UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

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| CANDIDATE NAME | |
| CENTRE NUMBER | |
| CANDIDATE NUMBER | |

*3483758140*

**CHEMISTRY** **9701/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2013**

**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.
Electronic calculators may be used.
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 **9** printed pages and **3** blank pages.




UNIVERSITY of CAMBRIDGE International Examinations

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*For Examiner's Use*

**1** Calcium hydroxide, $Ca(OH)_2$, is slightly soluble in water, approximately 1 g $dm^{-3}$ at 25 °C. The molar enthalpy of solution of a solid is defined as the enthalpy change when one mole of the solid dissolves in water.

**(a) (i)** Predict how the solubility of calcium hydroxide in water changes as the temperature is increased. Explain this prediction using Le Chatelier's Principle in terms of the equilibrium between the solid calcium hydroxide and the aqueous solution, as shown in the equation below.

$$Ca(OH)_2(s) \rightleftharpoons Ca^{2+}(aq) + 2OH^-(aq) \qquad \Delta H_{soln} = -16.7\ kJ\ mol^{-1}$$

Predict how the solubility will change as the temperature is increased. .....

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Explanation .....

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**(ii)** Display your prediction in the form of a sketch graph between 0 °C and 100 °C. Label the axes with units and give numerical values to ensure that the line clearly shows the solubility at 25 °C.


[4]

**(b)** If you were to carry out an experiment to investigate how the **solubility** of calcium hydroxide varies as the **temperature increases** name,

**(i)** the independent variable,

.....

**(ii)** the dependent variable. .....

[1]

**(c)** You are to plan an experiment to determine as accurately as possible the concentration of a saturated aqueous solution of calcium hydroxide by titration with hydrochloric acid. You are reminded that the approximate solubility of calcium hydroxide is 1 g $dm^{-3}$ at 25 °C.

The following information gives some of the hazards associated with calcium hydroxide and hydrochloric acid.

> **Hydrochloric acid**, HCl(aq)
> **Corrosive**; Causes burns: Irritating to respiratory system.
> Solutions equal to or more concentrated than 6.5 mol $dm^{-3}$ are **corrosive**.
> Solutions equal to or more concentrated than 2 mol $dm^{-3}$ but more dilute than 6.5 mol $dm^{-3}$ are said to be **irritant**.
> **Calcium hydroxide**, $Ca(OH)_2$(s)
> **Irritant**; risk of serious damage to eyes.

You are provided with the following materials:

250 $cm^3$ of saturated calcium hydroxide,
50 $cm^3$ of 2.00 mol $dm^{-3}$ hydrochloric acid.

Give a step-by-step description of how you would carry out the experiment by including:

**(i)** a balanced equation for the reaction between aqueous calcium hydroxide and hydrochloric acid,

**(ii)** a list of apparatus with volumes where appropriate,

**(iii)** a suitable indicator with relevant colours,

**(iv)** a calculation of the approximate concentration of a saturated aqueous solution of calcium hydroxide in mol $dm^{-3}$ at 25 °C,
[$A_r$: H, 1.0; O, 16.0; Ca, 40.1]

**(v)** a detailed method for the dilution of the hydrochloric acid such that when a titration is carried out the two reacting volumes are approximately equal at the end-point. The relevant calculations and reasoning must be shown in full.

**(vi)** a detailed method for carrying out sufficient titrations to allow an accurate end-point to be obtained,

**(vii)** an outline calculation to show how the results are to be used to determine the accurate concentration of the aqueous calcium hydroxide.
[$A_r$: Cl, 35.5]

For Examiner's Use

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[8]

**(d)** State one hazard that must be considered when planning the experiment and describe a precaution that should be taken to keep risks from this hazard to a minimum. You should use the information in **(c)**.

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[2]

[Total: 15]

**QUESTION 2 STARTS ON THE NEXT PAGE.**

For Examiner's Use

**2** Hydrated copper(II) sulfate can be represented as $CuSO_4.xH_2O$ where x is the number of molecules of $H_2O$ for each $CuSO_4$. When the compound is heated, it loses the molecules of water leaving anhydrous copper(II) sulfate.

A suggested equation is:

$$CuSO_4.xH_2O(s) \rightarrow CuSO_4(s) + xH_2O(g)$$

An experiment is carried out to attempt to determine the value of x.

- An open crucible is weighed and the mass recorded.
- A sample of hydrated copper(II) sulfate is added to the crucible and the new mass recorded.
- The crucible with hydrated copper(II) sulfate is heated strongly for five minutes and allowed to cool back to room temperature.
- The crucible with the contents is then reweighed and the mass recorded.

**(a)** Calculate the relative formula masses, $M_r$, of $CuSO_4$ and $H_2O$.
[$A_r$: H, 1.0; O, 16.0; S, 32.1; Cu, 63.5]

[1]

**(b)** The results of several of these experiments are recorded below.

Process the results in the table to calculate both the number of moles of anhydrous copper(II) sulfate and the number of moles of water.

Record these values in the additional columns of the table.
You may use some or all of the columns.

Masses should be recorded to **two decimal places**, while the numbers of moles should be recorded to **three significant figures**.

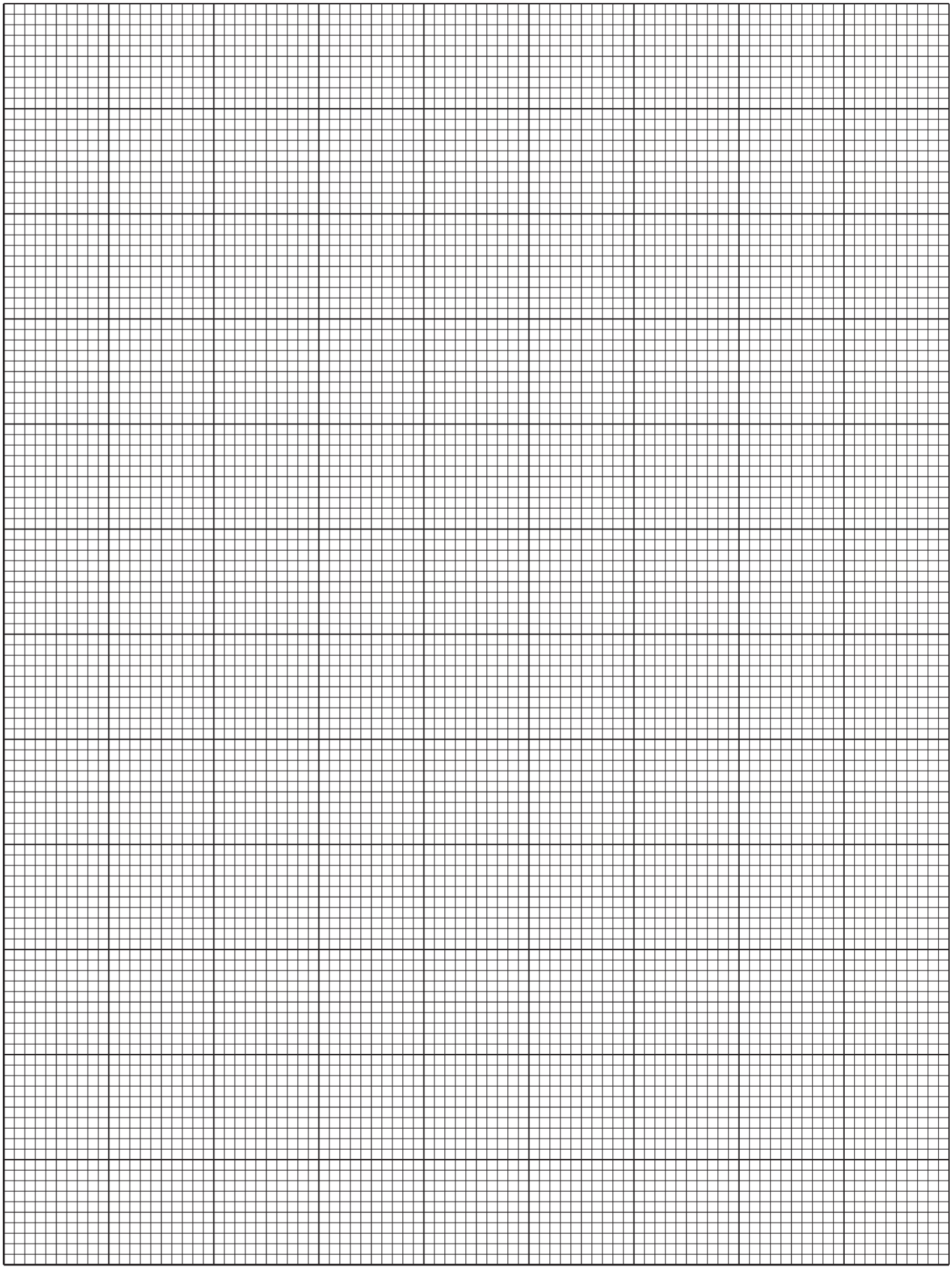
Label the columns you use. For each column you use include units where appropriate and an expression to show how your values are calculated.

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

| A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| mass of crucible / g | mass of crucible + $CuSO_4.xH_2O$ / g | mass of crucible + $CuSO_4$ / g | | | | |
| 15.20 | 16.76 | 16.20 | | | | |
| 15.10 | 16.90 | 16.25 | | | | |
| 14.95 | 16.95 | 16.23 | | | | |
| 15.15 | 17.25 | 16.49 | | | | |
| 15.05 | 17.32 | 16.47 | | | | |
| 14.90 | 17.24 | 16.43 | | | | |
| 14.92 | 17.42 | 16.52 | | | | |
| 15.30 | 17.99 | 17.02 | | | | |
| 15.07 | 17.96 | 16.92 | | | | |
| 15.01 | 18.09 | 16.98 | | | | |

[2]

**(c)** Plot a graph to show the relationship between the number of moles of anhydrous copper(II) sulfate, $CuSO_4$ (*x*-axis), and the number of moles of water (*y*-axis).
Draw the line of best fit. It is recommended that you do not include the origin in your choice of scaling.



[3]





**[Turn over**

*For Examiner's Use*

**(d)** 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 you are describing.

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..... [3]

**(e)** Determine the slope of the graph. You must 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.

[3]

**(f)** Comment on the reliability of the data provided in **(b)**.

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**(g)** **(i)** Use the value of the slope of your graph calculated in **(e)** to suggest the correct formula for hydrated copper(II) sulfate.

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**(ii)** Explain your answer to **(i)**.

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[2]

[Total: 15]

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