at 20 °C the enzymes in the yeast work slowly, because fewer collisions have enough energy, so the rate is too low. **B1** at 60 °C the enzymes denature, their active sites changing shape, so the rate falls and the yeast dies. **B1** 35 °C gives a reasonable rate without denaturing the enzymes. [3]

B6 AHF-Q6 — **B1** $CH_2{=}CH_2(g) + H_2O(g) \rightleftharpoons CH_3CH_2OH(g)$. **B1** a temperature of about 300 °C. **B1** a phosphoric acid catalyst, H_3PO_4, on a silica support. [3]

B7 AHF-Q8 — **M1** amount of glucose = 90.0 ÷ 180.0 = 0.500 mol. **M1** two moles of CO_2 form per mole of glucose, so 1.00 mol of CO_2. **A1** volume = 1.00 × 24.0 = 24.0 dm³, to three significant figures. [3]

B8 AHF-Q9 — **B1** the forward reaction is exothermic, so a lower temperature would shift the equilibrium to the right and give a higher equilibrium yield. **B1** but at a lower temperature the rate would be too slow, even with the catalyst. **B1** 300 °C is a compromise that gives an acceptable yield at an acceptable rate. [3]

B9 AHF-Q12 — **B1** the O–H bond in ethanol is polar, because oxygen is much more electronegative than hydrogen. **B1** hydrogen bonds form between the δ+ H of one ethanol molecule and a lone pair on the O of another; reject any answer that breaks covalent bonds. **B1** propane has only van der Waals forces, of similar strength to ethanol's, so more energy is needed to separate ethanol molecules. [3]

B10 AHF-Q15 — **B1** the major product is propan-2-ol, $CH_3CH(OH)CH_3$. **B1** H^+ adds to the CH_2 end of the double bond, giving the secondary carbocation $CH_3C^+HCH_3$. **B1** the secondary carbocation is more stable than the primary one, having two electron-releasing alkyl groups, so it forms faster and water bonds to the middle carbon. [3]

B11 AHF-Q18 — **B1** in both reactions the O–H bond breaks and hydrogen is given off, ethanol forming the ethoxide ion, $CH_3CH_2O^-$, and water the hydroxide ion. **B1** the ethyl group releases electron density towards the oxygen, so the negative charge on ethoxide is more concentrated than on hydroxide. **B1** ethoxide therefore attracts H^+ more strongly, so ethanol releases H^+ less readily: it is a weaker acid and reacts more slowly. [3]

© 2026 Ink Learning Ltd. All rights reserved.

B12 AHF-Q19 **M1** amount of sodium = 0.230 ÷ 23.0 = 0.0100 mol. **M1** 2Na gives 1H_2, so 0.00500 mol of hydrogen forms. **A1** volume = 0.00500 × 24.0 = 0.120 dm^3 (120 cm^3), to three significant figures. [3]

B13 AHF-Q21 **M1** amount of ethanol = 2.30 × 10^6 g ÷ 46.0 = 5.00 × 10^4 mol. **M1** each glucose gives two ethanol, so 2.50 × 10^4 mol of glucose is needed. **A1** mass = 2.50 × 10^4 × 180.0 = 4.50 × 10^6 g, 4.50 tonnes, to three significant figures. [3]

B14 AHF-Q22 **M1** $C_6H_{12}O_6(aq) \rightarrow 2CH_3CH_2OH(aq) + 2CO_2(g)$, so one glucose gives two ethanol and two carbon dioxide. **M1** atom economy = mass of desired product ÷ total mass of reactants × 100 = (2 × 46.0) ÷ 180.0 × 100. **A1** atom economy = 92.0 ÷ 180.0 × 100 = 51.1%, the other 48.9% leaving as carbon dioxide, 2 × 44.0 = 88.0. [3]

SECTION C · Long, 6 marks or more

C1 AHF-Q11 **Indicative content** [6]

B1 photosynthesis, $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$, absorbs six molecules of CO_2 for each glucose the crop makes. **B1** fermentation, $C_6H_{12}O_6(aq) \rightarrow 2CH_3CH_2OH(aq) + 2CO_2(g)$, releases two molecules of CO_2 for each glucose fermented. **B1** combustion, $2CH_3CH_2OH(l) + 6O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l)$, releases four molecules of CO_2 when the two ethanol burn. **B1** the 2 + 4 = 6 molecules of CO_2 released equal the 6 absorbed in photosynthesis, which is the basis of the claim. **B1** but fossil fuels are burned in farming, making fertiliser, transporting the crop and in the fractional distillation, releasing CO_2 the crop did not absorb. **B1** so the claim is not fully valid: bioethanol gives lower net CO_2 emissions than petrol but is not carbon neutral; ignore answers about cost.

Levels

Level 3 (5–6 marks) all three equations are correct and balanced, the six molecules of carbon dioxide absorbed are shown to equal the two plus four released, the fossil-fuel inputs of farming, fertiliser, transport and distillation are identified, and the claim is judged partly valid with the reason.

Level 2 (3–4 marks) the photosynthesis and combustion equations are given and the carbon dioxide balance is argued; the fermentation equation or the molecule count is incomplete, or fossil-fuel inputs are listed without a judgement following from them.

Level 1 (1–2 marks) the claim is accepted because the crop absorbs the carbon dioxide released on burning, with one equation or none and no thought for the fuel used in farming, transport or distillation.

© 2026 Ink Learning Ltd. All rights reserved.

THIS BOOK ONLINE

Scan the code, or type the address, to open the questions in this book online:

inklearning.co.uk/chemistry/practise/questions/alcohols-production-and-classification/

© 2026 Ink Learning Ltd. All rights reserved.