

**ADVANCED GCE****CHEMISTRY**

Unifying Concepts in Chemistry

2816/01

Candidates answer on the question paper

OCR Supplied Materials:

- *Data Sheet for Chemistry* (Inserted)

Other Materials Required:

- Scientific calculator

Wednesday 28 January 2009**Afternoon****Duration:** 1 hour 15 minutes

Candidate Forename		Candidate Surname	
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Centre Number						Candidate Number				
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INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use 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.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.

INFORMATION FOR CANDIDATES

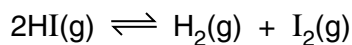
- The number of marks is given in brackets [] at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- A copy 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.
- This document consists of **12** pages. Any blank pages are indicated.

FOR EXAMINER'S USE

Qu.	Max.	Mark
1	15	
2	12	
3	14	
4	19	
TOTAL	60	

Answer **all** the questions.

- 1 The decomposition of gaseous hydrogen iodide to form hydrogen and iodine gases is a reversible reaction.



- (a) Write the expression for K_c for an equilibrium mixture of these three gases.

[1]

- (b) A student added 0.50 mol HI(g) to a 1.0 dm³ container. The container was sealed and the contents were allowed to reach equilibrium at constant temperature.

The student then analysed the equilibrium mixture and found that 0.11 mol I₂(g) was present.

- (i) Complete the table below to show the amount of each gas in the equilibrium mixture.

gas	HI(g)	H ₂ (g)	I ₂ (g)
initial amount / mol	0.50	0.00	0.00
equilibrium amount / mol			0.11

[2]

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

$K_c = \dots\dots\dots$ units, if any $\dots\dots\dots$ [3]

- (c) The student compressed the equilibrium mixture so that its volume was reduced. The temperature was kept constant.

Comment on the value of K_c and the composition of the equilibrium mixture under these new conditions.

.....

 [2]

- (d) The student repeated the experiment at a higher temperature and found that more $I_2(g)$ was present at equilibrium.

Comment on the value of K_c and explain what additional information this tells you about the reaction.

.....

 [2]

- (e) Hydrogen iodide gas is mixed with chlorine gas.

Two reactions take place forming different compounds of iodine, **A** and **B**.

Compounds **A** and **B** each contain I and Cl only.

- In the first reaction, compound **A** forms as a reddish brown liquid.
Compound **A** contains 78.15% of I by mass.
- In the second reaction, compound **B** forms as yellow crystals.
Compound **B** has a molar mass of 467 g mol^{-1} .

Deduce possible identities for **A** and **B** and write balanced equations for their formation.

A:

equation:

B:

equation: [5]

[Total: 15]

- 2 The reaction between nitrogen monoxide, NO, and oxygen, O₂, has the following rate equation.

$$\text{rate} = k[\text{NO}(\text{g})]^2[\text{O}_2(\text{g})]$$

- (a) What is the overall order of this reaction?

..... [1]

- (b) The reaction rate is $6.90 \times 10^{-7} \text{ mol dm}^{-3} \text{ s}^{-1}$ when

- the concentration of NO(g) is $2.80 \times 10^{-4} \text{ mol dm}^{-3}$
- the concentration of O₂(g) is $1.44 \times 10^{-3} \text{ mol dm}^{-3}$.

Calculate the rate constant, k , for this reaction. State the units.

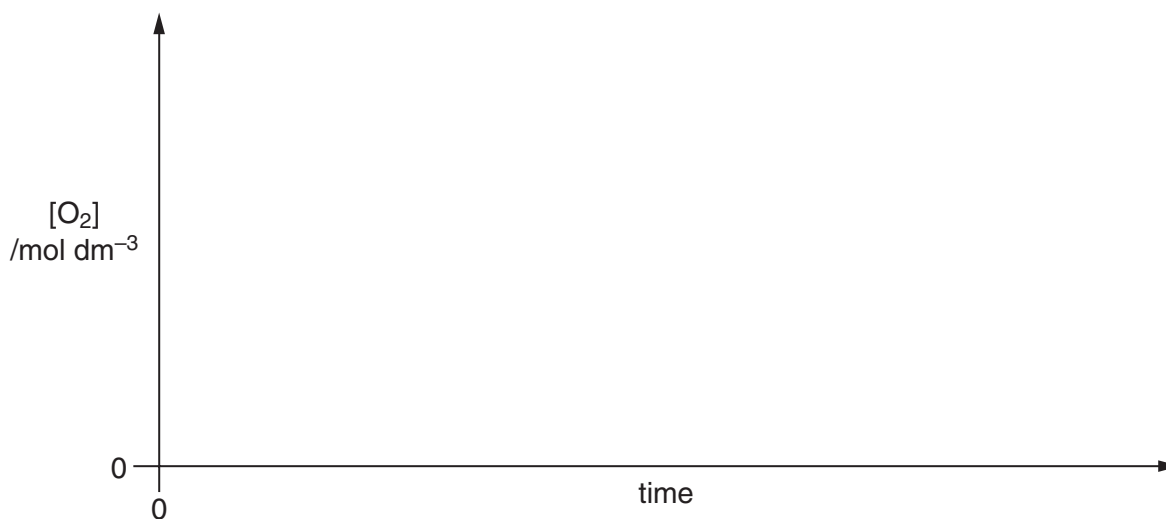
Give your answer to an appropriate number of significant figures.

rate constant, $k =$

units [3]

- (c) The rate equation was determined experimentally.

- (i) On the axes below, sketch a graph to show how the concentration of O₂ changes during the course of the reaction.



[1]

- (ii) Explain how you would use the graph to determine the **initial** rate of the reaction.

.....

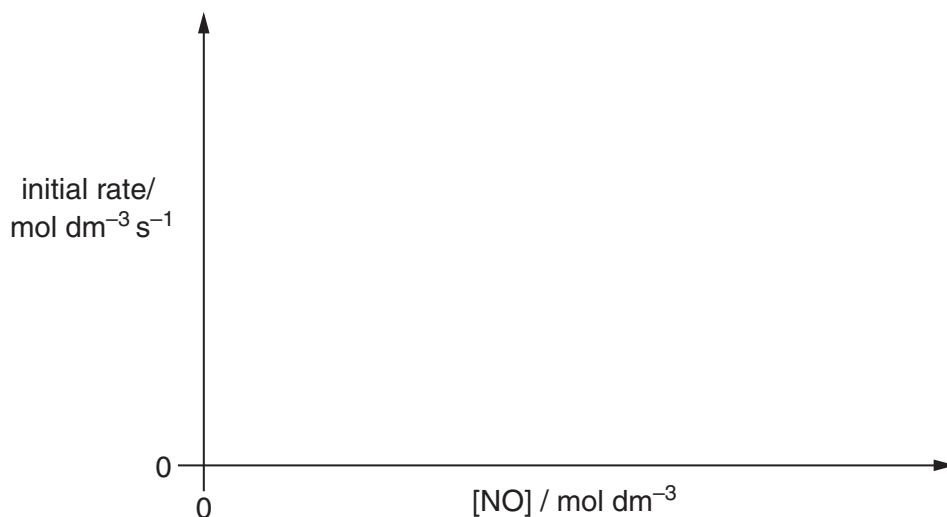
 [2]

- (iii) How could you use the graph to confirm that the reaction is first order with respect to O_2 ?

.....
 [1]

- (d) The experiment was repeated using different initial concentrations of NO.

- (i) Using the axes below, sketch a graph to show how the initial rate of the reaction would change with different initial concentrations of NO.



[1]

- (ii) Predict, with a reason, what would happen to the rate when the initial concentration of $NO(g)$ is tripled.

effect on rate:

reason:

..... [2]

- (iii) Predict what would happen to the rate when the initial concentration of $NO(g)$ is doubled **and** the initial concentration of $O_2(g)$ is tripled.

effect on rate: [1]

[Total: 12]

Turn over

- 3** Sulphur dioxide is used as a wine preservative. Sulphur dioxide reacts with water forming sulphurous acid, H_2SO_3 .

H_2SO_3 is a weak Brønsted–Lowry acid.



- (a)** What is the value of $\text{p}K_a$ for H_2SO_3 at 25°C ?

$\text{p}K_a = \dots\dots\dots$ [1]

- (b) (i)** Write an expression for K_a for the equilibrium above.

[1]

- (ii)** Use the expression for K_a from **(i)** to calculate the pH of a $0.0265 \text{ mol dm}^{-3}$ aqueous solution of H_2SO_3 at 25°C .

[3]

- (iii)** The measured pH of $0.0265 \text{ mol dm}^{-3}$ sulphurous acid at 25°C is slightly lower than the pH value calculated using the expression above.

Suggest a reason for this difference.

.....
 [1]

(c) The constant K_w has a value of $1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$ at 25°C .

(i) What name is commonly given to K_w ?

..... [1]

(ii) Write the expression for K_w .

$K_w =$ [1]

(d) In aqueous solution, potassium hydroxide acts as a strong alkali.

Calculate the pH of $0.0265 \text{ mol dm}^{-3} \text{ KOH(aq)}$ at 25°C . Show your working.

[2]

(e) A student mixed 25.0 cm^3 $0.0265 \text{ mol dm}^{-3} \text{ H}_2\text{SO}_3(\text{aq})$ with 25.0 cm^3 $0.0265 \text{ mol dm}^{-3} \text{ KOH(aq)}$.

- The student evaporated the water from the solution and obtained a solid **C**.

The student then mixed together 25.0 cm^3 $0.0265 \text{ mol dm}^{-3} \text{ H}_2\text{SO}_3(\text{aq})$ with 50.0 cm^3 $0.0265 \text{ mol dm}^{-3} \text{ KOH(aq)}$.

- The student evaporated the water from the solution and obtained a solid **D**.

Deduce the formulae of compounds **C** and **D**.

Write equations for their formation from KOH(aq) and $\text{H}_2\text{SO}_3(\text{aq})$.

formula of compound **C**:

equation:

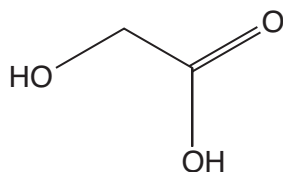
formula of compound **D**:

equation: [4]

[Total: 14]

- 4 Alpha-hydroxy-acids (AHAs) are used in skin-care products. For effective treatment of the skin, it is important that the pH of cosmetics is closely controlled. Products are sold in a buffered form with different pH ranges for different uses.

Glycolic acid, shown below, is used as an AHA in many cosmetics.



glycolic acid

- (a) Deduce the molecular formula of glycolic acid.

..... [1]

- (b) Glycolic acid is manufactured in two stages.

- **Stage 1** Chloroethanoic acid, ClCH_2COOH , is reacted with aqueous sodium hydroxide.
- **Stage 2** The resulting solution is acidified.

Write equations for each stage in the manufacture of glycolic acid.

Stage 1:

Stage 2:

[3]

The buffer contains a solution of glycolic acid and its sodium salt, sodium glycolate.

- Explain what a buffer is and how **this** buffer system works. Include equations in your answer.
- Calculate the proportions of glycolic acid and sodium glycolate in this skin-care product.

Glycolic acid has a K_a value of $1.48 \times 10^{-4} \text{ mol dm}^{-3}$.

[9]

Quality of Written Communication [1]

TURN OVER FOR QUESTION 4(d)

- (d) A chemist investigated compound **E**, $C_xH_yO_z$, as a prospective cosmetic for skin-care.

A sample of 4.362 g of compound **E** was analysed by burning in oxygen to form 5.119 g of CO_2 and 1.575 g of H_2O . Mass spectrometry produced a molecular ion peak at $m/e = 150.0$.

Calculate the molecular formula of compound **E**. Show your working.

[5]

[Total: 19]

END OF QUESTION PAPER

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