OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE **2816/01**

CHEMISTRY

Unifying Concepts in Chemistry

THURSDAY 12 JUNE 2008 Afternoon

Time: 1 hour 15 minutes

Additional materials: Scientific calculator
Data Sheet for Chemistry (Inserted)

*C U P / T 3 3 5 2 2 *

Candidate Forename | Candidate Surname

Centre Number | Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	**11**	
2	**15**	
3	**11**	
4	**9**	
5	**14**	
TOTAL	**60**	

This document consists of **12** printed pages and a *Data Sheet for Chemistry*.

[Turn over

Answer **all** the questions.

1 The hydrolysis of ethyl ethanoate is a reversible reaction. The equation for the equilibrium is shown below.

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

A student mixed together 8.0 mol ethyl ethanoate and 5.0 mol water. He also added a small amount of hydrochloric acid to catalyse the reaction.

The student left the mixture until it had reached equilibrium at constant temperature. He found that 2.0 mol of ethanoic acid had formed.

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

[1]

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

component	$CH_3COOC_2H_5$	H_2O	CH_3COOH	C_2H_5OH
initial amount / mol	8.0	5.0	0.0	0.0
equilibrium amount / mol			2.0	

[2]

(ii) The mole fraction of CH_3COOH can be found from the composition of the equilibrium mixture.

Explain what is meant by the term *mole fraction* and calculate the mole fraction of CH_3COOH in the equilibrium mixture.

mole fraction .....

.....

mole fraction of CH_3COOH

[2]

(iii) Calculate K_c to an appropriate number of significant figures. State the units, if any.

K_c = …… units ..... [3]

(c) The student left the mixture at a higher temperature until a new equilibrium had been reached. He again measured the equilibrium amount of ethanoic acid and found that it had increased.

What conclusions can be drawn about the reaction and its equilibrium constant?

.....

.....

.....

.....

.....

.....

.....[3]

[Total: 11]

2 Hydrogen peroxide, H_2O_2, is a strong oxidising agent that has bleaching properties.

(a) Hydrogen peroxide oxidises iodide ions, $I^-(aq)$, in the presence of acid, $H^+(aq)$.

The rate equation for this reaction is shown below.

$$\text{rate} = k[H_2O_2(aq)][I^-(aq)]$$

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

Some of the experimental results are shown in the table below.

experiment	$[H_2O_2(aq)]$ / mol dm^{-3}	$[I^-(aq)]$ / mol dm^{-3}	$[H^+(aq)]$ / mol dm^{-3}	initial rate / mol dm^{-3} s^{-1}
1	0.020	0.010	0.0050	2.30×10^{-6}
2	0.040	0.010	0.0050	
3	0.020	0.010	0.0025	
4	0.100	0.005	0.0100	

(i) Deduce the initial rates for experiments 2, 3 and 4. Complete the table.

[3]

(ii) Use the results of experiment 1 to calculate the rate constant *k* for this reaction. State the units for *k*.

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

(iii) The overall equation for this reaction is shown below.

$$H_2O_2(aq) + 2I^-(aq) + 2H^+(aq) \longrightarrow I_2(aq) + 2H_2O(l)$$

The rate equation is: rate = $k[H_2O_2(aq)][I^-(aq)]$.

Explain what the overall equation and the rate equation tell us about the reaction.

.....

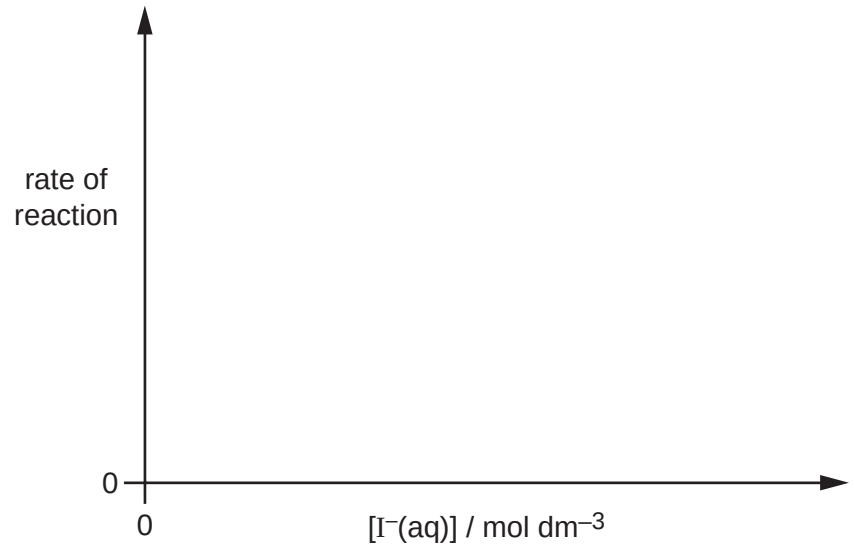
.....

.....

.....

.....[3]

(b) Using the axes below, sketch a graph to show how the rate of this reaction changes with increasing $I^-(aq)$ concentration.



[1]

(c) Hydrogen peroxide is used in the preparation of 'carbamide peroxide', widely used by dentists as a 2.30 mol dm^{-3} solution for teeth-whitening.

Carbamide peroxide has the following percentage composition by mass.

H, 6.38%; O, 51.06%; N, 29.79%; C, 12.77%.

The empirical formula of carbamide peroxide is the same as its molecular formula.

Calculate the mass of carbamide peroxide that is required to prepare 150 cm^3 of a teeth-whitening solution for use by dentists.

[5]

[Total: 15]

3 Potassium hydroxide, KOH, is a strong alkali and vitamin C is a weak Brønsted-Lowry acid.

(a) What is meant by a *weak Brønsted-Lowry acid*?

.....

.....

.....

.....[2]

(b) An aqueous solution of KOH had a pH of 12.72 at 25 °C.

$K_w = 1.00 \times 10^{-14}\,mol^2\,dm^{-6}$ at 25 °C.

(i) What is the expression for K_w?

.....[1]

(ii) Calculate the concentration, in mol dm^{-3}, of this solution of KOH.

[2]

(c) Vitamin C, $C_6H_8O_6$, has a K_a value of $6.76 \times 10^{-5}\,mol\,dm^{-3}$.

The equilibrium for the dissociation of vitamin C in water is shown below.

$$C_6H_8O_6(aq) \rightleftharpoons H^+(aq) + C_6H_7O_6^-(aq)$$

0.500 g of vitamin C was dissolved in water to form a solution with a volume of $125\,cm^3$.

Calculate the pH of the solution formed.

[6]

[Total: 11]

4 In this question, one mark is available for the quality of use and organisation of scientific terms.

A buffer solution can be prepared by mixing together a weak acid with a salt of the weak acid.

The pK_a values of some weak acids are shown below.

weak acid	pK_a
chloroethanoic acid	2.9
methanoic acid	3.8
ethanoic acid	4.8
carbonic acid	6.4
boric acid	9.2

- Explain what is meant by the term *buffer solution*.
- Explain, with equations, how a buffer solution works.
- Choose from the table above the most appropriate weak acid that could be used to prepare a buffer solution with a pH in the range of 3.5–4.5. Explain how you made your choice and suggest a salt that could be added to this weak acid to prepare the buffer solution.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[8]

Quality of Written Communication [1]

[Total: 9]

TURN OVER FOR QUESTION 5

5 Calcium cyanamide, $CaCN_2$, is an environmentally-friendly fertiliser commonly referred to as 'nitrogen-lime'. It can be prepared in a three-stage synthesis using the readily available raw materials, limestone (calcium carbonate) and coke (carbon).

Stage 1 The calcium carbonate is first converted into calcium oxide by heat.

Stage 2 The calcium oxide is heated with coke to form calcium carbide, CaC_2.

Stage 3 Calcium carbide is reacted with nitrogen gas at a high temperature to produce calcium cyanamide, $CaCN_2$, and an element.

(a) Write balanced equations for the reactions that take place in the three stages of this synthesis.

.....

.....

.....[3]

(b) Calcium cyanamide is an ionic compound.

Suggest a '*dot-and-cross*' diagram for the cyanamide ion, CN_2^{2-}.

The carbon atom is located between the two nitrogen atoms.

[2]

(c) On making contact with water present in the soil, calcium cyanamide is hydrolysed.

Suggest an equation for this hydrolysis.

State the benefits of the hydrolysis products for the farmer.

.....

.....

.....

.....

.....[4]

(d) The calcium carbide obtained in Stage 2 can also be reacted with water to prepare ethyne gas, C_2H_2. Ethyne is commonly called 'acetylene' and is used in oxy-acetylene welding.

- Write a balanced equation for the reaction between calcium carbide and water.

- Calculate the volume of ethyne gas, measured at room temperature and pressure, r.t.p., that could be made from 20 kg of limestone.

  1 mol of ethyne occupies 24 dm^3 at r.t.p.

- Write a balanced equation for the reaction that takes place to produce the oxy-acetylene flame during welding.

[5]

[Total: 14]

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE