

OXFORD CAMBRIDGE AND RSA EXAMINATIONS Advanced GCE

CHEMISTRY

2816/01

Unifying Concepts in Chemistry

Wednesday 18 JUNE 2003

Afternoon

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.	Qu. Max. Mark	
1	14	
2	14	
3	13	
4	10	
5	9	
TOTAL	60	

This question paper consists of 11 printed pages and 1 blank page.

Answer all the questions.

- 1 Bromine can be formed by the oxidation of bromide ions. This question compares the rates of two reactions that produce bromine.
 - (a) Bromine is formed by the oxidation of bromide ions with acidified bromate(V) ions.

 $5Br^{-}(aq) + 6H^{+}(aq) + BrO_{3}^{-}(aq) \longrightarrow 3Br_{2}(aq) + 3H_{2}O(I)$

This reaction was carried out several times using different concentrations of the three reactants. The initial rate of each experimental run was calculated and the results are shown below. In each case, initial concentrations are shown.

experiment	[Br ⁻ (aq)] /mol dm ⁻³	[H ⁺ (aq)] /mol dm ⁻³	[BrO ₃ ⁻ (aq)] /mol dm ⁻³	initial rate /10 ⁻³ mol dm ⁻³ s ⁻¹
1	0.10	0.10	0.10	1.2
2	0.10	0.10	0.20	2.4
3	0.30	0.10	0.10	3.6
4	0.10	0.20	0.20	9.6

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



(ii) Deduce the rate equation.



2 Phosgene, COCl₂, is a highly toxic gas, used in making organic chemicals, dyestuffs and resins. Phosgene can be manufactured by the reaction of carbon monoxide and chlorine in the presence of a catalyst.

An equilibrium system exists between carbon monoxide, chlorine and phosgene.

 $CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$ $\Delta H = -108 \text{ kJ mol}^{-1}$

(a) Explain how changes in temperature and pressure could be used to increase the equilibrium yield of $COCl_2$.

(b) The equilibrium partial pressures in this system are shown below.

compound	СО	Cl ₂	COCl2
partial pressure / Pa	2.5 × 10 ^{−6}	2.5 × 10 ^{−6}	4.13 × 10 ^{−5}

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

.....

[1]

(ii) Write the expression for K_p in this equilibrium system and calculate the numerical value of K_p .

For

Examiner's Use

For Examiner's Use

[2]

(c) Phosgene is a polar molecule. The diagram below shows a molecule of phosgene and two related molecules, **A** and **B**.

5



(i) Add the partial charges (δ + and δ –) to the diagrams of the three molecules above.

(ii) Molecule A is the most polar of the three molecules.

Suggest why this is so.

(iii) Compound A reacts with water as follows.



Phosgene also reacts with water.

Suggest an equation for this reaction.

[2]

[Total: 14]

- 3 Hydrogen chloride is used in the manufacture of many chemical compounds, including those used in metallurgy and food processing.
 - (a) There are two main industrial methods for preparing hydrogen chloride:
 - by direct combination of chlorine and hydrogen gases,
 - as a by-product of the chlorination of many organic hydrocarbons.

Write equations to show the formation of HCl from

- (i) chlorine and hydrogen[1]
- (ii) chlorine and hexane, $C_6 H_{14}$.

.....[1]

(b) Hydrochloric acid is usually sold as a solution prepared by dissolving hydrogen chloride gas in water.

A science technician bought 15.0 dm³ of 8.00 mol dm⁻³ hydrochloric acid which had been made by dissolving hydrogen chloride gas in water.

- 1 mol of gas molecules occupies 24.0 dm³ at room temperature and pressure, r.t.p.
- (i) Calculate the volume of hydrogen chloride gas at r.t.p. that dissolved to produce this hydrochloric acid.

[2]

(ii) Outline, with quantities, how the technician could make up 1.00 dm³ of 0.0200 mol dm⁻³ hydrochloric acid from the 8.00 mol dm⁻³ stock solution of hydrochloric acid.

(iii) Calculate the pH of $0.0200 \text{ mol dm}^{-3} \text{HC}l(\text{aq})$.

[2]

(c) Hydrochloric acid can be neutralised with aqueous ammonia to form ammonium chloride.

 $NH_3(aq) + HCl(aq) \longrightarrow NH_4Cl(aq)$

The technician titrated the $0.0200 \text{ mol dm}^{-3}$ hydrochloric acid prepared in (b)(ii) with aqueous ammonia.

A 20.0 cm³ sample of the 0.0200 mol dm⁻³ HCl(aq) was placed in a conical flask and the NH₃(aq) was added from a burette until the pH no longer changed. The pH curve for this titration is shown below.



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



(ii) Use the information above to calculate the concentration, in mol dm⁻³, of the aqueous ammonia.

[2]

(iii) The pH ranges in which the pH changes for three indicators are shown below.

indicator	pH range
alizarin yellow	10.1–12.0
methyl yellow	2.9-4.0
chlorophenol red	4.8–6.4

Explain which of the three indicators is most suitable for this titration.

.....[2]

- 4 Buffer solutions have many uses in medicine and in cosmetics and toiletries. Buffer solutions can be prepared by mixing aqueous solutions of methanoic acid, HCOOH, and sodium methanoate, HCOONa.
 - (a) In this part, one mark is available for the quality of written communication.

Describe what a buffer solution is and how a buffer solution works.

Use the HCOOH/HCOONa buffer solution in your answer.

Quality of Written Communication [1]

(b) Calculate the pH of a buffer solution containing equal volumes of 2.5 mol dm⁻³ HCOONa and 1.0 mol dm⁻³ HCOOH ($K_a = 1.6 \times 10^{-4}$ mol dm⁻³).

[3]

[Total: 10]

[2]

5 Read the section below and use your knowledge and understanding of chemistry to answer the questions that follow.

Compound X is a dicarboxylic acid, $M_r = 90$, present in many foods such as cocoa, green vegetables and rhubarb. Compound X may be harmful to humans because it reacts with calcium ions in the bloodstream to form solid particles. These are then deposited in the kidneys as 'kidney stones'.

Analysis of a kidney stone showed that it was made up almost entirely of a single compound **Y** with the percentage composition by mass: Ca, 31.3%; C, 18.7%; O, 50.0%.

Some people develop kidney stones more readily than others. Compound X is very soluble in water and people susceptible to kidney stones are advised to drink large quantities of water to flush this compound from their bodies.

- Calculate the empirical formula of compound Y, the main compound in kidney stones. [2]
- A kidney stone with a mass of 2.0 g was removed from a patient. Calculate the number of calcium ions that have been removed from the bloodstream to form this kidney stone.
 L = 6.02 × 10²³ mol⁻¹
- Deduce the molecular formula of compound X and suggest its structural formula. [2]
- Explain why compound X is very soluble in water.

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[Total: 9]