Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER					

8184126684

CHEMISTRY **9701/33**

Paper 3 Advanced Practical Skills 1 **October/November 2014**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Give details of the practical session and laboratory where appropriate, in the boxes provided.
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.

Qualitative Analysis Notes are printed on pages 14 and 15.

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.

Session
Laboratory

For Examiner's Use	
1	
2	
Total	

This document consists of **13** printed pages and **3** blank pages.

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CAMBRIDGE International Examinations

[Turn over

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1 You are to determine the enthalpy change of reaction, ΔH, for the reaction shown below.

$$Cu(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2(g)$$

Since copper is an unreactive metal it does not react directly with dilute acids. You will therefore need to find the enthalpy change of reaction for two reactions that do occur. The equations for these two reactions are below.

$$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g) \qquad \textbf{Reaction 1}$$

$$Mg(s) + CuSO_4(aq) \rightarrow MgSO_4(aq) + Cu(s) \qquad \textbf{Reaction 2}$$

You will carry out experiments to find the enthalpy changes for each of **Reaction 1** and **Reaction 2** and use these values to calculate the enthalpy change for the reaction of copper with sulfuric acid.

TURN OVER FOR EXPERIMENTAL METHOD

Determining the enthalpy change for Reaction 1

$$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$$ **Reaction 1**

(a) Method

FA 1 is 1.00 mol dm^{-3} sulfuric acid, H_2SO_4.
FA 2 is magnesium powder, Mg.

Read through the method before you start any practical work and prepare a suitable table for your results.

- Weigh the stoppered tube containing **FA 2**. Record the mass.
- Support the plastic cup in the 250 cm^3 beaker.
- Use the measuring cylinder to transfer 25 cm^3 of **FA 1** into the plastic cup.
- Measure the temperature of **FA 1** in the plastic cup and start the stop clock. Record this temperature as being the temperature at time = 0.
- Measure, and record, the temperature of this **FA 1** every half minute for 2 minutes.
- At time = $2\frac{1}{2}$ minutes add the **FA 2** to the acid and stir carefully to reduce acid spray.
- Measure the temperature of the mixture in the cup at time = 3 minutes and then every half minute up to time = 7 minutes.
- Continue stirring occasionally throughout this time.
- Weigh the stoppered tube that had contained **FA 2**. Record the mass.
- Calculate and record the mass of **FA 2** added to the sulfuric acid.
- Rinse the plastic cup with water and shake to dry.

I	
II	
III	
IV	
V	
VI	

[6]

(b) (i) On the grid below plot a graph of temperature (*y*-axis) against time (*x*-axis).

(ii) Complete the graph by inserting **two**, **straight** lines of best fit:

- one to show the temperature up to time = $2\frac{1}{2}$ minutes,
- one to show the temperature after time = $2\frac{1}{2}$ minutes.

I	
II	
III	
IV	

(iii) From your graph, use the two straight lines of best fit to calculate the change in temperature at time = $2\frac{1}{2}$ minutes.

temperature change = ... °C
[4]

(c) Calculations

(i) In the reaction in **(a)**, the sulfuric acid was in excess. Without carrying out any additional tests, what observation could you have made during your experiment to confirm this?

....

....

(ii) Calculate the energy change that occurred during the reaction in **(a)**.
[Assume that 4.2 J is needed to raise the temperature of 1.0 cm^3 of solution by 1.0 °C.]

energy change = ... J

(iii) Use your answer to **(ii)** to calculate the enthalpy change, in $kJ\,mol^{-1}$, for the reaction between sulfuric acid and magnesium.
[A_r : Mg, 24.3]

$$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$$ **Reaction 1**

enthalpy change for **Reaction 1** = ... $kJ\,mol^{-1}$
sign *value*
[4]

Determining the enthalpy change for Reaction 2

$$Mg(s) + CuSO_4(aq) \rightarrow MgSO_4(aq) + Cu(s) \qquad \textbf{Reaction 2}$$

(d) Method

FA 3 is 1.00 mol dm^{-3} copper(II) sulfate, $CuSO_4$.
FA 4 and **FA 5** are magnesium powder, Mg.

Read through the method before you start any practical work and prepare a suitable table for your results.

- Weigh the stoppered tube containing **FA 4**. Record the mass.
- Support the plastic cup in the 250 cm^3 beaker.
- Use the measuring cylinder to transfer 25 cm^3 of **FA 3** into the plastic cup.
- Measure the temperature of **FA 3** in the plastic cup and record the temperature.
- Add the **FA 4** to the **FA 3** in the cup and stir the mixture constantly.
- Measure and record the maximum temperature reached during the reaction.
- Calculate and record the maximum temperature change that occurred during the reaction.
- Weigh the stoppered tube that had contained **FA 4**. Record the mass.
- Calculate and record the mass of **FA 4** added to the copper(II) sulfate.
- Empty the contents of the plastic cup into the 100 cm^3 beaker labelled **waste**.
- Rinse the plastic cup and shake to dry.

- Repeat this experiment using **FA 5** in place of **FA 4**.

[2]

(e) Calculations

(i) Using your results from **(d)**, calculate the mean temperature rise.

mean temperature rise = ... °C

(ii) Using your results from **(d)**, calculate the mean mass of magnesium used.

mean mass = ... g

(iii) Show, using a suitable calculation, that the copper(II) sulfate was in excess in these reactions.

(iv) Using your values from **(i)** and **(ii)**, calculate the enthalpy change, in $kJ\,mol^{-1}$, for the reaction between magnesium and copper(II) sulfate.
[Assume that 4.2 J is needed to raise the temperature of $1.0\,cm^3$ of solution by 1.0 °C.]
[A_r : Mg, 24.3]

$$Mg(s) + CuSO_4(aq) \rightarrow MgSO_4(aq) + Cu(s)$$ **Reaction 2**

enthalpy change for **Reaction 2** = ... $kJ\,mol^{-1}$
sign *value*

[4]

Enthalpy change for Reaction 3

Reaction 3 is shown below.

$Cu(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2(g)$ **Reaction 3**

(f) Use your values for the enthalpy changes for **Reactions 1** and **2** to calculate the enthalpy change for **Reaction 3**.

$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$ **Reaction 1**

$Mg(s) + CuSO_4(aq) \rightarrow MgSO_4(aq) + Cu(s)$ **Reaction 2**

Show clearly how you obtained your answer.

(If you were unable to calculate the enthalpy changes for **Reactions 1** and **2**, you should assume that the value for **Reaction 1** is $-444\,kJ\,mol^{-1}$ and that the value for **Reaction 2** is $-504\,kJ\,mol^{-1}$. Note: these are not the correct values.)

enthalpy change for **Reaction 3** = ... $kJ\,mol^{-1}$
sign *value*

[2]

(g) (i) The method you used to determine the enthalpy change for **Reaction 1** was more accurate than the method you used to determine the enthalpy change for **Reaction 2**. Suggest **two** reasons why the method used for **Reaction 2** was less accurate. Explain your answers.

1 ....

....

....

2 ....

....

....

(ii) A student suggested that the accuracy of the method used for **Reaction 2** could be improved by using a larger volume of copper(II) sulfate. Is this a correct suggestion? Give a reason for your answer.

....

....

[3]

[Total: 25]

2 Qualitative Analysis

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations**.

You should indicate clearly at what stage in a test a change occurs.
Marks are **not** given for chemical equations.
No additional tests for ions present should be attempted.

If any solution is warmed, a boiling tube MUST be used.

Rinse and reuse test-tubes and boiling tubes where possible.

Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.

(a) **FA 6** is a solid that contains one cation and one anion. One of the ions present is included in the lists on pages 14 and 15. This ion contains the element nitrogen.

(i) State which nitrogen-containing ions could be present. Select reagents for use in tests that would distinguish between them.

....

....

....

(ii) Carry out tests on **FA 6** using the reagents selected in **(i)** to identify the nitrogen-containing ion. Record your tests and observations in the space below.

(iii) Identify the nitrogen-containing ion in **FA 6**.

Ion present is ....

[5]

(b) Half fill the 250 cm^3 beaker with water and heat the water to about 60 °C. This is the water bath to be used in one of the following tests.

Carry out the following tests on **FA 7** and complete the table below.

test	*observations*
To a 1 cm depth of **FA 7** in a test-tube, add a few drops of dilute hydrochloric acid.	
To a 1 cm depth of **FA 7** in a test-tube, add a few drops of aqueous potassium iodide, then	
add aqueous ammonia.	
To a 1 cm depth of **FA 7** in a test-tube, add a few drops of aqueous sodium hydroxide and then add aqueous ammonia dropwise, with gentle shaking, until the precipitate **just** dissolves, then	No observation required.
add one spatula measure of glucose and leave to stand in the hot water bath. When you have completed this test, dispose of the solution and rinse the test-tube.	

[4]

(c) Solid **FA 8** contains one cation and one anion from those included in the lists on pages 14 and 15.

Carry out the following tests on **FA 8**. For each test record your observations.

(i) In a hard-glass test-tube heat approximately half of the **FA 8**, gently at first and then more strongly. Leave to cool.

....

....

....

(ii) To a 2 cm depth of dilute nitric acid in a boiling tube, add the remaining **FA 8**.

Keep the solution obtained for tests (iii) and (iv).

....

....

....

(iii) To a 1 cm depth of the solution from **(ii)** in a test-tube, add aqueous sodium hydroxide until no further change occurs.

....

....

....

(iv) To a 1 cm depth of the solution from **(ii)** in a test-tube, add aqueous ammonia until no further change occurs.

....

....

....

(v) Use your observations from **(i)** to **(iv)** to identify the ions present in **FA 8**.

Ions present .... and ....

[6]

[Total: 15]

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Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

ion	*reaction with*	
	NaOH(aq)	NH_3(aq)
aluminium, Al^{3+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH_4^+(aq)	no ppt. ammonia produced on heating	–
barium, Ba^{2+}(aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca^{2+}(aq)	white ppt. with high [Ca^{2+}(aq)]	no ppt.
chromium(III), Cr^{3+}(aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu^{2+}(aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe^{2+}(aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe^{3+}(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg^{2+}(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn^{2+}(aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn^{2+}(aq)	white ppt. soluble in excess	white ppt. soluble in excess

2 Reactions of anions

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $Cl^-(aq)$	gives white ppt. with $Ag^+(aq)$ (soluble in $NH_3(aq)$)
bromide, $Br^-(aq)$	gives cream ppt. with $Ag^+(aq)$ (partially soluble in $NH_3(aq)$)
iodide, $I^-(aq)$	gives yellow ppt. with $Ag^+(aq)$ (insoluble in $NH_3(aq)$)
nitrate, $NO_3^-(aq)$	NH_3 liberated on heating with $OH^-(aq)$ and Al foil
nitrite, $NO_2^-(aq)$	NH_3 liberated on heating with $OH^-(aq)$ and Al foil; NO liberated by dilute acids (colourless NO $\rightarrow$ (pale) brown NO_2 in air)
sulfate, $SO_4^{2-}(aq)$	gives white ppt. with $Ba^{2+}(aq)$ (insoluble in excess dilute strong acids)
sulfite, $SO_3^{2-}(aq)$	SO_2 liberated with dilute acids; gives white ppt. with $Ba^{2+}(aq)$ (soluble in excess dilute strong acids)

3 Tests for gases

gas	*test and test result*
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	"pops" with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns acidified aqueous potassium manganate(VII) from purple to colourless

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