THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

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

Thursday 17 June 2010
Afternoon

Duration: 1 hour 15 minutes

OCE/14639

2816016

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			
4			
Total			

OCR is an exempt Charity

Turn over

Answer **all** the questions.

1 The preparation of ethyl ethanoate from ethanoic acid and ethanol is a reversible reaction which can be allowed to reach equilibrium.

$$CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$$

(a) Write the expression for K_c for this equilibrium system.

[1]

(b) A student mixed together 8.0 mol ethanoic acid and 14.5 mol ethanol. A small amount of hydrochloric acid was also added to catalyse the reaction. He left the mixture for two days to reach equilibrium, after which time 1.5 mol ethanoic acid remained.

(i) Complete the table below to show the equilibrium composition of the mixture.

component	CH_3COOH	C_2H_5OH	$CH_3COOC_2H_5$	H_2O
initial amount/mol	8.0	14.5	0.0	0.0
equilibrium amount/mol				

[2]

(ii) Calculate K_c to **two** significant figures.

The total volume of the equilibrium mixture is 1.0 dm^3.

K_c = ... **[2]**

(c) The student added more ethanol to the mixture at constant temperature.

(i) State, giving a reason, what would happen to the equilibrium composition of the mixture.

.....

.....

..... **[1]**

(ii) What happens to the value of K_c?

..... **[1]**

(d) State, giving a reason, what would happen to the equilibrium position if the concentration of the acid catalyst were to be increased.

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

(e) The student repeated the experiment at a higher temperature and found that the value of K_c decreased.

Explain what additional information this tells you about this reaction.

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

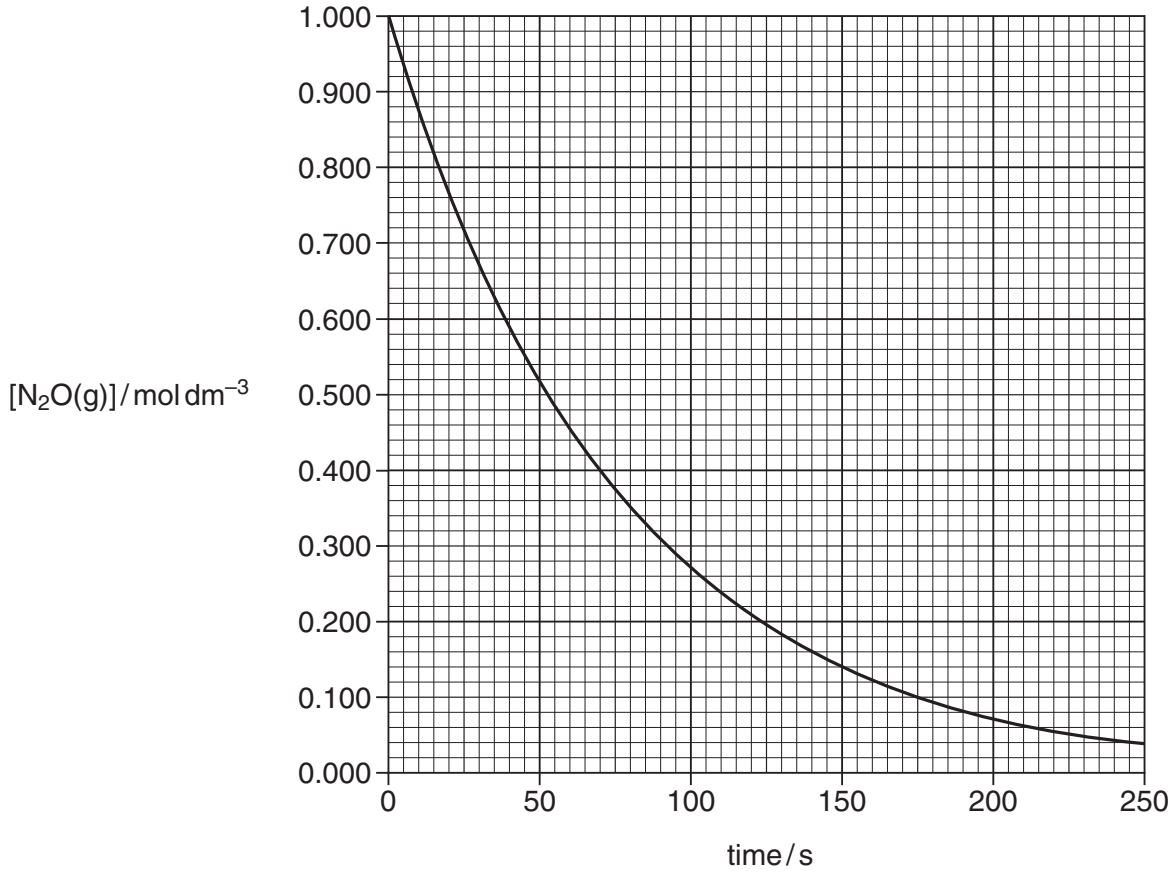
[Total: 11]

2 Nitrous oxide, N_2O, is a colourless gas with a mild, pleasant odour and sweet taste. It is widely used as a propellant in aerosol cans of whipped cream.

(a) When heated strongly, nitrous oxide decomposes into its elements.

$$2N_2O(g) \rightarrow 2N_2(g) + O_2(g)$$

This reaction is first order with respect to N_2O. This can be confirmed from the graph below using half-lives.



(i) What is meant by the *half-life* of a reaction?

.....

..... **[1]**

(ii) Use this graph to show that this reaction is first order with respect to N_2O.

State the half-life.

.....

.....

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

(iii) What would be the effect on the half-life of this reaction of doubling the initial concentration of N_2O?

..... **[1]**

(b) (i) Write down the rate equation for this reaction.

..... **[1]**

(ii) Use the graph to work out the rate of reaction, in $mol\,dm^{-3}\,s^{-1}$, at 70 seconds.

Show your working on the graph.

rate = ...$mol\,dm^{-3}\,s^{-1}$ **[2]**

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

k = ... units: ..... **[2]**

(c) What evidence is there that the mechanism of this reaction takes place in more than a single step?

.....

.....

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

(d) Nitrous oxide is formed when ammonium nitrate, NH_4NO_3, is gently heated.

$$NH_4NO_3(s) \rightarrow N_2O(g) + 2H_2O(l)$$

(i) What mass of N_2O is formed by heating 100 g of NH_4NO_3?

[2]

(ii) In this reaction, what happens to the oxidation number of each nitrogen atom in the ammonium nitrate?

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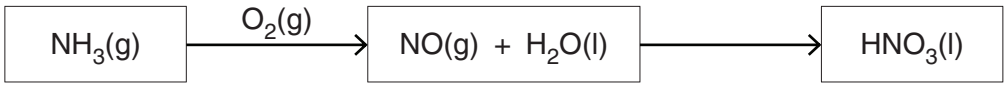
.....

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

(e) Ammonium nitrate is prepared from nitric acid, HNO_3, and ammonia, NH_3.

Each year in the UK, 700 000 tonnes of nitric acid are manufactured for the production of fertilisers, dyes and explosives.

Nitrogen monoxide, NO, is an intermediate in the production of nitric acid from ammonia.



(i) Construct a balanced equation for the formation of NO(g) from NH_3(g).

..... **[1]**

(ii) Assuming that 1 mol NH_3 produces 1 mol HNO_3, and that all NH_3 is converted, calculate the mass of NH_3 that is required to meet the annual demand for HNO_3 in the UK.

1 tonne = 10^6 g

answer = ... **[2]**

[Total: 18]

3 A student carried out some practical work on acids and alkalis.

(a) The student measured the pH of aqueous solutions of hydrochloric acid, HC*l*, and ethanoic acid, CH_3COOH. The results are shown below.

acid	concentration / mol dm^{-3}	pH
HC*l*	0.0200	1.70
CH_3COOH	0.0200	3.23

(i) Why are the pH values of the two acids different?

.....

..... **[1]**

(ii) Calculate the value, including units, of K_a for ethanoic acid.

answer = ... **[3]**

(iii) The student mixed together 25 cm^3 of 0.0200 mol dm^{-3} HC*l* with 75 cm^3 of water.

Determine the pH of the diluted acid. Show your working.

pH = ... **[2]**

(b) The ionic product of water, K_w, has a value of 1.0×10^{-14} mol^2 dm^{-6}.

(i) Complete the expression for K_w below.

K_w = ... **[1]**

(ii) Calculate the pH of 0.015 mol dm^{-3} NaOH(aq). Show your working.

pH = ... **[2]**

(c) The student pipetted 25.0 cm^3 of 0.0200 mol dm^{-3} $CH_3COOH(aq)$ into a conical flask.

She then slowly added an **excess** of 0.0150 mol dm^{-3} NaOH(aq) from a burette. In total, 50.00 cm^3 of the alkali were added.

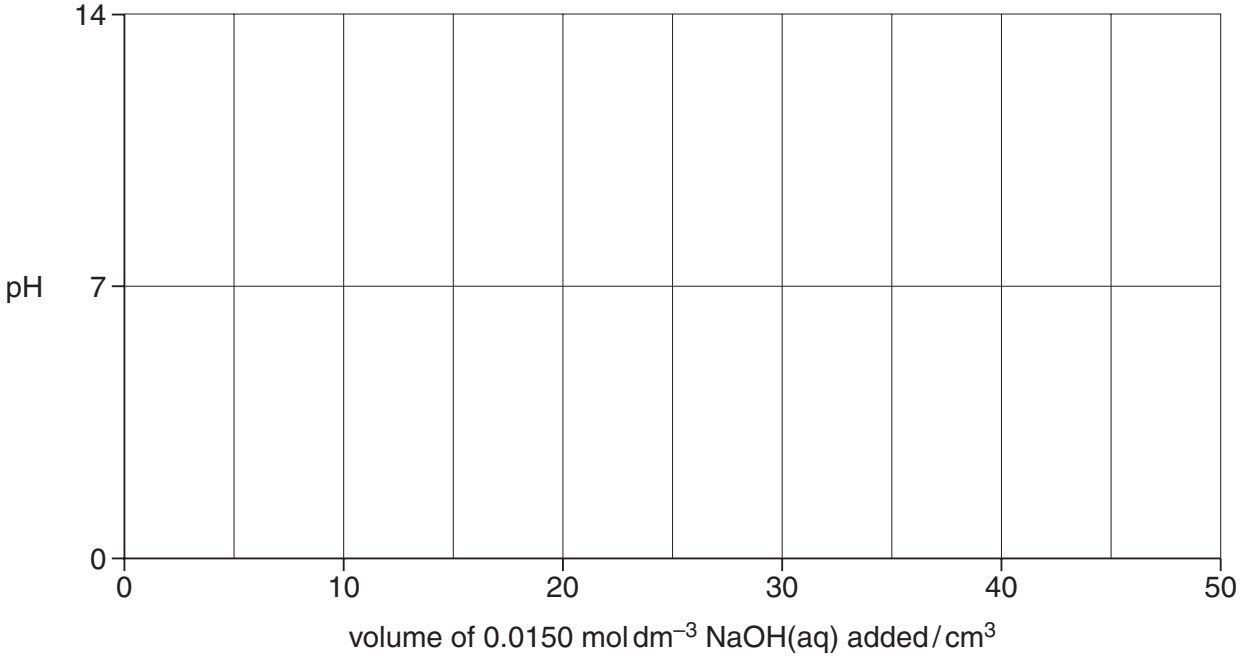
The pH of the solution was measured throughout with a pH meter.

The equation for the reaction is shown below.

$$CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l)$$

(i) Sketch the pH curve for this titration on the grid below.

The initial and final pH values do **not** need to be shown accurately.



[3]

(ii) This titration could be carried out using an indicator. The pH ranges for four indicators are shown below.

indicator	pH range
clayton yellow	12.2–13.2
thymol blue	8.0–9.6
brilliant yellow	6.6–7.8
resazurin	3.8–6.4

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

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.....

..... **[1]**

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

The student prepared a buffer solution by mixing together 25 cm^3 of 1.00 mol dm^{-3} ethanoic acid, CH_3COOH, and 25 cm^3 of 1.00 mol dm^{-3} sodium ethanoate, CH_3COONa.

- Explain what is meant by a *buffer solution* and how this ethanoic acid/sodium ethanoate buffer solution works. Use equations in your answer.

- What would be the effect on the pH of this buffer solution if the CH_3COONa had been twice the concentration of the ethanoic acid? Explain your answer. You do not need to carry out any calculations.

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..... **[7]**

Quality of Written Communication **[1]**

[Total: 21]

4 Maleic anhydride, $C_4H_2O_3$, is an important industrial chemical.

(a) Maleic anhydride is produced on a large scale by passing a mixture of butane and air over a hot catalyst.

(i) An incomplete equation for this reaction is given below.

Complete and balance the equation for this reaction.

$$C_4H_{10} + \ldots\ldots\ldots\ldots \rightarrow C_4H_2O_3 + \ldots\ldots\ldots\ldots$$

[1]

(ii) Calculate the mass, in kg, of maleic anhydride that could be made by completely converting 30 m^3 of butane in this reaction.

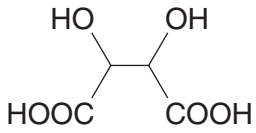
1 m^3 = 1000 dm^3; $M_r(C_4H_2O_3)$ = 98.0

Assume that gas volumes have been measured at room temperature and pressure.

1 mol of gas molecules occupies 24 dm^3 at room temperature and pressure.

mass = ... kg **[2]**

(b) Maleic anhydride can be converted into tartaric acid by reaction with water and a suitable oxidising agent. The structure of tartaric acid is shown below.

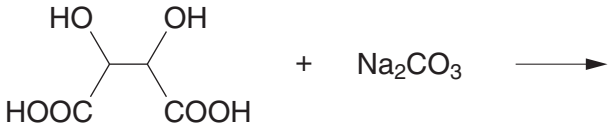


Deduce the **empirical** formula of tartaric acid.

[1]

(c) A student reacted an aqueous solution of tartaric acid with an excess of sodium carbonate, Na_2CO_3.

(i) Complete the equation below for this reaction.



[2]

(ii) Suggest another chemical, apart from a carbonate, that would react with an aqueous solution of tartaric acid.

.....

Write an equation for your chosen reaction.

[3]

(d) Maleic anhydride can be prepared by the dehydration of maleic acid, HOOCCH=CHCOOH.

Suggest the structure of maleic anhydride.

[1]

[Total: 10]

END OF QUESTION PAPER