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

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

* 5 4 9 3 6 6 8 3 7 9 *

CHEMISTRY **9701/35**

Advanced Practical Skills 1 **May/June 2013**

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 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.

Qualitative Analysis Notes are printed on pages 10 and 11.

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 **11** printed pages and **1** blank page.

IB13 06_9701_35/4RP

UNIVERSITY *of* CAMBRIDGE International Examinations

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1 You will determine the enthalpy change, ΔH, for the reaction of anhydrous magnesium sulfate, $MgSO_4$, with water to form hydrated magnesium sulfate, $MgSO_4.7H_2O$. In step 1 you will dissolve a known mass of anhydrous magnesium sulfate in a known volume of water and find the temperature change. In step 2 you will find the temperature change on adding a known mass of hydrated magnesium sulfate to a known volume of water. You will then use your results to calculate the enthalpy change for the reaction.

$$MgSO_4(s) + 7H_2O(l) \rightarrow MgSO_4.7H_2O(s)$$

FA 1 is anhydrous magnesium sulfate, $MgSO_4$.
FA 2 is hydrated magnesium sulfate, $MgSO_4.7H_2O$.
distilled water

(a) Method

Step 1

$$MgSO_4(s) + aq \rightarrow MgSO_4(aq)$$

- Place the plastic cup in the 250 cm^3 beaker.
- Use the measuring cylinder to transfer 25 cm^3 of distilled water into the plastic cup.
- Weigh the container with **FA 1** and record the balance reading in a suitable form in the space below.
- Place the thermometer in the water and record the initial temperature in the table of results. Tilt the cup if necessary so that the bulb of the thermometer is fully covered. This is the temperature at time zero. Start timing.
- Record the temperature of the water at 1 minute and at 2 minutes.
- At 2½ minutes tip all the **FA 1** into the water and stir to dissolve.
- Record the temperature of the solution at 3, 4, 5, 6, 7 and 8 minutes.
- Reweigh the container with any residual **FA 1** and record the balance reading and the mass of **FA 1** used.
- Rinse out the plastic cup and shake it to remove excess water.

Results

Mass

Temperature

Time in minutes	0	1	2	3	4	5	6	7	8
Temperature / °C									

I	
II	
III	
IV	
V	

[5]

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(b) Plot temperature on the *y*-axis against time on the *x*-axis on the grid below. You will use the graph to determine the theoretical temperature change at 2½ minutes.

Draw two straight lines of best fit on your graph, one for the temperature of the water before adding **FA 1** and the other for the cooling of the solution once the reaction is complete. Extrapolate the two lines to 2½ minutes and determine the change in temperature at this time.

temperature change at 2½ minutes = ... °C
[4]

I	
II	
III	
IV	

For Examiner's Use

(c) Method

Step 2

$$MgSO_4.7H_2O(s) + aq \rightarrow MgSO_4(aq)$$

- Read through the method and prepare a suitable table for your results.
- Place the plastic cup in the 250 cm^3 beaker.
- Use the measuring cylinder to transfer 25 cm^3 of distilled water into the plastic cup.
- Weigh the container with **FA 2** and record the balance reading below.
- Place the thermometer in the water and record the initial temperature. Tilt the cup if necessary so that the bulb of the thermometer is fully covered.
- Tip all the **FA 2** into the water and stir to dissolve.
- Record the lowest temperature.
- Reweigh the container with any residual **FA 2** and record the balance reading and the mass of **FA 2** used.

Results

I	
II	
III	

[3]

For Examiner's Use

(d) Calculations

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

(i) Using your answer to **(b)**, calculate the heat energy produced when **FA 1** was added to water in **step 1**.
(Assume that 4.3 J of heat energy changes the temperature of 1.0 cm^3 of solution by 1.0 °C.)

heat energy produced = ... J

(ii) Calculate the enthalpy change, in $kJ\,mol^{-1}$, when 1 mole of **FA 1**, $MgSO_4$, is dissolved.
(A_r: O, 16.0; Mg, 24.3; S, 32.1)

enthalpy change = ... $kJ\,mol^{-1}$
(sign) (value)

(iii) Using your results from **(c)**, calculate the heat energy absorbed when **FA 2** was added to water in **step 2**.
(Assume that 4.3 J of heat energy changes the temperature of 1.0 cm^3 of solution by 1.0 °C.)

heat energy absorbed = ... J

(iv) Calculate the enthalpy change, in $kJ\,mol^{-1}$, when 1 mole of **FA 2**, $MgSO_4.7H_2O$, is dissolved.
(A_r: H, 1.0; O, 16.0; Mg, 24.3; S, 32.1)

enthalpy change = ... $kJ\,mol^{-1}$
(sign) (value)

(v) Use your answers to parts **(ii)** and **(iv)** and the equations for the reactions shown in **steps 1** and **2** to determine the enthalpy change, in $kJ\,mol^{-1}$, for the reaction below.

$$MgSO_4(s) + 7H_2O(l) \rightarrow MgSO_4.7H_2O(s)$$

I	
II	
III	
IV	
V	
VI	

enthalpy change, ΔH = ... $kJ\,mol^{-1}$
(sign) (value) [6]

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(e) **(i)** Complete the following table.

The maximum error in a single thermometer reading is .... °C.
The maximum error in measuring the change in temperature in **step 2** is .... °C.

(ii) Calculate the maximum percentage error in the temperature change in **step 2**.

maximum percentage error in the temperature change in **step 2** = ... %
[2]

(f) **(i)** A student suggested that the experiment could be made more accurate by using 50 cm^3 of water in **step 1** and **step 2**. State whether the student is correct or incorrect and justify your answer.

The student is ....

because ....

....
[1]

(ii) Another student carried out **step 2** twice for a different hydrated salt and obtained the following results.

First result: mass used = 3.34 g; drop in temperature = 4.0 °C
Second result: mass used = 4.18 g; drop in temperature = 5.0 °C

The student then used the mean mass and mean temperature drop when calculating the enthalpy change for the reaction. Explain whether or not the student was justified in using the results in this way, by showing appropriate calculations.

....

....

....

....
[2]

[Total: 23]

For Examiner's Use

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.

FA 3, **FA 4** and **FA 5** are aqueous solutions of salts. Read through the tests before starting the practical work.

(a) Many cations are identified by using aqueous sodium hydroxide and aqueous ammonia in small amounts and then to excess. Carry out the following tests and record all your observations in the table below.
Do **not** discard the final products in these tests as you will need to use them in part **(b)**.

test	*observations*		
	FA 3	**FA 4**	**FA 5**
(i) To 1 cm depth of solution in a test-tube, add aqueous sodium hydroxide,			
until in excess. (do not discard)			
(ii) To 1 cm depth of solution in a test-tube, add aqueous ammonia,			
until in excess. (do not discard)			

[3]

For Examiner's Use

(b) At least one of the solutions contains a second cation, the ammonium ion, NH_4^+. Devise a test to identify which salt or salts contain the ammonium ion. You are to use the products of the reactions in **(a)** when carrying out your test.

(i) Which of the following sets of products will you use in your test? Tick the appropriate box.

- products with excess aqueous sodium hydroxide ☐
- products with excess aqueous ammonia ☐

(ii) Describe the test and expected observations if NH_4^+ is present.

....

....

....

(iii) Carry out your test and record your observations clearly in the space below.

[4]

For Examiner's Use

(c) **FA 3**, **FA 4** and **FA 5** each contains a different anion which is sulfate, chloride, or nitrate. Using the Qualitative Analysis Notes on page 11, select reagents to allow you to identify positively which anion is in each salt using the minimum number of tests. Record your reagents and your observations in the table below.

Indicate where a test is unnecessary using a dash, —.

reagent(s)	FA 3	FA 4	FA 5

I	
II	
III	
IV	
V	

[5]

(d) From your observations in **(a)**, **(b)** and **(c)**, identify as many ions that could be present as possible.

	FA 3	FA 4	FA 5
cation(s)			
anion			

I	
II	
III	
IV	
V	

[5]

[Total: 17]

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
lead(II), Pb^{2+}(aq)	white ppt. soluble in excess	white 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

[Lead(II) ions can be distinguished from aluminium ions by the insolubility of lead(II) chloride.]

2 Reactions of anions

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chromate(VI), $CrO_4^{2-}(aq)$	yellow solution turns orange with $H^+(aq)$; gives yellow ppt. with $Ba^{2+}(aq)$; gives bright yellow ppt. with $Pb^{2+}(aq)$
chloride, $Cl^-(aq)$	gives white ppt. with $Ag^+(aq)$ (soluble in $NH_3(aq)$); gives white ppt. with $Pb^{2+}(aq)$
bromide, $Br^-(aq)$	gives cream ppt. with $Ag^+(aq)$ (partially soluble in $NH_3(aq)$); gives white ppt. with $Pb^{2+}(aq)$
iodide, $I^-(aq)$	gives yellow ppt. with $Ag^+(aq)$ (insoluble in $NH_3(aq)$); gives yellow ppt. with $Pb^{2+}(aq)$
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 $Ba^{2+}(aq)$ or with $Pb^{2+}(aq)$ (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 dichromate(VI) from orange to green

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