OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced GCE

CHEMISTRY 2816/01

Unifying Concepts in Chemistry

Wednesday **21 JANUARY 2004** Morning 1 hour 15 minutes

Candidates answer on the question paper.
Additional materials:
Data Sheet for Chemistry
Scientific calculator

Candidate Name	Centre Number	Candidate Number

TIME 1 hour 15 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces provided on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- You may use the *Data Sheet for Chemistry*.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	16	
2	17	
3	13	
4	14	
TOTAL	60	

This question paper consists of 11 printed pages and 1 blank page.

Registered Charity Number: 1066969
[Turn over

Answer **all** the questions.

1 The formation of ethyl ethanoate and water from ethanoic acid and ethanol is a reversible reaction which can be allowed to reach equilibrium. The equilibrium is shown below.

$$CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$$

(a) Write the expression for K_c for this equilibrium system.

[2]

(b) A student mixed together 6.0 mol ethanoic acid and 12.5 mol ethanol. A small amount of hydrochloric acid was also added to catalyse the reaction. He left the mixture for two days to reach equilibrium in a water bath at constant temperature, after which time 1.0 mol ethanoic acid remained.

(i) Complete the table below to show the equilibrium composition of the equilibrium mixture.

component	CH_3COOH	C_2H_5OH	$CH_3COOC_2H_5$	H_2O
initial amount / mol	6.0	12.5	0.0	0.0
equilibrium amount / mol				

[2]

(ii) Calculate K_c to two significant figures. State the units, if any. The total volume of the equilibrium mixture is 1.0 dm^3.

K_c = ... units ..... [2]

(c) The student was concerned that the mixture may **not** have reached equilibrium. What could he do to be sure that equilibrium had been reached?

.....

.....

.....[2]

(d) The student added more ethanol to the mixture.

(i) State, giving a reason, what would happen to the composition of the equilibrium mixture.

.....

.....

.....[2]

(ii) What happens to the value of K_c?

.....[1]

(e) The student added more of the acid catalyst to the mixture.
State, giving a reason, what would happen to the composition of the equilibrium mixture.

.....

.....

.....[2]

(f) The student repeated the experiment at a higher temperature and found that the value of K_c decreased.

(i) State, giving a reason, what would happen to the composition of the equilibrium mixture.

.....

.....

.....[2]

(ii) What additional information does this information tell you about the reaction?

.....

.....[1]

[Total: 16]

2 Hydrogen peroxide, H_2O_2, is a colourless liquid, widely used as an oxidising agent, antiseptic, and bleach for hair and cloth.

Hydrogen peroxide reacts with iodide ions, I^-, in the presence of acid, $H^+(aq)$, forming iodine, I_2.

(a) Suggest a balanced equation for the overall reaction between $H_2O_2(aq)$, $I^-(aq)$ and $H^+(aq)$ to form aqueous iodine.

.....[2]

(b) Three experiments were carried out using different initial concentrations of $H_2O_2(aq)$, $I^-(aq)$ and $H^+(aq)$. The initial rate of formation of I_2 was measured for each experiment.

The experimental results are shown below.

experiment	$[H_2O_2(aq)]$ /mol dm^{-3}	$[I^-(aq)]$ /mol dm^{-3}	$[H^+(aq)]$ /mol dm^{-3}	rate /mol dm^{-3} s^{-1}
1	0.010	0.010	0.005	1.15×10^{-6}
2	0.010	0.020	0.005	4.60×10^{-6}
3	0.010	0.020	0.010	4.60×10^{-6}

(i) Showing all your reasoning, determine the reaction orders for I^- and for H^+.

.....

.....

.....

.....

.....

.....[4]

(ii) This reaction is first order with respect to H_2O_2.
Use this information and your answers to **(i)** to complete the rate equation for this reaction.

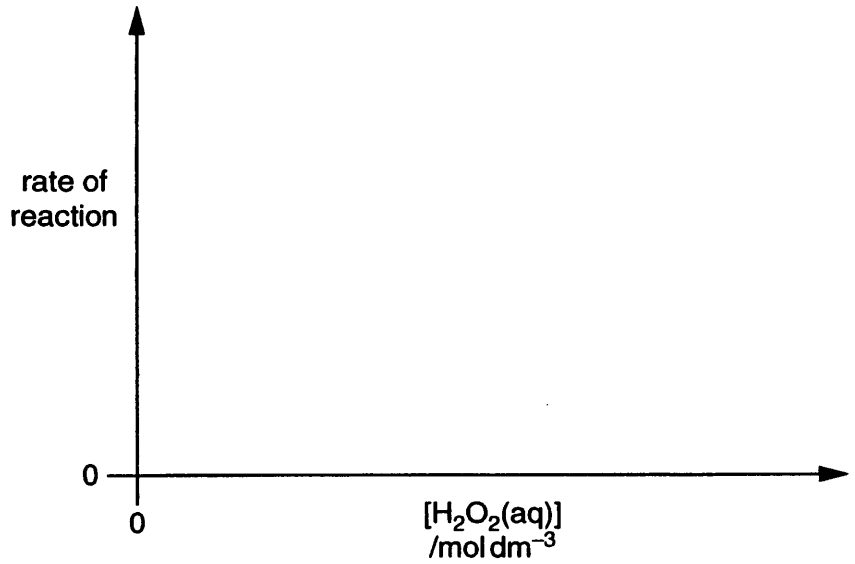
rate = ...[2]

(iii) Calculate the rate constant *k* for this reaction. State the units for *k*.

rate constant, *k* ..... units ..... [3]

(c) This reaction was shown to be first order with respect to H_2O_2 by plotting a rate-concentration graph.

Using the axes below, sketch a graph to show how the rate of this reaction changes with increasing H_2O_2 concentration.



[2]

(d) Hydrogen peroxide readily decomposes to give water and oxygen.

Hydrogen peroxide is sold by volume strength. For example, 20-volume H_2O_2 yields 20 volumes of oxygen gas for each volume of aqueous H_2O_2 solution.

(i) Construct an equation for the decomposition of hydrogen peroxide.

.....[1]

(ii) Determine the concentration, in mol dm^{-3}, of 20-volume hydrogen peroxide.

Show all your working clearly.

answer ..... mol dm^{-3} [3]

[Total: 17]

3 Carbonic acid, H_2CO_3, is a weak Bronsted-Lowry acid formed when carbon dioxide dissolves in water. Blood contains several buffer solutions and healthy blood is buffered to a pH of 7.40. The most important buffer solution in blood is a mixture of carbonic acid and hydrogencarbonate ions, HCO_3^-.

The equilibrium in the carbonic acid / hydrogencarbonate buffer system is shown below.

$$H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq) \qquad K_a = 4.17 \times 10^{-7}\,\text{mol dm}^{-3}$$

(a) Carbonic acid is a weak Bronsted-Lowry acid.

What is meant by the following terms?

(i) A *Bronsted-Lowry acid.*

.....

..... [1]

(ii) A *weak* acid.

.....

..... [1]

(iii) pH.

..... [1]

(iv) A *buffer solution.*

.....

..... [1]

(b) In this question, one mark is available for the quality of written communication.

Explain how the carbonic acid / hydrogencarbonate buffer works. Use equations to help your answer.

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.....[4]

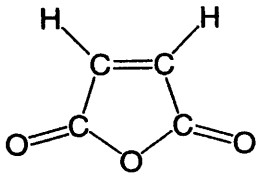
Quality of Written Communication [1]

(c) Calculate the ratio $\frac{[HCO_3^-(aq)]}{[H_2CO_3(aq)]}$ in healthy blood with a pH of 7.40.

[4]

[Total: 13]

4 Maleic anhydride (*cis*-butenedioic anhydride) is an important industrial chemical. The structure of maleic anhydride is shown below.



maleic anhydride
$C_4H_2O_3$

(a) In industry, maleic anhydride is produced on a large scale by oxidation of butane in air over a hot catalyst.

(i) Suggest the industrial source of butane.

.....[1]

(ii) An incomplete equation for this reaction is given below.

Complete the equation.

$$C_4H_{10} + \text{.....} \rightarrow C_4H_2O_3 + \text{.....}$$

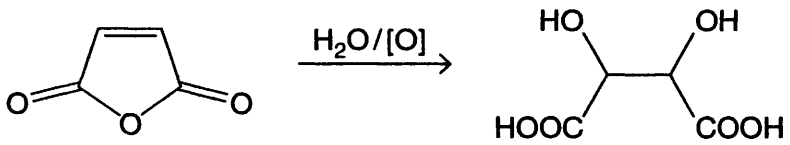
[2]

(iii) Calculate the mass, in kg, of maleic anhydride that could be made by completely converting 30 m^3 of butane in this reaction. (1 m^3 = 1000 dm^3)

Assume that the molar volume of butane under the conditions used is 24 dm^3.

answer ..... kg [3]

(b) Maleic anhydride can be converted into tartaric acid by reaction with water and a suitable oxidising agent.



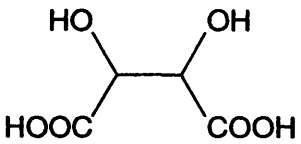
maleic anhydride **tartaric acid**

Deduce the **empirical** formula of tartaric acid.

[2]

(c) 'Cream of tartar' is often used in cookery.
This compound can be prepared by reacting aqueous solutions of tartaric acid and potassium hydroxide in 1:1 molar proportions.

(i) Complete the equation below for the preparation of 'cream of tartar'.



\+ KOH → + ...

tartaric acid **'cream of tartar'**

[2]

(ii) Suggest another chemical that would react with aqueous tartaric acid. The chemical you choose should **not** be a hydroxide or an oxide.

State what you would expect to see and write an equation for your chosen reaction.

chemical .....

observation(s) .....

.....

equation

[4]

[Total: 14]