UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

4299232691

CHEMISTRY **9701/53**

Paper 5 Planning, Analysis and Evaluation **May/June 2012**

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 may lose marks if you do not show your working or if you do not use appropriate units.
Use of a 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 **8** printed pages.

DC (SLM) 58572

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[Turn over

1 When an excess of aqueous sodium hydroxide, NaOH, is added to 100 cm^3 of aqueous copper(II) sulfate, $CuSO_4$, a precipitate of copper(II) hydroxide, $Cu(OH)_2$, is produced.

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The stoichiometric equation for this reaction is,

$$CuSO_4\ (aq)\ +\ 2NaOH\ (aq) \longrightarrow Cu(OH)_2\ (s)\ +\ Na_2SO_4\ (aq)$$

The following information gives some of the hazards associated with these reactants.

Copper(II) sulfate (solid hydrated copper(II) sulfate $CuSO_4.5H_2O$)
Harmful. Dangerous for the environment.
Harmful if swallowed. Irritating to eyes and skin.
Solutions of concentrations equal to or greater than 1 mol dm^{-3} should be labelled HARMFUL.

Sodium hydroxide (solid NaOH)
Corrosive. Solutions of concentrations equal to or greater than 0.5 mol dm^{-3} are CORROSIVE.
Solutions of concentrations equal to or greater than 0.05 mol dm^{-3} but less than 0.5 mol dm^{-3} are IRRITANT.

You are to plan an experiment to investigate the molar ratio of the equation above and confirm that it remains unchanged as the concentration of the copper(II) sulfate changes.

(a) (i) Predict quantitatively how the number of moles of the precipitated copper(II) hydroxide varies as the molar concentration of the copper(II) sulfate increases until saturation is reached.

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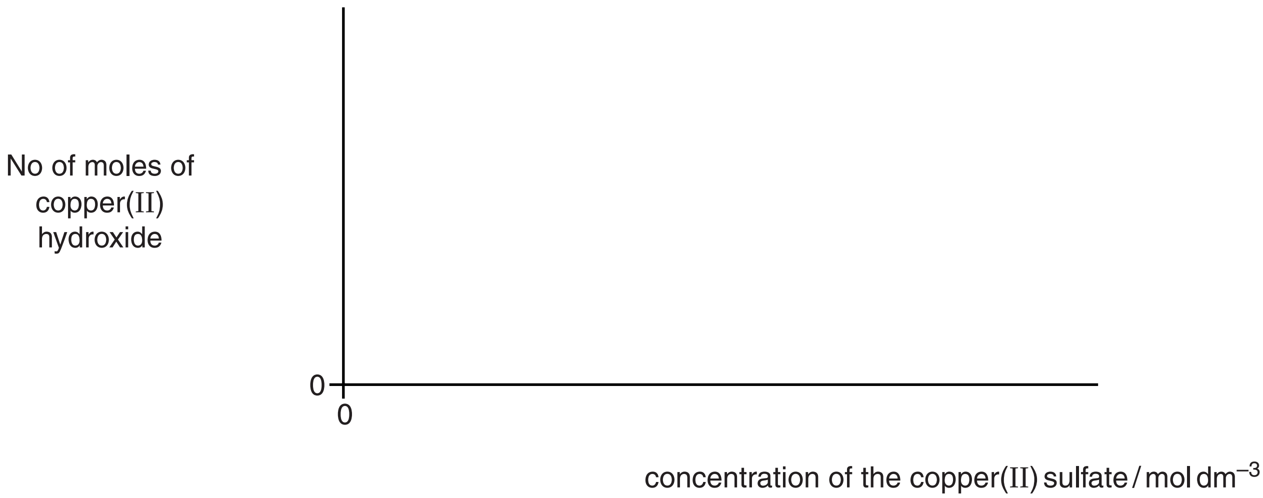
....

(ii) Display your prediction in the form of a sketch graph. Remember that you are using 100 cm^3 of aqueous copper(II) sulfate. Label clearly the point representing the saturated solution of copper(II) sulfate. A saturated solution at 25 °C has a concentration of 1.39 mol dm^{-3}. Give appropriate numerical scales to the two axes.



[3]

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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) one other variable to be controlled .... [2]

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

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

aqueous sodium hydroxide, NaOH (2.0 mol dm^{-3})
solid hydrated copper(II) sulfate, $CuSO_4.5H_2O$

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

(i) prepare enough solutions of copper(II) sulfate of an appropriate range of concentrations to give sufficient data to plot a graph as in **(a)(ii)**,

(ii) collect and dry the precipitated copper(II) hydroxide,

(iii) calculate the molar concentration of one of the solutions of copper(II) sulfate.
[A_r: H, 1.0; O, 16.0; S, 32.1; Cu, 63.5]

[5]

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(d) **(i)** State two hazards that must be considered when planning the experiment.

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....

....

(ii) State a precaution that should be taken to minimise the risk of one of these hazards.

....

....

....[3]

(e) Draw up a table with appropriate headings to show the data you would record when carrying out your experiments and the values you would calculate in order to construct a graph to support or reject your prediction in **(a)**. The headings should include the appropriate units.

[2]

[Total: 15]

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2 The variation of the volume with temperature of a fixed mass of an ideal gas at constant pressure may be represented by a relationship known as Charles's law,

$$V = kT$$

where V is the volume of a gas, T is the temperature in Kelvin and k is a constant.

An experiment was carried out to attempt to verify this law.

- A specially adapted gas syringe was filled with a sample of gas. The syringe was placed in a temperature controlled chamber at 25 °C and left for 5 minutes. The initial volume of gas at this temperature was 26.0 cm^3.
- The temperature was adjusted and, after leaving for 5 minutes, the change in gas volume for the new temperature was recorded.
- The experiment was repeated several times at different temperatures and the results recorded.

(a) The results of the experiment are recorded below.

Process the results in the table to calculate the volume of the gas and the corresponding temperature in Kelvin to enable you to plot a graph to show their inter-relationship.

(Note 0 °C is 273 K).

Record these values to **three significant figures** in the additional columns of the table. You may use some or all of the columns.

Label the columns you use. For each column you use include units where appropriate and an expression to show how your values are calculated.

You may use the column headings A to E in these expressions (e.g. A–B).

A	B	C	D	E
temperature of the gas /°C	change in volume of the gas /cm^3			
–23	–4.20			
–4	–2.50			
11	–2.10			
29	0.40			
42	1.50			
63	3.30			
77	4.50			
94	7.00			
117	8.00			
131	9.20			

[2]

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

[3]

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(c) Circle and label on the graph any point(s) you consider to be anomalous.
For each anomalous point give a different reason why it is anomalous, clearly indicating which point(s) you are describing.

....

....

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....

....[3]

(d) **(i)** Determine the slope of the graph. Mark clearly on the graph any construction lines and show clearly in your calculation how the intercepts were used in the calculation of the slope.

(ii) Record the volume of the gas at 273 K.

[3]

(e) Comment on the reliability of the data provided in **(a)**.

[1]

(f) Indicate whether the results do or do not confirm Charles's law.

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....

Give a reason for your answer.

....

....

....

....[2]

(g) As the pressure of a gas is reduced its volume increases. On your graph on page 6 draw another line showing how the volume varies with temperature if the experiment were repeated using the same fixed mass of gas at a lower pressure. [1]

[Total: 15]