Centre Number	Candidate Number	Name

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CHEMISTRY **9701/04**

Paper 4 Structured Questions A2 Core

May/June 2005

1 hour 15 minutes

Candidates answer on the Question Paper.
Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, Centre number and candidate number in the spaces at the top of this page.
Write in dark blue or black pen in the spaces provided on the Question Paper.
You may use a pencil for any diagrams, graphs, or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
The number of marks is given in brackets [ ] at the end of each question or part question.
You may lose marks if you do not show your working or if you do not use appropriate units.
A Data Booklet is provided.
You may use a calculator.

If you have been given a label, look at the details. If any details are incorrect or missing, please fill in your correct details in the space given at the top of this page.

Stick your personal label here, if provided.

For Examiner's Use	
1	
2	
3	
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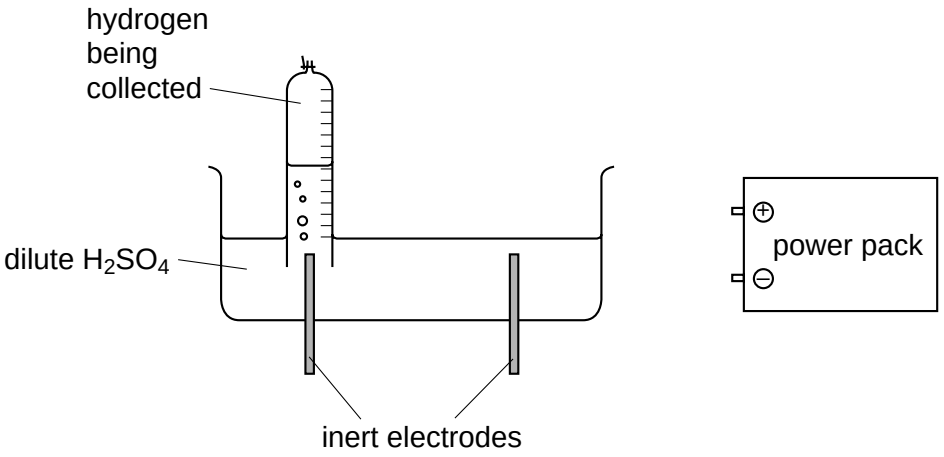
6	
TOTAL	

This document consists of **11** printed pages and **1** blank page.

Answer **all** the questions in the spaces provided.

1 A student decided to determine the value of the Faraday constant by an electrolysis experiment. The following incomplete diagram shows the apparatus that was used.



(a) **(i)** Apart from connecting wires, what **two** additional pieces of equipment are needed for this experiment?

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.....

(ii) Complete the diagram, showing additional equipment connected in the circuit, and showing the powerpack connected to the correct electrodes.

(iii) List the measurements the student would need to make in order to use the results to calculate a value for the Faraday constant.

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.....

[7]

(b) **(i)** Using an equation, state the relationship between the Faraday constant, *F*, the Avogadro constant, *L*, and the charge on the electron, *e*.

.....

(ii) The value the student obtained was: 1 Faraday = 9.63×10^4 Coulombs

Use this value and your equation in **(b)(i)** to calculate the Avogadro constant (take the charge on the electron to be 1.60×10^{-19} Coulombs)

.....

.....

[2]

[Total: 9]

2 **(a)** What do you understand by the term *order of reaction*?

..... [1]

(b) Cyanohydrins can be made by reacting ketones with an acidified solution of sodium cyanide.

$$(CH_3)_2C{=}O + H^+ + CN^- \longrightarrow (CH_3)_2C(OH)CN$$

In a series of experiments, the reaction was carried out with different concentrations of the three reagents, and the following relative initial rates were obtained.

experiment number	$[(CH_3)_2CO]$ / mol dm^{-3}	$[H^+]$ / mol dm^{-3}	$[CN^-]$ / mol dm^{-3}	relative initial rate / mol dm^{-3} sec^{-1}
1	0.020	0.060	0.060	1.00
2	0.020	0.050	0.050	0.833
3	0.020	0.050	0.060	1.00
4	0.025	0.050	0.050	1.042

(i) Use the data in the table to deduce the order of the reaction with respect to

propanone .....

hydrogen ions .....

cyanide ions .....

(ii) Hence write a rate equation for this reaction.

.....

Two different mechanisms have been suggested for this reaction

Mechanism A:
$$(CH_3)_2C{=}O + H^+ \longrightarrow (CH_3)_2COH^+$$
$$(CH_3)_2COH^+ + CN^- \longrightarrow (CH_3)_2C(OH)CN$$

Mechanism B:
$$(CH_3)_2C{=}O + CN^- \longrightarrow (CH_3)_2C(O^-)CN$$
$$(CH_3)_2C(O^-)CN + H^+ \longrightarrow (CH_3)_2C(OH)CN$$

(iii) Which mechanism is consistent with the rate equation you deduced in **(ii)**, and which step in this mechanism is the slower (rate determining) step? Explain your answer.

.....

.....

.....

.....

[7]

[Total: 8]

[Turn over

3 Limestone is an important raw material, used in building, steel making and agriculture.

The first stage in using limestone is often to heat it in a kiln.

$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$ $\quad \Delta H = +178\,kJ\,mol^{-1}$ reaction **1**

Water is then added to the 'quicklime' produced in the kiln, to make 'slaked lime'.

$CaO(s) + H_2O(l) \longrightarrow Ca(OH)_2(s)$ $\quad \Delta H = -82\,kJ\,mol^{-1}$ reaction **2**

(a) (i) Suggest **two** reasons why reaction **1** needs heating to a high temperature.

.....

.....

(ii) Explain whether $MgCO_3$ would require a higher or a lower temperature than $CaCO_3$ for its decomposition.

.....

.....

.....

[5]

Before the widespread use of cement, bricks and stones used for buildings were bonded together with a mixture of slaked lime, sand and water, known as lime mortar. On exposure to the air, the lime mortar gradually set hard due to the following reaction.

$$Ca(OH)_2(s) + CO_2(g) \longrightarrow CaCO_3(s) + H_2O(l)$$

(b) Use the data given above to calculate the enthalpy change for this reaction.

.....

.....

..... [1]

(c) One of the major ores of magnesium is the mixed carbonate called dolomite, $CaMg(CO_3)_2$.

Calculate the percentage loss in mass that would be observed when a sample of dolomite is heated at a high temperature until the reaction had finished.

.....

.....

..... [2]

[Total: 8]

[Turn over

4 **(a)** **(i)** State the electronic configuration of the iron atom.

.....

(ii) Apart from its electronic structure, state **two** properties of iron or its compounds that are characteristic of a transition element.

.....

.....

[3]

(b) Acidified solutions of iron(II) salts can be titrated using a dilute solution of potassium manganate(VII), $KMnO_4$.

(i) Use the *Data Booklet* to calculate the standard cell potential and to write a balanced ionic equation for the reaction that takes place during the titration.

.....

.....

.....

(ii) Explain why no indicator is required for this titration. What colour change would you see at the end point?

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.....

[4]

(c) Use the reaction between Fe^{3+} ions and water molecules to explain the meanings of the terms *ligand* and *complex formation*.

.....

.....

.....

..... [2]

(d) An important biological molecule containing iron is haemoglobin.

(i) What is the role of haemoglobin in the body?

.....

(ii) Use your answer to **(i)** to explain why carbon monoxide is poisonous.

.....

.....

.....

[2]

(e) In a possible industrial synthesis of ethanol, the complex $Fe(CO)_5$ catalyses the reaction between carbon monoxide, hydrogen and methanol according to the following equation.

$$CH_3OH + 2CO + H_2 \xrightarrow[300\,atm]{200\,^{\circ}C} CH_3CH_2OH + CO_2$$

Describe a test (reagents and observations) that would distinguish ethanol from methanol.

reagents .....

observation with methanol .....

observation with ethanol..... [2]

[Total: 13]

[Turn over

5 **(a)** Give an expression for K_a as applied to the weak acid RCO_2H.

.....

..... [1]

(b) The K_a values for three carboxylic acids are listed in the table below.

acid	K_a / mol dm^{-3}
CH_3CO_2H	1.8×10^{-5}
$ClCH_2CO_2H$	1.4×10^{-3}
Cl_2CHCO_2H	5.5×10^{-2}

(i) Describe and explain the trend in acid strength illustrated by these values.

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.....

(ii) Calculate the pH of a 0.100 mol dm^{-3} solution of $ClCH_2CO_2H$.

.....

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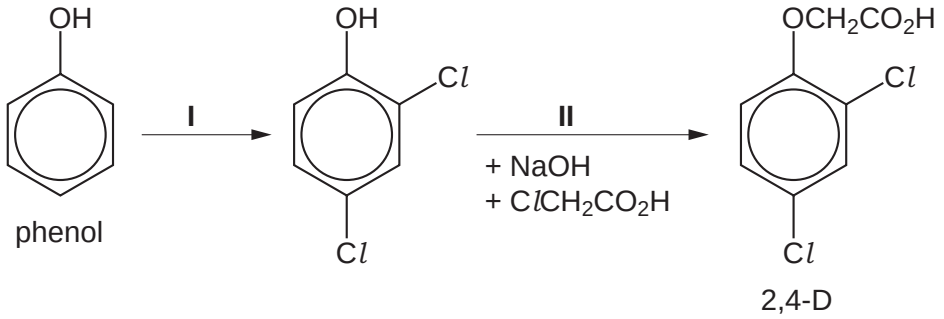
.....

(iii) Calculate the pK_a value for Cl_2CHCO_2H.

.....

.....
[5]

(c) The acid $ClCH_2CO_2H$ features in the industrial synthesis of the important weedkiller 2,4-D.



phenol

2,4-D

(i) Suggest a possible reagent for reaction **I**.

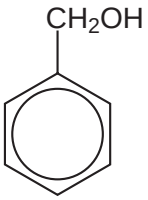
.....

(ii) What type of reaction is

reaction **I**, ...

reaction **II**? .....

(iii) Describe a test (reagents and observations) that would distinguish phenol from compound **A**.



compound **A**

reagents .....

observation with phenol .....

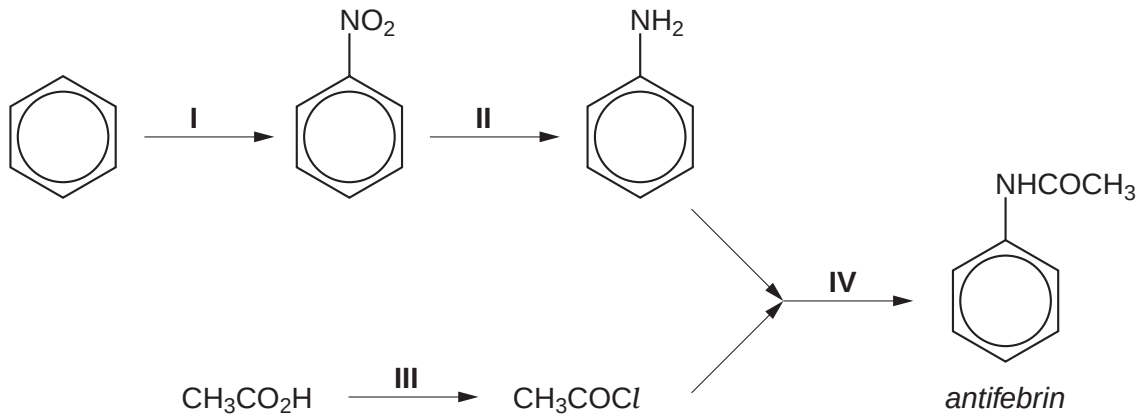
observation with compound **A** .....

[5]

[Total: 11]

[Turn over

6 The antipyretic (fever-reducing) drug *antifebrin* can be made from benzene and ethanoic acid by the following route.



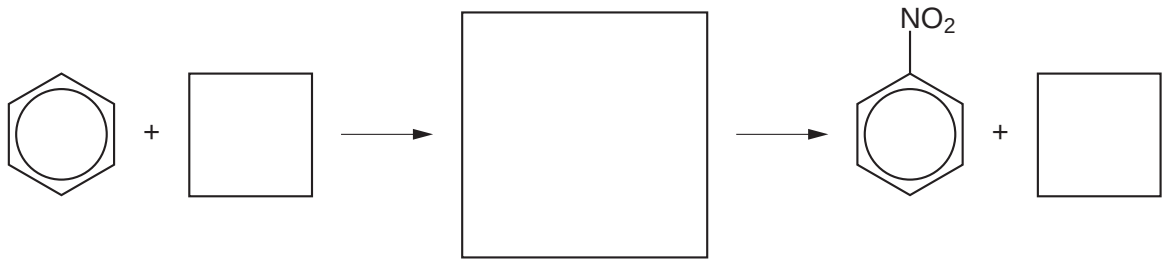
(a) **(i)** What type of reaction is reaction **I**?

.....

(ii) Suggest the reagents and conditions for reaction **I**.

.....

(iii) Complete the following scheme showing the mechanism of reaction **I**, by drawing appropriate formulae in the three boxes.



[6]

(b) **(i)** What type of reaction is reaction **II**?

.....

(ii) Suggest the reagents and conditions for reaction **II**.

.....

[2]

(c) Suggest the reagents and conditions for reaction **III**.

..... [1]

(d) **(i)** Apart from the benzene ring, name the functional group in *antifebrin*.

.....

(ii) What reagents and conditions are needed to hydrolyse *antifebrin*?

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[2]

[Total: 11]

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