2.8 Organic Chemistry: 1-hour Pack

AQA 8462 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Alkanes are a homologous series of saturated hydrocarbons.

(a) State the general formula of an alkane. **(1)**

(b) Deduce the molecular formula of the alkane that has 8 carbon atoms in its chain. **(1)**

(c) Name the alkane with the molecular formula C_5H_{12}. **(1)**

(Total for Question 1 is 3 marks)

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2 Extended response: Ethanol can be produced by fermentation of sugars using yeast, or by hydration of ethene using steam and a catalyst. Compare these two methods as ways to produce ethanol for use as a fuel or a solvent. In your answer discuss starting materials, conditions, relative speed, and whether the ethanol is renewable.

(Total for Question 2 is 6 marks)

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3 An organic chemist tests the purity of a sample of hexane by measuring its boiling range and comparing with literature value of hexane bp 68.7°C. The sample boils between 64.0°C and 74.5°C. Explain what these results indicate about the sample and give one laboratory technique the chemist could use to purify it.

(a) Explain what the observed boiling range indicates about the sample purity and why. **(2)**

(b) Give one laboratory technique the chemist could use to purify the hexane sample and briefly state how it separates components. **(2)**

(Total for Question 3 is 4 marks)

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4 A student is given an unknown organic liquid and tests show it decolourises bromine water slowly in the dark and burns with a clean, pale blue flame. The student suggests the liquid contains an alkene. State whether the observations support the suggestion and give one further test that would help confirm an alkene is present.

(a) Do the observations support the suggestion that the liquid contains an alkene? Explain briefly. **(2)**

(b) Give one further simple laboratory test to confirm an alkene and the expected result. **(1)**

(Total for Question 4 is 3 marks)

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5 Propanoic acid can be formed by oxidation of propan-1-ol.

(a) Give the structural formula of propan-1-ol. **(1)**

(b) Name a suitable oxidising agent and conditions used to oxidise propan-1-ol to propanoic acid in the laboratory. **(2)**

(Total for Question 5 is 3 marks)

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6 But-2-ene is an alkene with four carbon atoms.

(a) Draw (or describe in words) the displayed structural formula of but-2-ene, showing all atoms and bonds. **(2)**

(b) State the molecular formula of but-2-ene. **(1)**

(Total for Question 6 is 3 marks)

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7 The table shows the boiling points of the first four alkanes.
Methane (CH_4): -161 C
Ethane (C_2H_6): -89 C
Propane (C_3H_8): -42 C
Butane (C_4H_{10}): -1 C

Alkane	Molecular formula	Boiling point (C)
Methane	CH4	-161
Ethane	C2H6	-89
Propane	C3H8	-42
Butane	C4H10	-1

(a) Describe the trend shown in the table between chain length and boiling point. **(2)**

(b) Explain, in terms of intermolecular forces, why boiling point increases with chain length. **(2)**

(c) Which statement about hexane (C_6H_{14}) compared with methane (CH_4) is correct? **(1)**

- ☐ A) Hexane is more flammable and less viscous than methane
- ☐ B) Hexane is less flammable and more viscous than methane
- ☐ C) Hexane and methane have identical viscosity and flammability
- ☐ D) Hexane is a gas at room temperature, like methane

(Total for Question 7 is 5 marks)

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8 If there is a limited supply of oxygen, propane can undergo incomplete combustion instead of complete combustion.

(a) State two products, other than water, that can form during the incomplete combustion of a hydrocarbon fuel. **(2)**

(b) Explain why carbon monoxide gas is dangerous to humans. **(2)**

(c) Suggest one practical measure that reduces the risk of carbon monoxide poisoning in a home with a gas boiler. **(1)**

(Total for Question 8 is 5 marks)

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9 A commercial sample of ethene is passed over a hot catalyst and polymerises to poly(ethene). A chemist recovers 15.0 g of ethene monomer and produces 720 g of poly(ethene). Calculate the percentage yield of the polymerisation. Assume the polymer contains repeat units derived one-to-one from ethene monomer. Show your working.

(a) Calculate the theoretical mass of poly(ethene) expected from 15.0 g ethene if all monomer polymerised (assume 1 g monomer gives 1 g repeat unit). **(1)**

(b) Calculate the percentage yield given actual mass of polymer is 720 g (note: excess monomer from other sources was present; use the recovered monomer to determine percentage yield relative to what reacted). The chemist started with a large batch; 15.0 g of monomer was recovered unreacted and 720 g polymer was isolated. Assume initial total ethene available = recovered unreacted + that incorporated into polymer. **(2)**

(Total for Question 9 is 3 marks)

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10 A student investigates the rate of hydrogenation of cyclohexene to cyclohexane using different catalysts. The table shows initial rates (mol dm-3 s-1) at the same temperature with catalyst A, B and C.

Catalyst A: 2.40×10^{-4}
Catalyst B: 6.00×10^{-4}
Catalyst C: 1.20×10^{-3}

(a) State which catalyst is most active. **(1)**

(b) Calculate how many times more active catalyst C is than catalyst A. Give your working. **(2)**

(c) Suggest one physical property of the catalyst surface that could explain higher activity of catalyst C. **(1)**

(Total for Question 10 is 4 marks)

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11 But-1-ene reacts with hydrogen in the presence of a nickel catalyst.

(a) Write the structural formula of but-1-ene. **(1)**

(b) State the structural formula of the product after hydrogenation (addition of H_2) with Ni catalyst. **(2)**

(c) Give the name of the product. **(1)**

(Total for Question 11 is 4 marks)

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12 A sample of ethanol is oxidised by heating with acidified potassium dichromate(VI) solution to produce ethanoic acid.

(a) State the colour change observed as ethanol is oxidised by the acidified potassium dichromate(VI), and name the type of reaction taking place. **(2)**

(b) Write the word equation for the oxidation of ethanol to ethanoic acid. **(1)**

(Total for Question 12 is 3 marks)

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Mark scheme · 2.8 Organic Chemistry: 1-hour Pack

Question 1

(a) C_nH_{2n+2} **B1**

(a) Answer: C_nH_{2n+2}

(b) C_8H_{18} cao **B1**

(b) Answer: C_8H_{18}

(c) pentane **B1**

(c) Answer: Pentane.

Question 2

Level 3 Detailed comparison. Discusses both fermentation and hydration with several accurate points about starting materials, conditions, speed, yield and renewability. Draws a supported conclusion about which method is more suitable in a given context. **5-6**

Level 2 Some comparison. Mentions both methods and at least two correct points such as different starting materials and one difference in conditions or speed. Limited conclusion or justification. **3-4**

Level 1 Simple statements or description of one method only, or brief, largely factual points without comparison or judgement. **0-2**

Indicative content:

- Fermentation: starting material is sugar (glucose) from biomass; hydration: starting material is ethene from crude oil (non-renewable).
- Fermentation conditions: yeast, warm (about 30-40°C), anaerobic, relatively low temperature and pressure; hydration conditions: steam, high temperature and pressure and acid catalyst, industrial conditions.
- Speed and yield: fermentation is slower, gives lower concentration of ethanol (often 10-15% in batch) and requires distillation to purify; hydration is faster, continuous process and can give higher yields and purer product.
- Renewability: fermentation uses renewable biomass (sugars); hydration uses ethene derived from fossil fuels so is non-renewable unless ethene from bio-ethanol cracking is used.
- Uses and choice: for renewable fuel fermentation may be preferred despite lower yield; for large-scale pure ethanol for industry hydration may be preferred. Conclude with a justified statement comparing suitability for fuel or solvent.

Question 3

(a) states that a wide boiling range indicates a mixture rather than a pure compound **M1**

(a) explains that impurities cause lower and higher boiling components leading to a broadened range compared to single sharp bp at 68.7°C **A1**

(a) Answer: The wide boiling range shows the sample is impure (a mixture). Different components boil at different temperatures, producing a broader range rather than a sharp bp at 68.7°C.

(b) names appropriate technique: fractional distillation or simple distillation plus mention of stationary phase chromatography as alternative **M1**

(b) explains method: fractional distillation separates components by different boiling points using a fractionating column, collecting hexane fraction around 68.7°C **A1**

(b) Answer: Fractional distillation: uses a fractionating column to separate components by differing boiling points, allowing collection of the hexane fraction at around 68.7°C.

Question 4

(a) states that decolourisation of bromine water indicates a C=C (unsaturation) so supports an alkene **M1**

(a) states that a clean pale blue flame (complete combustion, no soot) is not diagnostic of an alkene, which more often burns with a smoky flame, so the flame observation does not by itself support the alkene suggestion **A1**

(a) Answer: Yes. Decolourisation of bromine water indicates a C=C double bond, which supports the presence of an alkene; the clean pale blue flame is not diagnostic for an alkene (alkenes more often burn with a smoky flame).

(b) addition of potassium manganate(VII): acidified $KMnO_4$ changes from purple to colourless; neutral or alkaline $KMnO_4$ changes from purple to a brown precipitate of manganese dioxide (with formation of a diol) **B1**

(b) Answer: Add acidified potassium manganate(VII): the purple solution goes colourless (neutral or alkaline manganate(VII) gives a brown precipitate of MnO_2).

Question 5

(a) $CH_3CH_2CH_2OH$ cao **B1**

(a) Answer: $CH_3CH_2CH_2OH$

(b) mentions acidified potassium dichromate(VI) ($K_2Cr_2O_7$ with dilute H_2SO_4) as oxidising agent **M1**

(b) states gentle heating under reflux to give the carboxylic acid, oe **A1**

(b) Answer: $CH_3CH_2CH_2OH$; oxidise with acidified potassium dichromate(VI) ($K_2Cr_2O_7$ + dilute H_2SO_4) on heating under reflux to give propanoic acid.

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Question 6

(a) correct skeleton of 4 carbon atoms joined in a chain (C-C=C-C) **M1**

(a) double bond correctly placed between the second and third carbon atoms, with the correct number of hydrogen atoms shown on each carbon (CH_3-CH=CH-CH_3) **A1**

(a) Answer: CH_3-CH=CH-CH_3 (a chain of 4 carbons with a C=C double bond between carbons 2 and 3, and 3, 1, 1, 3 hydrogens on carbons 1 to 4 respectively).

(b) C_4H_8 **B1**

(b) Answer: C_4H_8

Question 7

(a) as the number of carbon atoms (chain length) increases, the boiling point increases **M1**

(a) oe, e.g. reference to the specific values showing the increase, or that longer-chain alkanes are more likely to be liquids at room temperature **A1**

(a) Answer: Boiling point increases as chain length increases.

(b) longer chains have a greater surface area/more electrons, so stronger London (intermolecular) forces exist between molecules (oe) **M1**

(b) more energy is needed to overcome these forces, so a higher temperature (boiling point) is needed; ignore reference to breaking covalent/C-C bonds **A1**

(b) Answer: Longer-chain alkane molecules have stronger intermolecular forces (more surface contact/electrons), so more energy is required to separate the molecules, giving a higher boiling point.

(c) B **B1**

(c) Answer: B) Hexane is less flammable and more viscous than methane.

Question 8

(a) carbon monoxide (CO) **B1**

(a) carbon/soot (C) **B1**

(a) Answer: Carbon monoxide and carbon (soot).

(b) carbon monoxide binds to haemoglobin in red blood cells in place of oxygen (oe) **M1**

(b) this reduces the amount of oxygen that can be carried/transported around the body, starving cells of oxygen (oe) **A1**

(b) Answer: Carbon monoxide binds to haemoglobin instead of oxygen, reducing the oxygen carried in the blood, which can starve cells of oxygen and cause suffocation.

(c) install a carbon monoxide alarm/detector (oe, e.g. ensure good ventilation, have the boiler serviced regularly) **B1**

(c) Answer: Fit a carbon monoxide alarm (or ensure adequate ventilation/regular appliance servicing).

Question 9

(a) theoretical mass = 15.0 g **B1**

(a) Answer: 15.0 g

(b) calculates mass of ethene that reacted = mass incorporated = 720 g (polymer mass) and mass available = 720 + 15.0 = 735 g; substitutes into percentage yield = (mass reacted / mass available) x 100 **M1**

(b) percentage yield = (720 / 735) x 100 = 97.96% -> 98.0% to 3 s.f. cao **A1**

(b) Answer: 98.0%

Question 10

(a) Catalyst C cao **B1**

(a) Answer: Catalyst C

(b) divides rates: $(1.20 \times 10^{-3}) / (2.40 \times 10^{-4})$ **M1**

(b) 5.0 times cao **A1**

(b) Answer: 5.0 times

(c) greater surface area (smaller particle size, higher dispersion) or presence of more active sites/porosity **B1**

(c) Answer: Greater surface area (e.g. smaller particle size) giving more active sites.

Question 11

(a) structural formula showing CH_2=$CHCH_2CH_3$ or equivalent drawn structure **B1**

(a) Answer: CH_2=$CHCH_2CH_3$

(b) adds H_2 across C=C to give CH_3-CH_2-CH_2-CH_3 structural formula **M1**

(b) final product: $CH_3CH_2CH_2CH_3$ cao **A1**

(b) Answer: $CH_3CH_2CH_2CH_3$

(c) butane cao **B1**

(c) Answer: Butane

Question 12

(a) colour changes from orange to green as the dichromate(VI) is reduced **M1**

(a) the ethanol undergoes oxidation cao **A1**

(a) Answer: The orange dichromate(VI) solution turns green; the ethanol is oxidised.

(b) ethanol + oxygen -> ethanoic acid + water, oe (accept use of [O] to represent oxidation by the dichromate) **B1**

(b) Answer: Ethanol + oxygen -> ethanoic acid + water

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