Centre number
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Centre Number Surname Other Names Candidate Signature Candidate Number For Examiner’s Use Examiner’s Initials Question Mark General Certificate of Education Advanced Level Examination January 2011 1 2 3 Chemistry Unit 4 Kinetics, Equilibria and Organic Chemistry 9. 00 am to 10. 45 am Wednesday 26 January 2011 CHEM4 4 5 6 7 For this paper you must have: â—€ the Periodic Table/Data Sheet, provided as an insert (enclosed) â —€ a calculator. TOTAL Time allowed â—€ 1 hour 45 minutes Instructions â —€ Use black ink or black ball-point pen. â—€ Fill in the boxes at the top of this page. â—€ Answer all questions. â—€ You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages. â—€ All working must be shown. â—€ Do all rough work in this book. Cross through any work you do not want to be marked. Information â— € The marks for questions are shown in brackets. â—€ The maximum mark for this paper is 100. â—€ The Periodic Table/Data Sheet is provided as an insert. â—€ Your answers to the questions in Section B should be written in continuous prose, where appropriate. â—€ You will be marked on your ability to: — use good English — organise information clearly — use accurate scientific terminology. Advice â—€ You are advised to spend about 70 minutes on Section A and about 35 minutes on Section B. (JAN11CHEM401) WMP/Jan11/CHEM4 CHEM4 2 Section A Answer all questions in the spaces provided. Do not write outside the box 1 The rate of hydrolysis of an ester X (HCOOCH2CH2CH3) was studied in alkaline conditions at a given temperature. The rate was found to be first order with respect to the ester and first order with respect to hydroxide ions. Name ester X. .... (1 mark) 1 (a) (i) 1 (a) (ii) Using X to represent the ester, write

a rate equation for this hydrolysis

reaction. .... (1 mark) 1 (a) (iii) When the initial concentration of X was 0. 024 mol dm—3 and the initial concentration of hydroxide ions was 0. 035 mol dm—3, the initial rate of the reaction was 8. 5 x 10—5 mol dm—3 s —1. Calculate a value for the rate constant at this temperature and give its units.

Calculation .....

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Units .....

.... (3 marks) 1 (a) (iv) In a second experiment at the same temperature, water was added to the original reaction mixture so that the total volume was doubled. Calculate the initial rate of reaction in this second

experiment. .... (1 mark) (02) WMP/Jan11/CHEM4 3 1 (a) (v) In a third experiment at the same temperature, the concentration of X was half that used in the experiment in part 1 (a) (iii) and the concentration of hydroxide ions was three times the original value. Calculate the initial rate of reaction in this third

experiment. .....

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..... (1 mark) 1 (a) (vi) State the effect, if any, on the value of the rate constant k when the temperature is lowered but all other conditions are kept constant. Explain your answer.

Effect .....

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Explanation .....

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..... (2 marks) 1 (b) Compound A reacts with compound B as shown by the overall equation A + 3B â†’ AB3 The rate equation for the reaction is rate = k[A][B]2 A suggested mechanism for the reaction is Step 1 Step 2 Step 3 A + B â†’ AB Do not write outside the box AB + B â†’ AB2 AB2 + B â†’ AB3 Deduce which one of the three steps is the rate-determining step. Explain your answer. Rate-determining

step .....

Explanation .....

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..... (2 marks) 11 Turn over (03) WMP/Jan11/CHEM4 4 Do not write outside the box There are no questions printed on this page DO NOT WRITE ON THIS PAGE ANSWER IN THE SPACES PROVIDED (04) WMP/Jan11/CHEM4 5 2 This question is about the pH of several solutions. Give all values of pH to 2 decimal places. 2 (a) (i) Write an expression for pH.

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..... (1 mark) 2 (a) (ii) Calculate the pH of 0. 154 mol dm—3 hydrochloric

acid. .....

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..... (1 mark) 2 (a) (iii) Calculate the pH of the solution formed when 10. 0 cm3 of 0. 154 mol dm—3 hydrochloric acid are added to 990 cm3 of

water. .....

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..... (2 marks) 2 (b) The acid dissociation constant, Ka, for the weak acid HX has the value 4. 83 x 10 —5 mol dm—3 at 25 °C. A solution of HX has a pH of 2. 48 Calculate the concentration of HX in the

solution. .....

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..... (4 marks) Question 2 continues on the next page Do not write outside the box Turn over (05) WMP/Jan11/CHEM4 6 2 (c) Explain why the pH of an acidic buffer solution remains almost constant despite the addition of a small amount of sodium

hydroxide. .....

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..... (2 marks) 2 (d) The acid dissociation constant, Ka, for the weak acid HY has the value 1. 35 x 10—5 mol dm—3 at 25 °C. A buffer solution was prepared by dissolving 0. 0236 mol of the salt NaY in 50. 0 cm3 of a 0. 428 mol dm—3 solution of the weak acid HY 2 (d) (i) Calculate the pH of this buffer

solution. .....

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..... (4 marks) Do not write outside the box (06) WMP/Jan11/CHEM4 7 2 (d) (ii) A 5. 00 x 10—4 mol sample of sodium hydroxide was added to this buffer solution. Calculate the pH of the buffer solution after the sodium hydroxide was

added. .....

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..... (4 marks) Do not write outside the box 18 Turn over for the next question Turn over (07) WMP/Jan11/CHEM4 8 3 Synthesis gas is a mixture of carbon monoxide and hydrogen. Methanol can be manufactured from synthesis gas in a reversible reaction as shown by the following equation. CO(g) + 2H2(g) 3 (a) CH3OH(g) H = —91 kJ mol—1 Do not write outside the box A sample of synthesis gas containing 0. 240 mol of carbon monoxide and 0. 380 mol of hydrogen was sealed together with a catalyst in a container of volume 1. 50 dm3. When equilibrium was established at temperature T1 the equilibrium mixture contained 0. 170 mol of carbon monoxide. Calculate the amount, in moles, of methanol and the amount, in moles, of hydrogen in the equilibrium mixture.

Methanol .....

.....

Hydrogen .....

..... (2 marks) 3 (b) A different sample of synthesis gas was allowed to reach equilibrium in a similar container of volume 1. 50 dm3 at temperature T1 At equilibrium, the mixture contained 0. 210 mol of carbon monoxide, 0.

275 mol of hydrogen and 0. 0820 mol of methanol. 3 (b) (i) Write an expression for the equilibrium constant Kc for this reaction. .... (1 mark) 3 (b) (ii) Calculate a value for Kc for the reaction at temperature T1 and state its units.

Calculation ....

Units .... (4 marks) 3 (b) (iii) State the effect, if any, on the value of Kc of adding more hydrogen to the equilibrium mixture. .... (1 mark) (08) WMP/Jan11/CHEM4 9 3 (c) The temperature of the mixture in part 3 (b) was changed to T2 and the mixture was left to reach a new equilibrium position. At this new temperature the equilibrium concentration of methanol had increased. Deduce which of T1 or T2 is the higher temperature and explain your answer. Higher temperature ....

Explanation ....

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..... (3 marks) 3 (d) The following reaction has been suggested as an alternative method for the production of methanol. CO2(g) + 3H2(g) CH3OH(g) + H2O(g) Do not write outside the box The hydrogen used in this method is obtained from the electrolysis of water. Suggest one possible environmental disadvantage of the production of hydrogen by

electrolysis. .....

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..... (1 mark) 3 (e) One industrial use of methanol is in the production of biodiesel from vegetable oils such as CH2OOCC17H35 CHOOCC17H31 CH2OOCC17H29 Give the formula of one compound in biodiesel that is formed by the reaction of methanol with the vegetable oil shown

above. .....

..... (1 mark) 13 Turn over (09) WMP/Jan11/CHEM4 10 4 (a) Name compound Y,

HOCH2CH2COOH .....

..... (1 mark) 4 (b) 4 (b) (i) Under suitable conditions, molecules of Y can react with each other to form a polymer. Draw a section of the polymer showing two repeating units. Do not write outside the box (1 mark) 4 (b) (ii) Name the type of polymerisation

involved. .....

..... (1 mark) 4 (c) When Y is heated, an elimination reaction occurs in which one molecule of Y loses one molecule of water. The organic product formed by this reaction has an absorption at 1637 cm—1 in

its infrared spectrum. Identify the bond that causes the absorption at 1637 cm—1 in its infrared

spectrum. .... (1 mark) 4 (c) (ii) Write the displayed formula for the organic product of this elimination reaction. 4 (c) (i) (1 mark) 4 (c) (iii) The organic product from part 4 (c) (ii) can also be polymerised. Draw the repeating unit of the polymer formed from this organic product. (1 mark) (10) WMP/Jan11/CHEM4 11 4 (d) At room temperature, 2-aminobutanoic acid exists as a solid. Draw the structure of the species present in the solid form. Do not write outside the box (1 mark) 4 (e) The amino acid, glutamic acid, is shown below. Draw the structure of the organic species formed when glutamic acid reacts with each of the following. 4 (e) (i) an excess of sodium hydroxide (1 mark) 4 (e) (ii) an excess of methanol in the presence of concentrated sulfuric acid (1 mark) 4 (e) (iii) ethanoyl chloride (1 mark) Question 4 continues on the next page Turn over (11) WMP/Jan11/CHEM4 12 4 (f) A tripeptide was heated with hydrochloric acid and a mixture of amino acids was formed. This mixture was separated by column chromatography. Outline briefly why chromatography is able to separate a mixture of compounds. Practical details are not

required. ....

.... (3 marks) Do not write outside the box 13 (12) WMP/Jan11/CHEM4 13 Turn over for the next question DO NOT WRITE ON THIS PAGE ANSWER IN THE SPACES PROVIDED Turn over (13) WMP/Jan11/CHEM4 14 5 Atenolol is an example of the type of medicine called a beta blocker. These medicines are used to lower blood pressure by slowing the heart rate. The structure of atenolol is shown below. OH H2N C O J 5 (a) CH2 O CH2 p CH CH2 H N CH3 CH CH3 q Do not write outside the box K Give the name of each of the circled functional groups labelled J and K on the structure of atenolol shown above. Functional group labelled

J ..... Functional group labelled K .....

(2 marks) 5 (b) The 1H n. m. r. spectrum of atenolol was recorded. One of the peaks in the 1H n. m. r. spectrum is produced by the CH2 group labelled p in the structure of atenolol. Use Table 2 on the Data Sheet to suggest a range of Î´ values for this peak. Name the splitting pattern of this peak. Range of Î´

values .....

Name of splitting

pattern ..... (2 marks) 5 (c) N. m. r. spectra are recorded using samples in solution. The 1H n. m. r. spectrum was recorded using a solution of atenolol in CDCl3 Suggest why CDCl3 and not CHCl3 was used as the solvent.