2.25 Alcohols, Carboxylic Acids and Polymers: 1-hour Pack

AQA 8464 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Alkenes such as ethene and propene can undergo addition polymerisation.

(space for your diagram)

(a) Define addition polymerisation. **(2)**

(b) Propene, $CH_2=CHCH_3$, undergoes addition polymerisation to form poly(propene). Draw the repeating unit of poly(propene), including the bracket and subscript n. **(3)**

(Total for Question 1 is 5 marks)

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2 Ethanol can be produced by the fermentation of sugar solution.

(a) Name the microorganism used in fermentation, and name the enzyme it contains that catalyses the reaction. **(2)**

(b) State two conditions needed for fermentation to occur. **(2)**

(c) Write a balanced symbol equation for the fermentation of glucose, $C_6H_{12}O_6$. **(2)**

(Total for Question 2 is 6 marks)

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3 Required practical: a student carries out an experiment to prepare a small sample of an ester from ethanoic acid and ethanol.

(a) State the two reagents used to prepare the ester, and name the catalyst added to the reaction mixture. **(3)**

(b) The mixture is gently warmed in a water bath rather than heated directly with a Bunsen burner flame. Explain why. **(2)**

(c) After heating, the mixture is poured into a solution of sodium carbonate. Describe the observation made and explain the purpose of this step. **(3)**

(d) Calculate the maximum theoretical mass of ethyl ethanoate that could be produced from 6.0 g of ethanoic acid, assuming ethanol is present in excess. (Mr of ethanoic acid = 60, Mr of ethyl ethanoate = 88) **(3)**

(e) The student's actual yield of ester was 6.2 g. Calculate the percentage yield, giving your answer to 3 significant figures. **(2)**

(Total for Question 3 is 13 marks)

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4 Higher tier only (Chemistry triple award). A carboxylic acid reacts with an alcohol to form an ester.

(a) Name the type of reaction that occurs between a carboxylic acid and an alcohol, and name the small molecule released. **(2)**

(b) Propanoic acid, C_2H_5COOH, reacts with methanol, CH_3OH, to form an ester. Write a balanced symbol equation for this reaction and name the ester formed. **(3)**

(Total for Question 4 is 5 marks)

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5 A student carries out an experiment, first adding a few drops of universal indicator to dilute ethanoic acid, then separately reacting a sample of the same acid with calcium carbonate chips.

(a) Higher tier only. Carboxylic acids are described as 'weak acids'. Explain what this means in terms of ionisation, and state how this affects the pH of the ethanoic acid compared with a strong acid of the same concentration. **(3)**

(b) Describe a method, including a positive test result, that the student could use to show that carbon dioxide gas is produced when calcium carbonate is added to the dilute ethanoic acid. **(3)**

(c) Write a balanced symbol equation, including state symbols, for the reaction between ethanoic acid and calcium carbonate. **(3)**

(Total for Question 5 is 9 marks)

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6 Ethanoic acid (Mr = 60) reacts with ethanol (Mr = 46) to form ethyl ethanoate (Mr = 88) and water. (Ar: H = 1, C = 12, O = 16)

(a) Calculate the relative formula mass (Mr) of methanoic acid, HCOOH. **(2)**

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(b) Calculate the percentage by mass of oxygen in methanoic acid. Give your answer to 1 decimal place. **(2)**

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(c) Higher tier only. Calculate the atom economy for the formation of ethyl ethanoate in this reaction. Give your answer to 1 decimal place. **(2)**

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(Total for Question 6 is 6 marks)

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7 Higher tier only (Chemistry triple award). Compare addition polymerisation and condensation polymerisation. In your answer, refer to the type(s) of monomer used, the type of link/repeating unit formed, and whether a by-product is released. Use named examples to support your answer.

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(Total for Question 7 is 6 marks)

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Mark scheme · 2.25 Alcohols, Carboxylic Acids and Polymers: 1-hour Pack

Question 1

(a) many small, unsaturated monomer molecules (each containing a C=C double bond) join together, oe **B1**

(a) to form one long-chain polymer molecule, with no other product formed, oe **B1**

(a) Answer: Addition polymerisation is a reaction in which many small, unsaturated monomer molecules (each containing a C=C double bond) join together to form one long-chain polymer molecule, with no other product formed.

(b) correct repeat unit skeleton -CH_2-$CH(CH_3)$-, with the C=C converted to a single C-C bond **M1**

(b) bonds shown correctly extending through both sides of the bracket to show the chain continues **M1**

(b) correct square bracket with subscript n placed outside, cao **A1**

(b) Answer: [-CH_2-$CH(CH_3)$-]n : a repeating unit of -CH_2-$CH(CH_3)$- enclosed in square brackets, with n as a subscript outside and the bonds extending through the brackets to show the chain continues.

Question 2

(a) yeast **B1**

(a) zymase (accept 'enzymes in yeast') **B1**

(a) Answer: Yeast; the enzyme zymase.

(b) warm temperature (approximately 25-40°C) **B1**

(b) anaerobic conditions (absence of oxygen/air) **B1**

(b) Answer: A warm temperature (around 25-40°C); anaerobic conditions (no oxygen present).

(c) correct products, ethanol and carbon dioxide **M1**

(c) correctly balanced: $C_6H_{12}O_6$ -> $2C_2H_5OH + 2CO_2$ cao **A1**

(c) Answer: $C_6H_{12}O_6$ -> $2C_2H_5OH + 2CO_2$

Question 3

(a) ethanoic acid **B1**

(a) ethanol **B1**

(a) (concentrated) sulfuric acid **B1**

(a) Answer: Ethanoic acid; ethanol; concentrated sulfuric acid (catalyst).

(b) ethanol and the ester product are flammable/volatile, so an open flame risks the vapour catching fire, oe **B1**

(b) a water bath provides gentler, more even heating, which is safer and reduces evaporation of the flammable liquids, oe **B1**

(b) Answer: Ethanol and the ester are flammable and volatile, so heating with a naked flame risks the vapour catching fire. A water bath provides gentler, more even heating, which is safer.

(c) observation: fizzing/effervescence (bubbles of gas seen) **B1**

(c) purpose: neutralises the leftover sulfuric acid catalyst and any unreacted ethanoic acid, oe **B1**

(c) so the ester (which does not mix with water and forms a separate layer) can be identified/separated cleanly, oe **B1**

(c) Answer: Fizzing (effervescence) is observed as carbon dioxide gas is released. The sodium carbonate neutralises the leftover sulfuric acid catalyst and unreacted ethanoic acid, so the ester (which forms a separate layer and does not mix with water) can be identified and separated cleanly.

(d) moles of ethanoic acid = 6.0 / 60 = 0.1 mol **M1**

(d) mole ratio acid:ester is 1:1, so moles of ester = 0.1 mol (ft) **M1**

(d) mass of ester = 0.1 x 88 = 8.8 g cao (ft) **A1**

(d) Answer: 8.8 g

(e) % yield = (actual yield / theoretical yield) x 100 = (6.2 / 8.8) x 100 (ft from part d) **M1**

(e) = 70.5% (awrt 70.5, ft) **A1**

(e) Answer: 70.5%

Question 4

(a) esterification (a condensation reaction) **B1**

(a) water **B1**

(a) Answer: Esterification (a condensation reaction); water is released.

(b) correct ester formula, $C_2H_5COOCH_3$ **M1**

(b) fully balanced equation: $C_2H_5COOH + CH_3OH$ -> $C_2H_5COOCH_3 + H_2O$ **M1**

(b) correct name: methyl propanoate cao **A1**

(b) Answer: $C_2H_5COOH + CH_3OH$ -> $C_2H_5COOCH_3 + H_2O$; the ester formed is methyl propanoate.

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Question 5

(a) a weak acid only partially ionises/dissociates in aqueous solution, oe **B1**

(a) so it produces fewer H^+ ions than a strong acid of the same concentration, oe **B1**

(a) so the carboxylic acid has a higher pH (is less acidic) than a strong acid of the same concentration, oe **B1**

(a) Answer: A weak acid only partially ionises in aqueous solution, producing fewer H^+ ions than a strong acid of the same concentration, so it has a higher pH (is less acidic) than a strong acid of the same concentration.

(b) collect the gas produced and bubble/pass it through limewater, oe **B1**

(b) using a delivery tube connecting the reaction vessel to a test tube of limewater, oe **B1**

(b) positive result: the limewater turns cloudy/milky if carbon dioxide is present **B1**

(b) Answer: Collect the gas given off using a delivery tube and bubble it through limewater. If carbon dioxide is present, the limewater turns cloudy (milky).

(c) correct formula for calcium ethanoate, $(CH_3COO)_2Ca$ **M1**

(c) correctly balanced: $2CH_3COOH + CaCO_3 \rightarrow (CH_3COO)_2Ca + H_2O + CO_2$ **M1**

(c) correct state symbols throughout: $2CH_3COOH(aq) + CaCO_3(s) \rightarrow (CH_3COO)_2Ca(aq) + H_2O(l) + CO_2(g)$ cao **A1**

(c) Answer: $2CH_3COOH(aq) + CaCO_3(s) \rightarrow (CH_3COO)_2Ca(aq) + H_2O(l) + CO_2(g)$

Question 6

(a) correct working shown, e.g. 1 + 12 + 16 + 16 + 1 **M1**

(a) Mr = 46 cao **A1**

(a) Answer: 46

(b) correct fraction, (32/46) x 100 (ft from part a) **M1**

(b) = 69.6% (awrt 69.6, ft) **A1**

(b) Answer: 69.6%

(c) atom economy = (Mr of desired product / sum of Mr of all reactants) x 100 = (88 / (60+46)) x 100 **M1**

(c) = 83.0% (awrt 83.0) **A1**

(c) Answer: 83.0%

Question 7

Level 1 Basic, isolated statement(s) about polymerisation with little or no comparison. Little or no reference to monomers, links or by-products. Examples may be missing or incorrect. **1-2**

Level 2 Relevant points about both types of polymerisation are made, with some links between them. At least one correct example is given. Some scientific terminology is used, but the comparison may be incomplete or contain minor inaccuracies. **3-4**

Level 3 A clear, logically structured comparison of addition and condensation polymerisation, correctly explaining the type(s) of monomer used, the type of link/repeating unit formed, and whether a by-product is released, supported by at least one correct named example of each. Accurate scientific terminology is used throughout. **5-6**

Indicative content:

- Addition polymerisation uses one type of monomer, which must be unsaturated (contains a C=C double bond), e.g. ethene forming poly(ethene) or propene forming poly(propene).
- In addition polymerisation, the double bond opens up and monomers join directly together; no other (by-)product is formed.
- Condensation polymerisation usually uses two different monomers, each with two functional groups (e.g. a diol and a dicarboxylic acid, or an amino acid with both $-NH_2$ and -COOH groups).
- In condensation polymerisation, a small molecule (usually water) is released as a by-product each time a new bond (e.g. an ester link or amide/peptide link) forms between monomers.
- Example of a condensation polymer: a polyester formed from a diol and a dicarboxylic acid, linked by ester bonds; or a polypeptide formed from amino acids, linked by peptide (amide) bonds.
- Both processes produce very large, long-chain polymer molecules made of many repeating units.

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