OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced GCE

CHEMISTRY 2816/01

Unifying Concepts

Friday **21 JANUARY 2005** 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	15	
2	17	
3	12	
4	16	
TOTAL	60	

This question paper consists of 10 printed pages and 2 blank pages.

Registered Charity Number: 1066969
[Turn over

Answer **all** the questions.

1 In the UK, almost all the sulphuric acid, H_2SO_4, is manufactured by the Contact process. One stage in the Contact process involves the reaction between sulphur dioxide and oxygen.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

Table 1.1 below shows values of the equilibrium constant, K_p, for this equilibrium at different temperatures.

temperature / °C	K_p / kPa^{-1}
25	4.0×10^{22}
200	2.5×10^{8}
800	1.3×10^{-3}

Table 1.1

(a) Write an expression for the equilibrium constant, K_p, of this reaction.

[2]

(b) In this question, one mark is available for the quality and use of scientific terms.

- The conversion of sulphur dioxide and oxygen into sulphur trioxide is carried out at slightly above atmospheric pressure. Comment on this statement.
- Explain what happens to the equilibrium amounts of SO_2, O_2 and SO_3 as temperature increases at constant pressure.
- Deduce the sign of ΔH for the forward reaction in the equilibrium. Explain your reasoning carefully.

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.....[6]

Quality of Written Communication [1]

(c) An equilibrium is set up for the SO_2, O_2, SO_3 equilibrium at 400 °C.

At this temperature

- the equilibrium partial pressure of SO_2 is 10 kPa
- the equilibrium partial pressure of O_2 is 50 kPa
- $K_p = 3.0 \times 10^2\ kPa^{-1}$.

Calculate the equilibrium partial pressure of SO_3 at 400 °C. Hence determine the percentage of SO_3 in the equilibrium mixture at this temperature.

answer .....% [3]

(d) In the UK, almost all the sulphuric acid manufactured uses sulphur as a starting material for SO_2 production. In some countries, metal ores such as zinc sulphide, ZnS, are used instead to form SO_2 by heating with air.

(i) Construct a balanced equation to show the reaction that takes place when zinc sulphide is heated in air.

.....[2]

(ii) Suggest why countries may find it more economic to manufacture sulphuric acid from zinc sulphide.

.....

.....[1]

[Total: 15]

2 One cause of low-level smog is the reaction of ozone, O_3, with ethene. The smog contains methanal, $CH_2O(g)$, and the equation for its production is shown below.

$$O_3(g) + C_2H_4(g) \longrightarrow 2CH_2O(g) + \tfrac{1}{2}O_2(g) \qquad \textbf{equation 2.1}$$

(a) The rate of the reaction doubles when the initial concentration of either $O_3(g)$ or $C_2H_4(g)$ is doubled.

(i) What is the order of reaction with respect to

O_3.....

C_2H_4?..... [1]

(ii) What is the overall order of the reaction? .....[1]

(iii) Write the rate equation for this reaction.

.....[1]

(b) For an initial concentration of ozone of 0.50×10^{-7} mol dm^{-3} and one of ethene of 1.0×10^{-8} mol dm^{-3}, the initial rate of methanal formation was 1.0×10^{-12} mol dm^{-3} s^{-1}.

(i) How could the **initial** rate of methanal formation be measured from a concentration/time graph?

.....

.....[2]

(ii) Calculate the value of the rate constant and state the units.

rate constant =..... units.....[3]

(iii) The initial rate of methanal formation is different from that of oxygen formation in equation **2.1**.

Explain why.

.....

.....[1]

(iv) The experiment was repeated but at a higher temperature. What would be the effect of this change on the rate and the rate constant of the reaction?

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.....[2]

(c) In the stratosphere, ozone forms when oxygen free radicals react with oxygen molecules.

$$O_2 + O \longrightarrow O_3$$

The oxygen free radicals are initially formed as diradicals when oxygen gas, O_2, is dissociated by strong ultraviolet radiation,

$$O_2(g) \longrightarrow 2O(g)$$

(i) Suggest why oxygen free radicals, O, are often called **di**radicals.

.....

.....[1]

(ii) Draw a '*dot-and-cross*' diagram of an ozone molecule. Show outer electrons only.

[2]

(iii) Chlorine free radicals formed from CFCs deplete the ozone layer in a chain reaction.

Typically, 1 g of chlorine free radicals destroys 150 kg of ozone during the atmospheric lifetime of the chlorine free radical (one to two years).

Calculate how many ozone molecules are destroyed in this chain reaction by a single chlorine free radical before the free radical is destroyed.

answer.....[3]

[Total: 17]

3 Phenol, C_6H_5OH, is a powerful disinfectant and antiseptic. Phenol is a weak Brønsted-Lowry acid.

(a) What is meant by the following terms;

(i) a *Brønsted-Lowry* acid;

.....[1]

(ii) a *weak* acid?

.....

.....[1]

(b) When phenol is mixed with aqueous sodium hydroxide, an acid-base reaction takes place.

$$C_6H_5OH(aq) + OH^-(aq) \rightleftharpoons C_6H_5O^-(aq) + H_2O(l)$$

....

In the spaces above,

- label one **conjugate acid-base pair** as acid 1 and base 1,
- label the other **conjugate acid-base pair** as acid 2 and base 2. [2]

(c) A solution of phenol in water has a concentration of $38\,g\,dm^{-3}$.
The acid dissociation constant, K_a, of phenol is $1.3 \times 10^{-10}\,mol\,dm^{-3}$.

(i) Write an expression for the acid dissociation constant, K_a, of phenol.

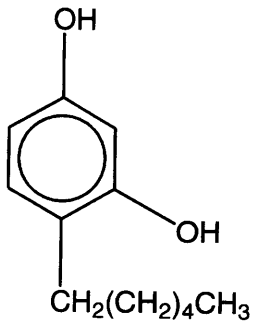
[1]

(ii) Calculate the pH of this solution.

answer.....[5]

(d) Hexylresorcinol is an antiseptic used in solutions for cleansing wounds and in mouthwashes and throat lozenges.

The structure of hexylresorcinol is shown below.



Identify a compound that could be added to hexylresorcinol to make a buffer solution. Explain your answer.

[2]

[Total: 12]

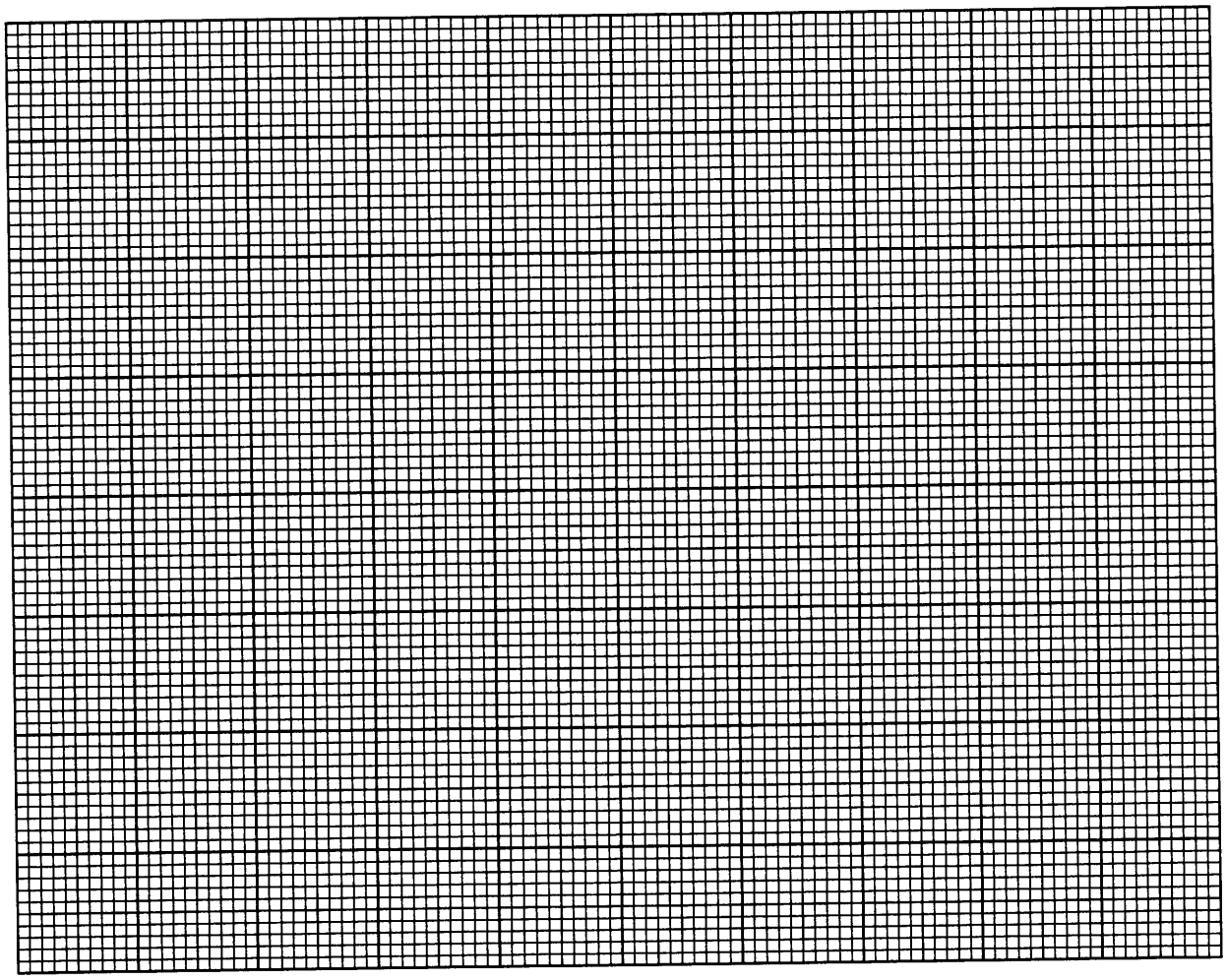
4 Titration curves can be used to decide on a suitable indicator for a titration.

You are supplied with the following solutions.

- 0.100 mol dm^{-3} NaOH(aq)
- 0.100 mol dm^{-3} CH_3COOH(aq), which has a pH of 2.9

(a) 50.0 cm^3 of 0.100 mol dm^{-3} NaOH(aq) is gradually added to 25.0 cm^3 of 0.100 mol dm^{-3} CH_3COOH(aq).

Sketch the titration curve for this addition. Label the axes and mark approximate values, to show the variation of pH.



[6]

(b) Phenolphthalein is a suitable indicator for a titration between CH_3COOH(aq) and NaOH(aq) whereas methyl orange is **not** suitable.

Explain these two statements.

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.....[2]

(c) The procedure in **(a)** was repeated with 25.0 cm^3 0.050 mol dm^{-3} $CH_3COOH(aq)$ instead of 0.100 mol dm^{-3} $CH_3COOH(aq)$.

What differences would there be in the titration curve plotted?

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.....[2]

(d) Compound **B** is an organic base. A student analysed this base by the procedure below.

He first prepared a solution of **B** by dissolving 4.32 g of **B** in water and making the solution up to 250 cm^3. The student then carried out a titration in which 25.00 cm^3 of this solution of **B** were neutralised by exactly 23.20 cm^3 of 0.200 mol dm^{-3} HC*l*.

1 mole of **B** reacts with 1 mole of HC*l*.

Use this information to calculate the molar mass of base **B** and suggest its identity.

[6]

[Total: 16]

END OF QUESTION PAPER