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

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

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CHEMISTRY **9701/05**

Paper 5 Planning, analysis and evaluation **October/November 2008**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
You are advised to show all working in calculations.
Use of Data Booklet is unnecessary.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
Total	

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

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1 The **solubility** of cerium(IV) sulphate, at a particular temperature, is defined as:
*the mass of cerium(IV) sulphate that will dissolve in and just **saturate** 100 g of solvent at that temperature.*

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Cerium(IV) sulphate will dissolve in water.

A **saturated** solution is one in which no more solid can dissolve at a particular temperature.
In a saturated solution in contact with undissolved solid, the following equilibrium is established.

$$Ce(SO_4)_2(s) + aq \rightleftharpoons Ce^{4+}(aq) + 2SO_4^{2-}(aq)$$

Cerium(IV) sulphate is unusual. Its solubility **decreases** as the temperature of the solution increases.

Cerium(IV) sulphate crystals also dissolve in dilute sulphuric acid, H_2SO_4, a corrosive aqueous solution.

You are to plan an experiment to investigate how the **solubility** of cerium(IV) sulphate crystals in dilute sulphuric acid depends on the concentration of the acid.

(a) By considering the ions present in a solution of cerium(IV) sulphate in sulphuric acid predict and explain how the solubility of the cerium(IV) sulphate will be affected by the concentration of the acid.

Prediction .....

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Explanation .....

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Display your prediction in the form of a graph.



[2]

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(b) In the experiment you are about to plan, identify the following.

(i) the independent variable .....

(ii) the dependent variable .....

(iii) another variable to be controlled .....[3]

(c) Design a two-part laboratory experiment to investigate your prediction in **(a)**.

Part 1 – solubility of cerium(IV) sulphate in water

In addition to the standard apparatus present in a laboratory you are provided with the following materials.

60 cm^3 distilled water
solid cerium(IV) sulphate, $Ce(SO_4)_2$

Give a step-by-step description of how you would

(i) prepare a saturated solution using all of the 60 cm^3 of distilled water,
(ii) control the variable given in **(b) (iii)**,
(iii) separate the saturated solution from undissolved solid,
(iv) obtain the mass of cerium(IV) sulphate and mass of water in the saturated solution,
(v) calculate the solubility of cerium(IV) sulphate from the experimental results.

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Part 2 – solubility of cerium(IV) sulphate in sulphuric acid

In addition to the standard apparatus present in a laboratory you are provided with the following materials.

5 mol dm^{-3} sulphuric acid
distilled water
solid cerium(IV) sulphate

Give a step-by-step description of how you would prepare a range of solutions of sulphuric acid of different concentrations. These solutions could then be used to investigate the solubility of cerium(IV) sulphate in different concentrations of sulphuric acid. See section **(e)**.

Your plan should include details of the following.

(i) the number and concentrations of the solutions to be prepared
(ii) the volumes of acid and water used to prepare the solutions
(iii) the apparatus and method you would use in their preparation

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(e) Draw up a table with appropriate headings to show the data you would record when investigating the solubility of cerium(IV) sulphate in the solutions of sulphuric acid planned in **(c)**, **Part 2**.

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[1]

[Total: 15]

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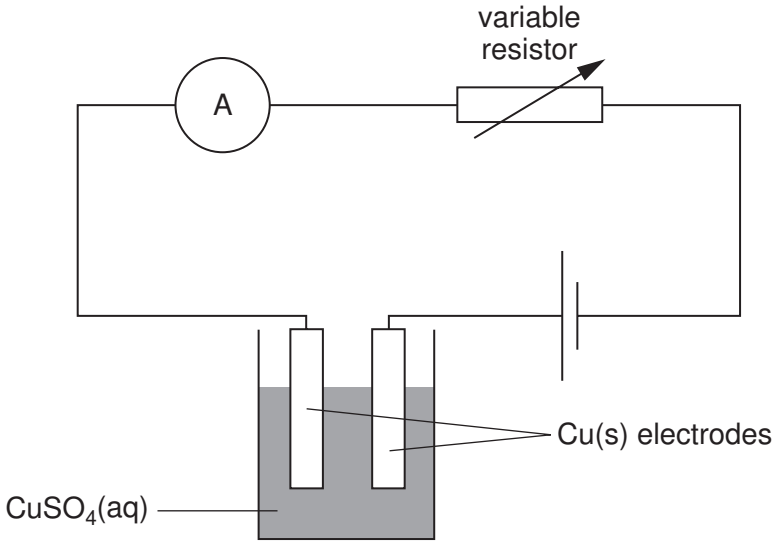
2 A student reads about the electrolysis of aqueous copper(II) sulphate and makes the following notes.

- reaction at the cathode $Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$
- reaction at the anode $Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$
- 1 mol of Cu(s) is deposited on the cathode by 2 mol of electrons.
- The Faraday constant is the charge in coulombs, C, on 1 mol of electrons.
- The Faraday constant $= 9.5 \times 10^4$ C mol^{-1}.

The student realises that a value for the Faraday constant can be determined experimentally using the following apparatus.



Method

- The cathode is cleaned and weighed before being placed in the copper(II) sulphate solution.
- The circuit is completed and the current set at 0.3 A by adjusting the variable resistor.
- The current is maintained at 0.3 A for exactly 40 minutes at which point the circuit is broken.
- The cathode is removed from the solution and carefully washed with distilled water to remove any copper(II) sulphate solution.
- Distilled water is removed from the cathode by rinsing it with propanone in which the water dissolves.
- The cathode is finally dried by allowing the propanone to evaporate from its surface.
- The cathode is reweighed and placed back in the solution.
- A constant current of 0.3 A is passed for a further 40 minutes when the rinsing, drying and weighing are repeated.
- This procedure is repeated a further 8 times.

The results of the experiment are recorded below.

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A	B	C	D	E	F
time /minutes	mass of cathode /g				
0	115.74				
40	115.97				
80	116.22				
120	116.46				
160	116.70				
200	116.94				
240	117.19				
280	117.49				
320	117.67				
360	117.92				
400	118.14				

(a) Use the additional columns of the table to record the charge passed and the mass of copper deposited on the cathode.

[charge in coulombs = time in seconds × current in amps; 1 minute = 60 seconds]

You may use some or all of the columns. Label the columns you use, including the units and an equation to show how the value is calculated. [2]

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(b) Present the data calculated in **(a)** in graphical form. Draw the line of best-fit.

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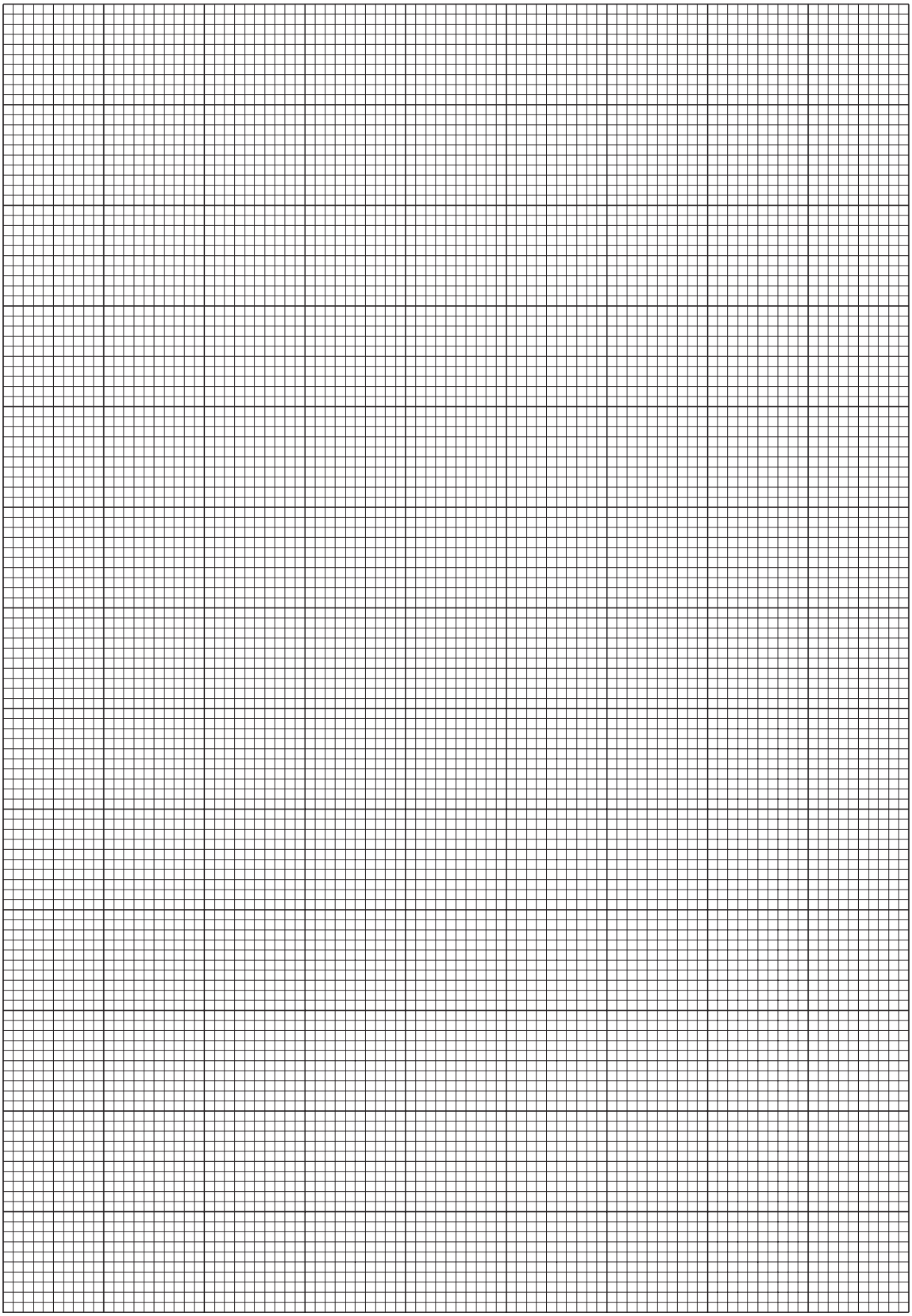

[4]

(c) Indicate clearly one anomalous point on the graph that you did not use when drawing the line of best-fit. By reference to the instructions for the experiment suggest an explanation for the anomaly.

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(d) The balance used by the student weighed to 2 decimal places. By reference to the results of the experiment explain why it would have been more appropriate to use an analytical balance weighing to 4 decimal places.

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(e) Draw construction lines on the graph to derive relevant values and use them to calculate a numerical value for the Faraday constant.

reaction at the cathode $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

[A_r: Cu; 63.5]

The value of the Faraday constant determined in this experiment is

..... C mol^{-1}. [2]

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(f) By considering the data you have processed and the graph you have drawn, decide if the experimental procedure described is suitable for the determination of the Faraday constant. Explain your reasoning.

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(g) What other measurements could be made during the course of the experiment to provide alternative data to confirm the determined value of the Faraday constant?

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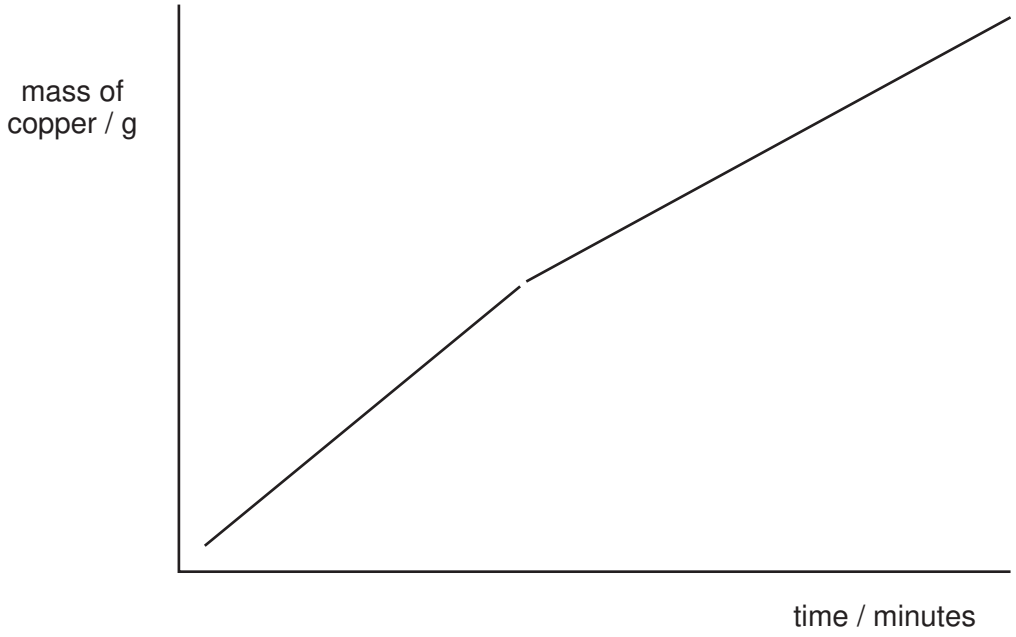
.....[1]

(h) Another student, performing the same experiment, plotted the mass of copper deposited against time, and obtained the results below.



Making reference to the experimental method, suggest an explanation for the shape of this graph.

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.....[1]

[Total: 15]

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