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HIGHER

C7H Organic Chemistry: Higher Tier Practice

AQA 8462 · Calculator allowed · about 95 minutes

Total Marks

Name: ______________________________ Date: ____ / ____ / ______

Answer ALL questions. Show all your working.

1 Name the homologous series that contains compounds with the general formula CnH2n+2 and give one chemical property common to members of this series.

(a) Name the homologous series with general formula CnH2n+2. **(1)**

(Total for Question 1 is 1 mark)

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2 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 2 is 3 marks)

3 Complete the structural formula for the organic product when but-1-ene reacts with hydrogen in the presence of a nickel catalyst. Give the name of the product.

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

(b) State the structural formula of the product after hydrogenation (addition of H2) with Ni catalyst. **(2)**

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

(Total for Question 3 is 4 marks)

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4 A sample of ethanol is oxidised by heating with acidified potassium dichromate(VI) solution to produce ethanoic acid. State the colour change observed and write the word equation for the oxidation of ethanol to 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 4 is 3 marks)

5 A crude sample containing an unknown straight-chain alkane of molecular formula C6H14 was cracked. One product was ethene and the other product was an alkane. Write the balanced equation for this cracking and name the alkane produced. Show working.

(a) Write a balanced equation showing cracking of C6H14 to give C2H4 and an alkane. Include state symbols where appropriate (g for gases). **(3)**

(b) Name the alkane product. **(1)**

(Total for Question 5 is 4 marks)

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6 Explain briefly why straight-chain alkanes tend to have higher boiling points than branched isomers of the same molecular formula.

(a) Give the explanation. **(2)**

(Total for Question 6 is 2 marks)

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7 A 0.500 g sample of propanoic acid (ethanoic alternative not used) is dissolved in water to make 250.0 cm3 of solution. Calculate the concentration in mol/dm3. Relative formula mass of propanoic acid (C3H6O2) = 74.0.

(a) Calculate the number of moles of propanoic acid in 0.500 g. **(1)**

....

(b) Calculate the concentration in mol/dm3 of the solution (250.0 cm3). **(2)**

....

(Total for Question 7 is 3 marks)

8 Butane ($C4H10$) has two structural (chain) isomers: butane and 2-methylpropane. Draw the displayed formula for 2-methylpropane and explain what is meant by the term 'structural isomers'.

(a) Draw the displayed formula for 2-methylpropane. **(2)**

(b) Explain what is meant by the term 'structural isomers', using butane and 2-methylpropane as your example. **(2)**

(Total for Question 8 is 4 marks)

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9 Propanoic acid can be formed by oxidation of propan-1-ol. Give the structural formula of propan-1-ol and outline the oxidising agent and conditions commonly used in the laboratory for this conversion.

(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 9 is 3 marks)

10 A student reacts ethanol with ethanoic acid in the presence of a few drops of concentrated sulfuric acid, warming the mixture gently, to make an ester. Write the equation for this esterification reaction and describe how the student could confirm the ester has been made, including the role of the catalyst and the warming.

(a) Write the equation for the reaction of ethanol with ethanoic acid to form the ester (word or symbol equation). **(1)**

(b) Describe how the student could confirm that an ester has formed, and explain the roles of the concentrated sulfuric acid and the gentle warming in the reaction. **(3)**

(Total for Question 10 is 4 marks)

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11 Describe what is meant by a 'functional group' in organic chemistry and give one example relevant to alcohols.

(a) Define functional group. **(1)**

(b) Give one example of a functional group and name the homologous series it identifies. **(1)**

(Total for Question 11 is 2 marks)

12 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 12 is 3 marks)

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13 A student burns propane (C3H8) in a Bunsen burner. When the air hole is fully open, propane undergoes complete combustion. When the air hole is closed, incomplete combustion occurs, producing carbon monoxide as well as water. Write balanced symbol equations for the complete combustion of propane and for the incomplete combustion of propane producing only carbon monoxide and water, and explain why incomplete combustion is more dangerous than complete combustion.

(a) Write balanced symbol equations for (i) the complete combustion of propane and (ii) the incomplete combustion of propane producing only carbon monoxide and water. **(3)**

(b) Explain why incomplete combustion is more dangerous than complete combustion. **(2)**

(Total for Question 13 is 5 marks)

14 Compare the environmental advantages and disadvantages of disposing of waste polymers by recycling, incineration with energy recovery, and landfill. In your answer consider resource use, energy, emissions and long-term impacts. Give a justified recommendation for the best overall method, referencing the science. (6 marks)

Compare recycling, incineration with energy recovery, and landfill for disposing of waste polymers. Consider resource use, energy, emissions and long-term impacts. Give a justified recommendation for the best overall method, referencing the science.

(Total for Question 14 is 6 marks)

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15 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}

State which catalyst is most active, calculate how many times more active catalyst C is than A, and suggest one physical property of the catalyst surface that could explain higher activity.

(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 15 is 4 marks)

16 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 degrees C. The sample boils between 64.0 degrees C and 74.5 degrees 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 16 is 4 marks)

Mark scheme · C7H Organic Chemistry: Higher Tier Practice

Question 1

- (a) **B1** alkanes cao
- **(a) Answer: Alkanes**

Question 2

- (a) **M1** states that decolourisation of bromine water indicates a C=C (unsaturation) so supports an alkene
- (a) **A1** links clean pale blue flame (no soot) to being a hydrocarbon but not diagnostic, so observation partly supports alkene suggestion
- **(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 shows it is a hydrocarbon but is not diagnostic for alkene.**
- (b) **B1** addition of dilute potassium manganate(VII) (acidified $KMnO_4$) gives colour change from purple to brown/manganese dioxide or formation of diol
- **(b) Answer: Add acidified potassium manganate(VII): purple solution goes colourless/brown precipitate (MnO_2).**

Question 3

- (a) **B1** structural formula showing $CH_2=CHCH_2CH_3$ or equivalent drawn structure
- **(a) Answer: $CH_2=CHCH_2CH_3$**
- (b) **M1** adds H_2 across C=C to give $CH_3-CH_2-CH_2-CH_3$ structural formula
- (b) **A1** final product: $CH_3CH_2CH_2CH_3$ cao
- **(b) Answer: $CH_3CH_2CH_2CH_3$**
- (c) **B1** butane cao
- **(c) Answer: Butane**

Question 4

- (a) **M1** colour changes from orange to green as the dichromate(VI) is reduced
- (a) **A1** the ethanol undergoes oxidation cao
- **(a) Answer: The orange dichromate(VI) solution turns green; the ethanol is oxidised.**
- (b) **B1** ethanol + oxygen -> ethanoic acid + water, oe (accept use of [O] to represent oxidation by the dichromate)
- **(b) Answer: Ethanol + oxygen -> ethanoic acid + water**

Question 5

- (a) **M1** determines remaining alkane by atom balance: $C_6H_{14} \rightarrow C_2H_4 + C_4H_{10}$
- (a) **M1** balances formula and includes (g) state symbols
- (a) **A1** final balanced equation: $C_6H_{14}(g) \rightarrow C_2H_4(g) + C_4H_{10}(g)$ cao
- **(a) Answer: $C_6H_{14}(g) \rightarrow C_2H_4(g) + C_4H_{10}(g)$**
- (b) **B1** butane cao
- **(b) Answer: Butane**

Question 6

- (a) **M1** states straight-chain has larger surface area/contact and therefore stronger london (induced dipole) forces
- (a) **A1** concludes this requires more energy to overcome so higher boiling point
- **(a) Answer: Straight-chain alkanes have a greater surface area and closer contact between molecules so stronger London dispersion forces; more energy is needed to overcome these forces so boiling point is higher.**

Question 7

- (a) **B1** 0.00676 mol (0.500 / 74.0 = 0.00675676... so 0.00676 to 3 s.f.)
- **(a) Answer: 0.00676 mol**
- (b) **M1** converts volume to dm^3 and substitutes: conc = 0.00675676... / 0.250
- (b) **A1** 0.0270 mol/dm^3 cao (0.00675676 / 0.250 = 0.02702704 -> 0.0270)
- **(b) Answer: 0.0270 mol/dm^3**

Question 8

- (a) **M1** shows a central carbon bonded to three other carbons (a branched skeleton) rather than a straight chain
- (a) **A1** fully correct displayed formula: central CH bonded to three CH_3 groups, with all H atoms shown
- **(a) Answer: Displayed formula: a central carbon bonded to three CH_3 groups and one H, i.e. $(CH_3)_3CH$, with all bonds and H atoms shown.**
- (b) **M1** states that structural isomers have the same molecular formula (both C_4H_{10}), oe
- (b) **A1** but a different structural arrangement of atoms/different structural formula, e.g. butane is a straight chain while 2-methylpropane is branched, oe
- **(b) Answer: Structural isomers have the same molecular formula (C_4H_{10}) but a different arrangement of atoms: butane is a straight chain while 2-methylpropane is branched.**

Question 9

- (a) **B1** $CH_3CH_2CH_2OH$ cao
- **(a) Answer: $CH_3CH_2CH_2OH$**
- (b) **M1** mentions acidified potassium dichromate(VI) ($K_2Cr_2O_7$ with dilute H_2SO_4) as oxidising agent
- (b) **A1** states gentle heating under reflux to give the carboxylic acid, oe
- **(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.**

Question 10

- (a) **B1** ethanoic acid + ethanol -> ethyl ethanoate + water, or $CH_3COOH + C_2H_5OH \rightarrow CH_3COOC_2H_5 + H_2O$
- **(a) Answer: Ethanoic acid + ethanol -> ethyl ethanoate + water**
- (b) **M1** a sweet or fruity smell, characteristic of esters, shows that a new product has formed, oe
- (b) **M1** concentrated sulfuric acid acts as a catalyst, increasing the rate of the (otherwise slow) esterification reaction without being used up, oe
- (b) **A1** gentle warming provides energy to increase the rate of reaction while limiting the loss of the volatile reactants and product by evaporation, oe
- **(b) Answer: A sweet, fruity smell shows an ester has formed. The concentrated sulfuric acid acts as a catalyst, speeding up the reaction without being used up; gentle warming increases the rate of reaction while limiting loss of the volatile reactants and product by evaporation.**

Question 11

- (a) **B1** a group of atoms in a molecule responsible for the characteristic chemical reactions of that molecule/homologous series, oe
- **(a) Answer: A functional group is a group of atoms responsible for the characteristic reactions of a molecule or homologous series.**
- (b) **B1** -OH (hydroxyl group) identifies the alcohols, oe (accept -COOH for carboxylic acids, or C=C for alkenes)
- **(b) Answer: The -OH (hydroxyl) group identifies the alcohols.**

Question 12

- (a) **B1** theoretical mass = 15.0 g
- **(a) Answer: 15.0 g**
- (b) **M1** 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
- (b) **A1** percentage yield = (720 / 735) x 100 = 97.96% -> 98.0% to 3 s.f. cao
- **(b) Answer: 98.0%**

Question 13

- (a) **M1** complete combustion balanced: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$
- (a) **M1** incomplete combustion balanced with only CO and water as products: $2C_3H_8 + 7O_2 \rightarrow 6CO + 8H_2O$
- (a) **A1** both equations fully balanced with correct formulae cao
- **(a) Answer: Complete combustion: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$. Incomplete combustion: $2C_3H_8 + 7O_2 \rightarrow 6CO + 8H_2O$.**
- (b) **M1** incomplete combustion produces carbon monoxide, a toxic gas, oe
- (b) **A1** carbon monoxide binds to haemoglobin in the blood, reducing the amount of oxygen it can carry, and is dangerous because it is colourless and odourless so hard to detect, oe
- **(b) Answer: Incomplete combustion is more dangerous because it produces carbon monoxide, a toxic, colourless, odourless gas that binds to haemoglobin in the blood and reduces the amount of oxygen the blood can carry.**

Question 14

- **Level 3** (5-6): Detailed, balanced comparison with clear science: explains resource conservation by recycling, energy recovery benefits and emissions trade-offs of incineration, and long-term pollution and land use issues for landfill. Reaches a justified recommendation supported by specific scientific reasons.
- **Level 2** (3-4): Some comparative points with relevant science: mentions at least two methods and at least one advantage and disadvantage for each. Recommendation given with some justification.
- **Level 1** (1-2): Simple statements about methods with limited science, e.g. 'recycling is good' or 'landfill is bad', lacking development or justification.
- **Indicative content:**
  - Recycling: saves raw materials (reduces need for crude oil feedstock), lowers energy compared with making polymers from monomer, reduces landfill volume; challenges: contamination, sorting costs, downcycling, not all polymers easily recycled.
  - Incineration with energy recovery: reduces waste volume, generates electricity/heat offsetting fossil fuel use; disadvantages include CO_2 and possible toxic emissions if not well controlled, requires pollution control equipment.
  - Landfill: low immediate cost and simple, but long-term land use and potential leachate/soil contamination, polymers persist and do not biodegrade quickly, methane not generally from plastics, takes space for many years.
  - Recommendation could justify prioritising recycling where feasible for resource and energy savings, energy recovery for non-recyclable polymers with strict emission controls, and avoiding landfill where possible; explain trade-offs clearly.

Question 15

- (a) **B1** Catalyst C cao
- **(a) Answer: Catalyst C**
- (b) **M1** divides rates: $(1.20 \times 10^{-3}) / (2.40 \times 10^{-4})$
- (b) **A1** 5.0 times cao
- **(b) Answer: 5.0 times**
- (c) **B1** greater surface area (smaller particle size, higher dispersion) or presence of more active sites/porosity
- **(c) Answer: Greater surface area (e.g. smaller particle size) giving more active sites.**

Question 16

- (a) **M1** states that a wide boiling range indicates a mixture rather than a pure compound
- (a) **A1** explains that impurities cause lower and higher boiling components leading to a broadened range compared to single sharp bp at 68.7 degrees C
- **(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 degrees C.**
- (b) **M1** names appropriate technique: fractional distillation or simple distillation plus mention of stationary phase chromatography as alternative
- (b) **A1** explains method: fractional distillation separates components by different boiling points using a fractionating column, collecting hexane fraction around 68.7 degrees C
- **(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 degrees C.**