Cambridge International A Level

**Cambridge International Examinations**
Cambridge International Advanced Level

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

*0255060262*

**CHEMISTRY** **9701/53**

Paper 5 Planning, Analysis and Evaluation **October/November 2014**

**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 an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, 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.

This document consists of **10** printed pages and **2** blank pages.


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CAMBRIDGE International Examinations

**1** The enthalpy change, $\Delta H_r$, for the reaction between magnesium atoms and aluminium ions to produce magnesium ions and aluminium atoms cannot be determined directly. However both metals react with dilute sulfuric acid and, using the enthalpy changes for these reactions, it is possible to use Hess' Law to determine $\Delta H_r$.

You are to plan experiments that will enable you to determine the value of the enthalpy change for the reaction of 1 mol of magnesium with excess aqueous aluminium ions.

You are provided with:

- 0.30 g of magnesium ribbon,
- 0.30 g of aluminium foil,
- 1.00 mol $dm^{-3}$ sulfuric acid,
- standard laboratory equipment.

**(a)** ● Write an equation for the reaction of magnesium and sulfuric acid.

.....

● Write an equation for the reaction of aluminium and sulfuric acid.

.....
[2]

**(b)** For the experiment to measure the enthalpy change when magnesium reacts with sulfuric acid name:

**(i)** the independent variable,

..... [1]

**(ii)** the dependent variable.

..... [1]

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**(c)** In the experiment, 20.0 $cm^3$ of 1.00 mol $dm^{-3}$ sulfuric acid is used with 0.30 g of magnesium.

**(i)** Calculate the minimum volume in $cm^3$ of sulfuric acid required to react completely with 0.30 g of magnesium.
[$A_r$: Mg, 24.3]

[1]

**(ii)** Suggest why 20.0 $cm^3$ of sulfuric acid is used.

.....

..... [1]

**(d)** You are also provided with 0.30 g of aluminium.
Calculate the minimum volume of 1.00 mol $dm^{-3}$ sulfuric acid required to react completely with 0.30 g of aluminium.
[$A_r$: A*l*, 27.0]

[2]

**(e)** Explain how you would carry out the experiment using the 0.30 g magnesium.

**(i)** List the measurements you would make.

.....

.....

.....

..... [1]

**(ii)** How would you do the experiment to make sure the results obtained would be as accurate as possible?

.....

.....

.....

..... [1]

**(iii)** How would you use the measurements made in the experiment to determine the enthalpy change of the reaction between 1 mol of magnesium and sulfuric acid?

.....

.....

.....

.....

.....

.....

.....

..... [2]

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**(f)** Write an ionic equation for the reaction between magnesium and aqueous aluminium ions.
If the enthalpy change of the reaction between magnesium and sulfuric acid is $\Delta H_1$ and that for aluminium and sulfuric acid is $\Delta H_2$, use Hess' Law to determine the enthalpy change, $\Delta H_r$, for the reaction between magnesium and aqueous aluminium ions.
Then determine the enthalpy change for 1 mol of magnesium in terms of $\Delta H_r$.

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.....

.....

..... [3]

[Total: 15]

**2** An aqueous solution of nickel(II) sulfate, $NiSO_4$, has a concentration of exactly 0.500 mol $dm^{-3}$.

In an experiment, 100.0 $cm^3$ of this solution was accurately measured into a beaker and 0.0200 mol of solid potassium iodate(V), $KIO_3$, was added to it.

After stirring, a saturated solution of nickel(II) iodate was formed together with a precipitate of nickel(II) iodate.

The precipitate was filtered off, dried and weighed. The mass of precipitate obtained was recorded in the table below.

The experiment was repeated six more times using 100.0 $cm^3$ of aqueous nickel(II) sulfate each time but adding increasing amounts of solid potassium iodate(V). The results obtained from these experiments were also recorded in the table below.

| experiment number | amount of potassium iodate(V) added / mol | mass of precipitate formed / g |
|---|---|---|
| 1 | 0.0200 | 3.87 |
| 2 | 0.0300 | 6.71 |
| 3 | 0.0400 | 7.92 |
| 4 | 0.0500 | 8.80 |
| 5 | 0.0600 | 11.97 |
| 6 | 0.0700 | 13.95 |
| 7 | 0.0800 | 15.92 |

The concentration of ions in a saturated solution of a slightly soluble salt can be expressed using a solubility product. For nickel(II) iodate this is defined as:

$$\text{solubility product} = [Ni^{2+}(aq)][IO_3^{-}(aq)]^2$$

**(a) (i)** Write an ionic equation for the reaction that has taken place. Include state symbols.

..... [1]

**(ii)** Use the equation in **(i)** to deduce the amount in mol of potassium iodate(V) that would react with the nickel(II) sulfate solution in this experiment.

[1]

**(iii)** If, after the amount in **(ii)** had been added further potassium iodate(V) was added, state what effect, if any, this would have on the mass of precipitate obtained.

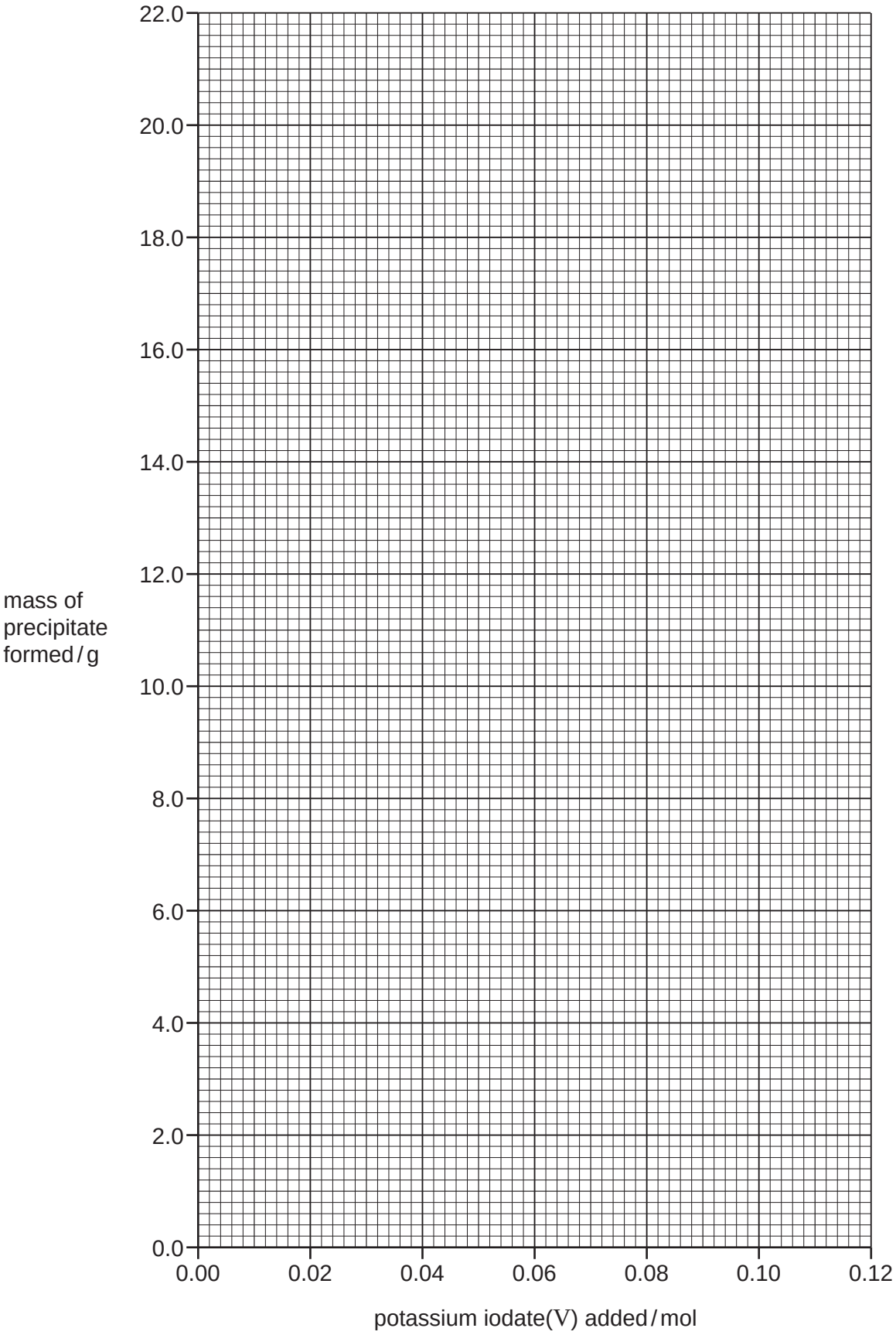
.....

.....

..... [1]

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**(b) (i)** Plot points on the grid below to show the amount in mol of potassium iodate(V) added against the mass of precipitate formed. Draw a line of best fit.




[2]

**(ii)** Circle any anomalous point(s) on your graph. [1]

**(iii)** Suggest which part of the experimental procedure would make it difficult to achieve accurate results.

.....

.....

.....

..... [1]

**(iv)** Add points on your graph to indicate the approximate mass of precipitate that would be obtained if each of the following amounts in mol of potassium iodate(V) were added.

- 0.1000 mol
- 0.1200 mol

[2]

**(c) (i)** In this reaction some of the nickel(II) iodate has been precipitated but some remains dissolved.

Calculate the total mass of nickel(II) iodate (both precipitated and dissolved) formed in experiment 3 when all of the added potassium iodate(V) ions have fully reacted with nickel(II) sulfate.

The relative formula mass of nickel(II) iodate is 408.7.

[1]

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**(ii)** Use your answer to **(i)** and the mass of precipitate of nickel(II) iodate in experiment 3 to calculate the mass of nickel(II) iodate dissolved in solution.

Calculate the amount in moles of nickel(II) iodate in solution.

Calculate the amount in moles of iodate(V) ions that remain in the 100.0 $cm^3$ of solution.

[3]

**(iii)** The solubility product of nickel(II) iodate = $[Ni^{2+}(aq)][IO_3^-(aq)]^2$.

In experiment 3, the amount in moles of $Ni^{2+}(aq)$ that remain in the 100.0 $cm^3$ of solution is 0.0306.

Use this, and your final answer in **(ii)**, to calculate the solubility product.

[2]

[Total: 15]

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