

**ADVANCED GCE****CHEMISTRY**

Unifying Concepts in Chemistry

2816/01

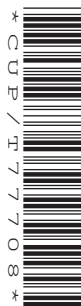
Candidates answer on the question paper

OCR Supplied Materials:

- *Data Sheet for Chemistry* (inserted)

Other Materials Required:

- Scientific calculator

Thursday 11 June 2009**Afternoon****Duration:** 1 hour 15 minutesCandidate
ForenameCandidate
Surname

Centre Number

Candidate Number

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

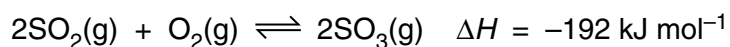
- The number of marks is given in brackets [] at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- A copy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

FOR EXAMINER'S USE

| Qu. | Max. | Mark |
|--------------|-----------|------|
| 1 | 13 | |
| 2 | 11 | |
| 3 | 16 | |
| 4 | 10 | |
| 5 | 10 | |
| TOTAL | 60 | |

Answer **all** the questions.

- 1 In the UK nearly all the sulphuric acid is manufactured in a series of steps, starting with sulphur. In one of these steps, sulphur dioxide is oxidised in a reversible reaction.



For this step, the pressure used is just above atmospheric pressure.

- (a) In a research laboratory, a chemist was developing improvements to this process.

The equilibrium partial pressures of $\text{SO}_2(\text{g})$ and $\text{SO}_3(\text{g})$ under the conditions used are shown in the table below.

| gas | $\text{SO}_2(\text{g})$ | $\text{SO}_3(\text{g})$ |
|------------------------------------|-------------------------|-------------------------|
| equilibrium partial pressure / kPa | 39 | 33 |

- (i) What is meant by the term *partial pressure*?

.....
 [1]

- (ii) The chemist used an overall pressure of 120 kPa.
 Determine the partial pressure of oxygen in the equilibrium mixture.

partial pressure O_2 = kPa [1]

- (iii) Write the expression for K_p for this equilibrium.

[1]

- (iv) Calculate K_p for this equilibrium, to an appropriate number of significant figures.
 State the units, if any.

K_p = units: [3]

- (b) The chemist continued his investigation by increasing the temperature. Deduce what happens to the value of K_p and the composition of the equilibrium mixture as temperature is increased. Explain your answer.

.....
.....
.....
..... [2]

- (c) Explain why the conversion of sulphur dioxide and oxygen into sulphur trioxide is favoured by high pressure. Suggest why, in practice, pressures near to atmospheric pressure are used.

.....
.....
.....
..... [2]

- (d) Each year in the UK, about 1×10^6 tonnes of sulphuric acid are prepared starting from sulphur. Because any unreacted materials are recycled, the overall percentage yield of H_2SO_4 is nearly 100%.

- (i) Calculate the mass of sulphur required to produce 1×10^6 tonnes of sulphuric acid annually in the UK. Assume that the overall percentage yield of H_2SO_4 is 100%.
1 tonne = 10^6 g.

[2]

- (ii) In some countries, metal ores containing PbS are heated in air to form SO_2 . In this reaction, lead forms the oxide PbO.

Construct a balanced equation to show the reaction that takes place when PbS is heated in air.

..... [1]

[Total: 13]

- 2 Chlorine dioxide, ClO_2 , is a liquid at room temperature and pressure. In an aqueous solution it is used as a bleach.

(a) In aqueous solution, chlorine dioxide, ClO_2 , reacts with hydroxide ions, OH^- .

This reaction is carried out three times using different concentrations of the two reactants. The initial rate of each reaction is determined and the results are shown below.

| experiment | $[\text{ClO}_2(\text{aq})]$ /mol dm ⁻³ | $[\text{OH}^-(\text{aq})]$ /mol dm ⁻³ | initial rate /mol dm ⁻³ s ⁻¹ |
|------------|--|---|---|
| 1 | 0.010 | 0.030 | 6.00×10^{-4} |
| 2 | 0.010 | 0.075 | 1.50×10^{-3} |
| 3 | 0.030 | 0.030 | 5.40×10^{-3} |

- (i) For each reactant, deduce the order of reaction. Show your reasoning.

$\text{OH}^-(\text{aq})$

.....

.....

.....

.....

$\text{ClO}_2(\text{aq})$

.....

.....

.....

..... [4]

- (ii) Deduce the rate equation for the reaction.

..... [1]

- (iii) Calculate the rate constant, k , for this reaction. State the units, if any.
Give your answer to an appropriate number of significant figures.

rate constant, k : units: [3]

- (b) The mechanism for this reaction takes place in several steps.

In the overall equation, 2 mol ClO_2 reacts with 2 mol OH^- to form an aqueous solution containing chlorate(III) ions and chlorate(V) ions.

Chlorate(III) ions have the formula ClO_2^- .

- (i) How does the rate equation provide evidence that the reaction takes place by more than one step?

.....

 [1]

- (ii) Suggest the overall equation.

.....

 [2]

[Total: 11]

- 3** Benzoic acid, $\text{C}_6\text{H}_5\text{COOH}$, is a weak acid, used for preserving fruit juices.

The acid dissociation constant, K_a , of benzoic acid is $6.30 \times 10^{-5} \text{ mol dm}^{-3}$ at 25°C .

- (a)** Write the equation for the dissociation of benzoic acid when dissolved in water.

..... [1]

- (b)** Write the expression for the acid dissociation constant, K_a , of benzoic acid.

[1]

- (c)** The solubility of benzoic acid in water is 3.40 g dm^{-3} at 25°C .

Calculate the pH of a saturated solution of benzoic acid in water at 25°C .

[5]

A chemist at the fruit juice company prepared a benzoic acid/sodium benzoate buffer with concentrations of $0.105 \text{ mol dm}^{-3} \text{ C}_6\text{H}_5\text{COOH}$ and $0.125 \text{ mol dm}^{-3} \text{ C}_6\text{H}_5\text{COONa}$.

- State what a buffer solution is and explain how this solution acts as a buffer solution. Include equations in your answer.
- Calculate the pH of this benzoic acid/sodium benzoate buffer at 25 °C. Show all your working.

..... [8

Quality of Written Communication [1]

[Total: 16]

Turn over

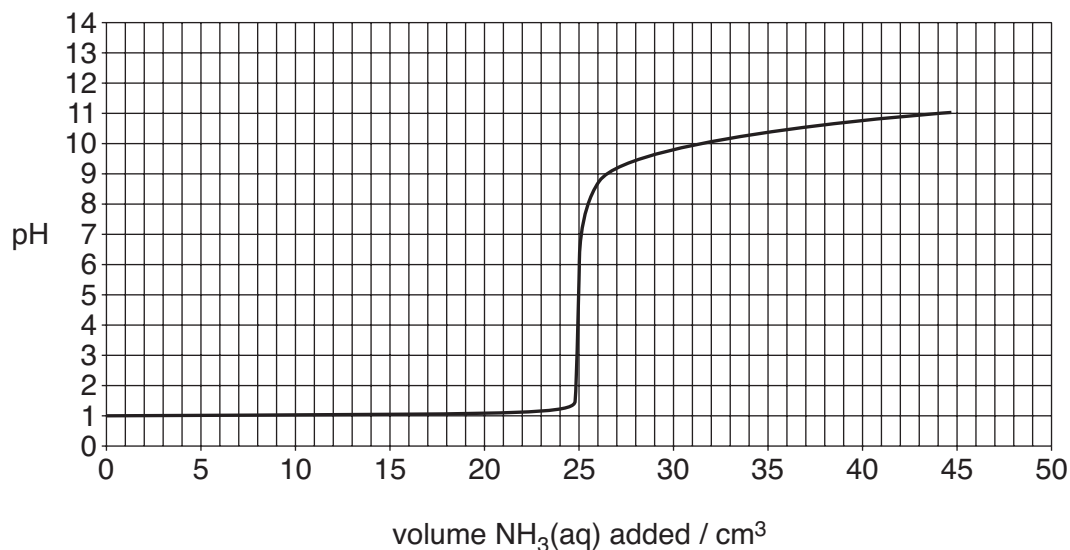
4 Nitric acid, HNO_3 , is a strong acid which can also behave as an oxidising agent.

(a) Nitric acid reacts with bases, such as aqueous ammonia, $\text{NH}_3(\text{aq})$, to form salts.

A 25.0 cm^3 sample of $\text{HNO}_3(\text{aq})$ was placed in a conical flask.

$\text{NH}_3(\text{aq})$ was added from a burette until the pH showed little further change.
The NH_3 concentration was the same as the HNO_3 concentration.

The pH curve for this titration is shown below.



(i) Deduce the concentration of the nitric acid.

[1]

(ii) How can you tell from this pH curve that aqueous ammonia is a weak base?

.....
 [1]

(iii) What is the formula for the salt formed in this reaction?

..... [1]

- (iv) The pH ranges for four indicators are shown below.

| indicator | pH range |
|-------------------|-----------|
| malachite green | 0.2–1.8 |
| resazurin | 3.8–6.4 |
| metacresol purple | 7.4–9.0 |
| alizarin yellow R | 10.1–12.0 |

Which of these four indicators is most suitable for this titration?

..... [1]

- (v) The titration was repeated but using $\text{NH}_3(\text{aq})$ with **twice** the concentration of the original ammonia solution.

What **two** differences would there be between this titration curve and the one shown in part (a)?

.....

 [2]

- (b) When nitric acid reacts with magnesium metal, different gases are formed, depending on the concentration of the nitric acid. Each reaction producing a gas is a redox reaction.

- With very dilute nitric acid, H_2 gas is evolved.
- With concentrated nitric acid, NO_2 gas is evolved.

- (i) Write a full equation and an ionic equation for the reaction of magnesium with very dilute nitric acid.

full equation

ionic equation [2]

- (ii) Use oxidation numbers to show the reduction that takes place when magnesium reacts with dilute and with concentrated nitric acid.

dilute HNO_3

concentrated HNO_3 [2]

[Total: 10]

5 This question looks at some chemicals in everyday situations.

- (a) Plaster of Paris may be used for setting broken limbs. The formula of Plaster of Paris is $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$. When water is added, the Plaster of Paris sets as it forms $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$.

What is the minimum mass of water needed to set 500 g of Plaster of Paris?

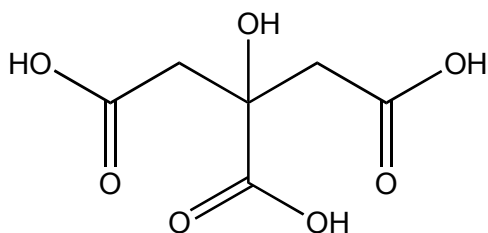
mass of water = [2]

- (b) A bottle contains 0.60 g of nitrogen, N_2 . Another bottle of the same volume is filled at the same temperature and pressure with 1.52 g of an unknown gas. Suggest the molecular formula of the unknown gas.

molecular formula = [2]

- (c) An orange-flavoured drink contains citric acid.

The structure of citric acid is shown below.



- (i) Determine the molecular formula of citric acid.

..... [1]

- (ii) 25.0 cm³ of the drink was titrated with NaOH(aq).

21.35 cm³ of 0.00425 mol dm⁻³ NaOH(aq) was needed to reach the end point of the titration.

1 mol of citric acid reacts with 3 mol of NaOH.

A person drank 250 cm³ of the orange-flavoured drink.
Calculate the mass of citric acid in 250 cm³ of the drink.

mass citric acid = [5]

[Total: 10]

END OF QUESTION PAPER

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