OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY

2816/01

Unifying Concepts

Monday **23 JANUARY 2006** 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	16	
2	17	
3	14	
4	13	
TOTAL	60	

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

Registered Charity Number: 1066969

For Examiner's Use

Answer **all** the questions.

1 Methanoic acid, HCOOH, is a weak organic acid which occurs naturally in ants and stinging nettles.

(a) Use an equation for the dissociation of methanoic acid to show what is meant by a *weak acid*.

.. ..

.....[1]

(b) A 1.50×10^{-2} mol dm^{-3} solution of HCOOH has $[H^+] = 1.55 \times 10^{-3}$ mol dm^{-3}.

(i) Calculate the pH of this solution and give one reason why the pH scale is a more convenient measurement for measuring acid concentrations than $[H^+]$.

....

. ...

.....[2]

(ii) Write the expression for K_a for methanoic acid.

[1]

(iii) Calculate the values of K_a and pK_a for methanoic acid.

[3]

(iv) Estimate the percentage of HCOOH molecules that have dissociated in this aqueous solution of methanoic acid.

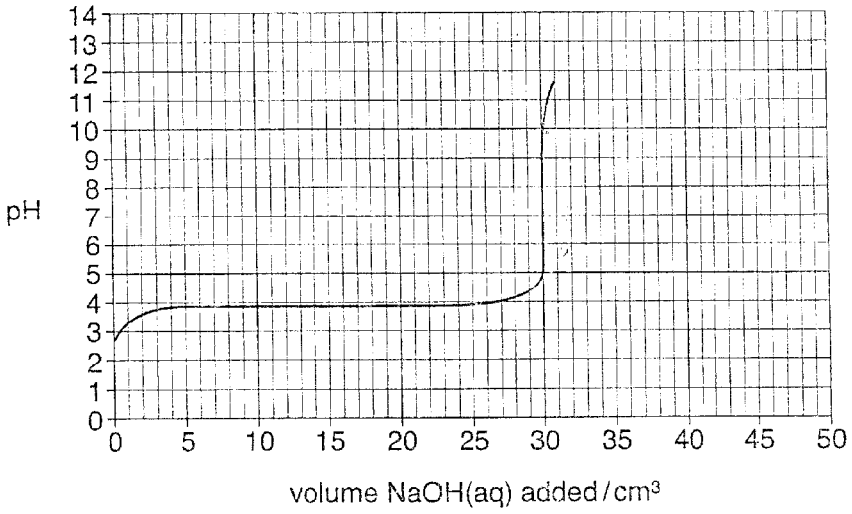
[1]

(c) A student titrated the 1.50×10^{-2} mol dm^{-3} methanoic acid with aqueous sodium hydroxide.
A 25.00 cm^3 sample of the HCOOH(aq) was placed in a conical flask and the NaOH(aq) was added from a burette until the pH no longer changed.

(i) Write a balanced equation for the reaction between HCOOH(aq) and NaOH(aq).

..[1]

(ii) Part of the pH curve for this titration is shown below.



Calculate the concentration, in mol dm^{-3}, of the aqueous sodium hydroxide.

concentration = ... mol dm^{-3} [3]

(iii) Calculate the pH of the aqueous sodium hydroxide.
$K_w = 1.00 \times 10^{-14}$ mol dm^{-3}

pH = ...[2]

For Examiner's Use

(iv) The pH ranges in which colour changes for three acid-base indicators are shown below.

indicator	pH range
metacresol purple	7.4 – 9.0
2,4,6-trinitrotoluene	11.5 – 13.0
ethyl orange	3.4 – 4.8

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

...

.....

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.....

..

.....[2]

[Total: 16]

For Examiner's Use

2 The preparation of hydrogen iodide, HI(g), from hydrogen and iodine gases is a reversible reaction which reaches equilibrium at constant temperature.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

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

[1]

(b) A student mixed together 0.30 mol $H_2(g)$ with 0.20 mol $I_2(g)$ and the mixture was allowed to reach equilibrium. At equilibrium, 0.14 mol $H_2(g)$ was present.

(i) Complete the table below to show the amount of each component in the equilibrium mixture.

component	$H_2(g)$	$I_2(g)$	HI(g)
initial amount / mol	0.30	0.20	0
equilibrium amount / mol			

[2]

(ii) Calculate K_c to an appropriate number of significant figures. State the units, if any.

K_c = ..

units, if any .....

[3]

(c) The student compressed the equilibrium mixture so that its volume was reduced. The temperature was kept constant.

Comment on the value of K_c **and** the composition of the equilibrium mixture under these new conditions.

.....

.....

.....

.....

.....

.....[2]

For Examiner's Use

(d) The student repeated the experiment at a higher temperature and found that less HI was present at equilibrium.

Explain what additional information this tells you about the reaction.

...

.

.....[2]

(e) Hydroiodic acid, HI(aq), is a strong acid that is an aqueous solution of hydrogen iodide. In the laboratory, hydroiodic acid can be prepared by the method below.

> A mixture of 480 g of iodine and 600 cm^3 of water was put into a flask. The mixture was stirred and hydrogen sulphide gas, $H_2S(g)$, was bubbled through for several hours.
>
> The mixture became yellow as sulphur separated out. The sulphur was filtered off and the solution was purified by fractional distillation. A fraction of HI(aq) was collected containing 440 g of HI in a total volume of 750 cm^3.

(i) Construct a balanced equation, with state symbols, for the preparation of hydroiodic acid.

.....

.....[2]

(ii) Determine the percentage yield of hydroiodic acid.

[3]

(iii) Calculate the pH of the hydroiodic acid fraction.

[2]

[To

For Examiner's Use

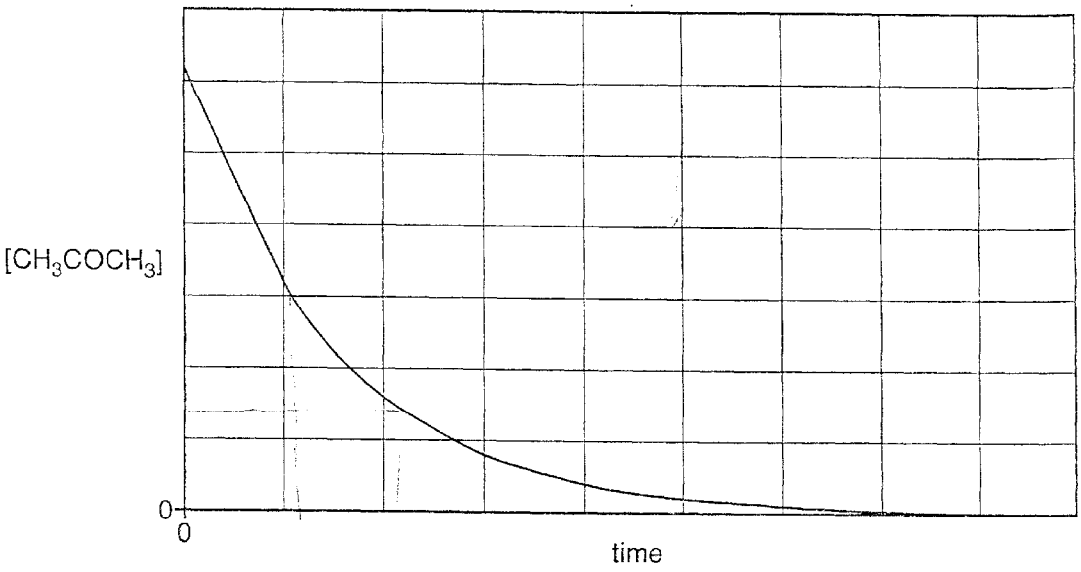
3 In this question, one mark is available for the quality of use and organisation of scientific terms.

Propanone reacts with iodine in the presence of dilute hydrochloric acid.

A student carried out an investigation into the kinetics of this reaction.

He measured how the concentration of propanone changes with time. He also investigated how different concentrations of iodine and hydrochloric acid affect the initial rate of the reaction.

The graph and results are shown below.



$[CH_3COCH_3]$ /mol dm^{-3}	$[I_2]$ /mol dm^{-3}	$[H^+]$ /mol dm^{-3}	initial rate /mol dm^{-3} s^{-1}
1.5×10^{-3}	0.0300	0.0200	2.1×10^{-9}
1.5×10^{-3}	0.0300	0.0400	4.2×10^{-9}
1.5×10^{-3}	0.0600	0.0400	4.2×10^{-9}

The overall equation for the reaction is given below.

$$CH_3COCH_3 + I_2 \rightarrow CH_3COCH_2I + HI$$

This is a multi-step reaction.

- What conclusions can be drawn about the kinetics of this reaction from the student's investigation? Justify your reasoning.

- Calculate the rate constant for this reaction, including units.

- Suggest the equations for a possible two-step mechanism for this reaction. Label the rate-determining step and explain your reasoning.

For Examiner's Use

.....

Quality of Written Communication [1]

[Total: 14]

For Examiner's Use

4 This question looks at different compounds used in medicine.

(a) Nitrous oxide, N_2O, is the gas used as a general anaesthetic.

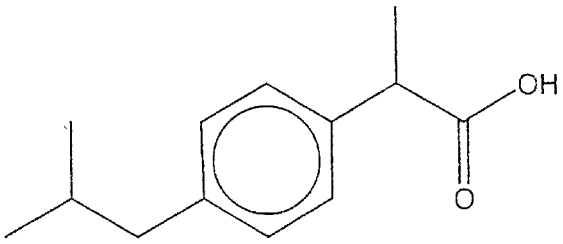
(i) What is the oxidation number of nitrogen in nitrous oxide?

....[1]

(ii) Suggest a '*dot-and-cross*' diagram for nitrous oxide. Show outer electrons only. The sequence of atoms in a nitrous oxide molecule is N N O.

[1]

(b) The structure of the painkiller ibuprofen is shown below.



(i) Determine the molecular formula of ibuprofen.

[1]

(ii) Suggest a chemical that would react with a solution of ibuprofen to produce a gas. Name the gas produced and write a balanced equation for the reaction.

chemical .....

gas .....

equation

[2]

For Examiner's Use

(c) Lidocaine, $C_{13}H_{20}N_2O_2$, is used as a local anaesthetic in dentistry. Lidocaine is administered by syringe as a solution containing 100 mg in 5.00 cm^3.

Calculate the concentration, in mol dm^{-3}, of lidocaine in the syringe.

concentration = ...mol dm^{-3} [3]

(d) Eugenol is used as a painkiller in dentistry. It is an organic compound of C, H and O.

A sample of 1.394 g of eugenol was analysed by burning in oxygen to form 3.74 g of CO_2 and 0.918 g of H_2O. The relative molecular mass of eugenol was shown to be 164 using a mass spectrometer.

Calculate the molecular formula of eugenol.

[5]

[Total: 13]

END OF QUESTION PAPER