

**ADVANCED GCE****CHEMISTRY**

Unifying Concepts in Chemistry

2816/01

Candidates answer on the Question Paper
A calculator may be used for this paper

OCR Supplied Materials:

- *Data Sheet for Chemistry* (inserted)

Other Materials Required:

- Scientific calculator

Monday 1 February 2010
Morning

Duration: 1 hour 15 minutes



Candidate
Forename

Candidate
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.
- You are advised to show all the steps in any calculations.
- This document consists of **12** pages. Any blank pages are indicated.

Examiner's Use Only:

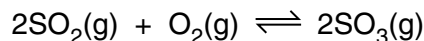
1			
2			
3			
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Total			



Answer **all** the questions.

- 1 In the UK, almost all 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.



The table below shows values of 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}

- (a) (i) Write the expression for the equilibrium constant, K_p , for this equilibrium.

[1]

- (ii) What does this value of K_p suggest about the position of equilibrium at 25 °C and the relative equilibrium proportions of the reactants and products?

.....

 [2]

- (b) Predict how the equilibrium position of this equilibrium is affected by the following changes.

Explain your answers.

- (i) The temperature is increased whilst keeping the pressure constant.

effect on equilibrium position
 [1]

effect on partial pressure of $\text{SO}_3(\text{g})$
 [1]

- (ii) The pressure is increased whilst keeping the temperature constant.

effect on equilibrium position

..... [1]

effect on partial pressure of $\text{SO}_3(\text{g})$

..... [1]

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

At this temperature,

- the equilibrium partial pressure of SO_2 is 25 kPa;
- the equilibrium partial pressure of O_2 is 125 kPa;
- $K_p = 3.0 \times 10^2 \text{ kPa}^{-1}$.

Calculate the equilibrium partial pressure of SO_3 at 400°C .

Hence determine the molar percentage of SO_3 in the equilibrium mixture at 400°C .

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 of sulphur to form SO_2 by heating in 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 instead of from sulphur.

.....

..... [1]

[Total: 13]

- 2 Solutions of hydrogen peroxide, H_2O_2 , are colourless and widely used as oxidising agents, antiseptic and bleaches for hair and cloth.

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

- (a) Suggest a balanced equation for the overall reaction between $\text{H}_2\text{O}_2(\text{aq})$, $\text{I}^-(\text{aq})$ and $\text{H}^+(\text{aq})$ to form aqueous iodine.

..... [2]

- (b) Three experiments were carried out using different initial concentrations of $\text{H}_2\text{O}_2(\text{aq})$, $\text{I}^-(\text{aq})$ and $\text{H}^+(\text{aq})$. The initial rate of formation of I_2 was measured for each experiment.

The experimental results are shown below.

experiment	$[\text{H}_2\text{O}_2(\text{aq})]$ /mol dm ⁻³	$[\text{I}^-(\text{aq})]$ /mol dm ⁻³	$[\text{H}^+(\text{aq})]$ /mol dm ⁻³	rate /mol dm ⁻³ s ⁻¹
1	0.050	0.010	0.005	5.75×10^{-6}
2	0.050	0.020	0.005	1.15×10^{-5}
3	0.050	0.040	0.010	2.30×10^{-5}

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

.....

 [4]

- (ii) This reaction is first order with respect to H_2O_2 .

Use this information and your answers to (i) to write the rate equation for this reaction.

..... [1]

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

rate constant, k : units: [3]

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

Hydrogen peroxide is sold by volume strength. For example, 40 volume hydrogen peroxide is used to bleach hair, fur and bones.

40 volume H_2O_2 produces 40 volumes of oxygen gas, measured at room temperature and pressure, r.t.p., 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 40 volume hydrogen peroxide.

1 mol of $\text{O}_2(\text{g})$ occupies 24.0 dm^3 at r.t.p.

Show all your working clearly.

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

[Total: 14]

3 This question looks at several acids.

- (a) Hydroiodic acid, $\text{HI}(\text{aq})$, is a strong acid that is an aqueous solution of hydrogen iodide gas. In the laboratory, hydroiodic acid is prepared by the method below.

A mixture of iodine and water is put into a flask. The mixture is stirred and hydrogen sulphide gas, $\text{H}_2\text{S}(\text{g})$, is bubbled through the mixture for several hours. The mixture becomes yellow as sulphur separates out.

The sulphur is filtered off and the solution is purified by fractional distillation.

A 225 cm^3 sample of hydroiodic acid is collected containing 47.2 g of HI.

- (i) Construct a balanced equation, with state symbols, for the preparation of hydroiodic acid from iodine and hydrogen sulphide.

..... [2]

- (ii) Calculate the pH of the hydroiodic acid sample that is collected.

pH = [2]

- (b) Ethanoic acid, CH_3COOH , is a weak acid with a K_a value of $1.70 \times 10^{-5} \text{ mol dm}^{-3}$.

- (i) Write an equation for the dissociation of ethanoic acid.

..... [1]

- (ii) The concentration of ethanoic acid in a solution **X** was $2.74 \times 10^{-3} \text{ mol dm}^{-3}$.

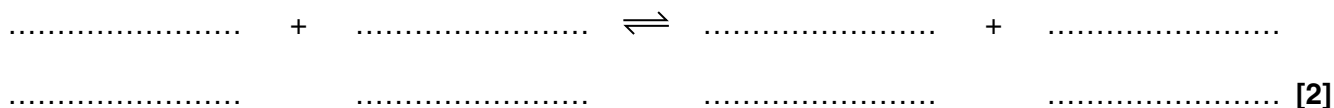
Calculate the pH of solution **X**.

pH = [3]

- (iii) When ethanoic acid is mixed with hydroiodic acid, an acid–base reaction takes place.

Complete the acid–base equilibrium that is set up and identify the acid–base pairs.

- 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**.



- (c) Methanoic acid, HCOOH , is an ant's main defence mechanism, squirted at potential intruders and injected in 'ant bites'.

- (i) The recommended treatment for an ant bite is 'bicarbonate of soda', which contains NaHCO_3 .

Suggest, with an equation, how NaHCO_3 helps to relieve the effect of an ant bite.

.....

 [2]

- (ii) Wasp stings are treated with vinegar. What does this suggest about the nature of the active ingredient in a wasp sting? Explain your answer.

.....

 [2]

- (iii) Methanoic acid can be used in buffer solutions.

Calculate the pH of a buffer solution containing equal volumes of 0.75 mol dm^{-3} methanoic acid and 1.92 mol dm^{-3} sodium methanoate.

For HCOOH , $K_a = 1.60 \times 10^{-4} \text{ mol dm}^{-3}$.

pH = [2]

[Total: 16]

Turn over

- 4 (a) A student analysed an unsaturated branched carboxylic acid, **A**, using a titration procedure.

The student dissolved 1.368 g of the compound in water and made the solution up to 100.0 cm³. The student titrated 25.0 cm³ of this solution with 0.152 mol dm⁻³ NaOH. The volume of NaOH(aq) required to reach the end-point was 19.80 cm³.

Each molecule of **A** has one acidic hydrogen atom and it behaves as a monoprotic (monobasic) acid.

- Calculate the molar mass of the unsaturated branched carboxylic acid **A**.
- Determine the molecular formula and show **two** possible structural isomers of the unsaturated branched carboxylic acid **A**.

[8]

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

This question considers different graphs used in chemistry.

- Explain how the shapes of rate–concentration graphs can be used to deduce the orders with respect to reactants.
- Explain how acid–base titration pH curves can be used to suggest suitable indicators for titrations of strong and weak acids with strong bases.

In your answer, include sketch graphs with labelled axes.

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[Total: 17]

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