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

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

0257891118

CHEMISTRY **9701/32**

Advanced Practical Skills 2 **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_32/4RP

CAMBRIDGE International Examinations

For Examiner's Use

1 You will determine the enthalpy change, ΔH, for the reaction of sodium carbonate, Na_2CO_3, with water and carbon dioxide to form sodium hydrogencarbonate, $NaHCO_3$. In step 1 you will react a known mass of sodium hydrogencarbonate with a known volume of dilute hydrochloric acid and find the temperature change. In step 2 you will find the temperature change on adding a known mass of sodium carbonate to a known volume of acid. You will then use your results to calculate the enthalpy change for the reaction.

$$Na_2CO_3(s) + H_2O(l) + CO_2(g) \rightarrow 2NaHCO_3(s)$$

FB 1 is sodium hydrogencarbonate, $NaHCO_3$.
FB 2 is sodium carbonate, Na_2CO_3.
FB 3 is 2.0 mol dm^{-3} hydrochloric acid, HCl.

(a) Method

Step 1

$$NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) + CO_2(g)$$

- Place the plastic cup in the 250 cm^3 beaker.
- Use the measuring cylinder to transfer 25 cm^3 of the acid, **FB 3**, into the plastic cup. The acid is in excess.
- Weigh the container with **FB 1** and record the balance reading in a suitable form below.
- Place the thermometer in the acid 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 acid at 1 minute and at 2 minutes.
- At 2½ minutes carefully tip all the **FB 1**, in small portions to avoid spray, into the acid and stir to dissolve it.
- Record the temperature of the solution at 3, 4, 5, 6, 7 and 8 minutes.
- Reweigh the container with any residual **FB 1** and record the balance reading and the mass of **FB 1** used.
- Rinse out the plastic cup and shake it to remove excess water.

Results

Mass

I	
II	
III	
IV	
V	

Temperature

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

[5]

For Examiner's Use

(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. The scale for temperature should extend at least 1 °C below your lowest recorded temperature.

Draw two straight lines of best fit on your graph, one for the temperature of the acid before adding **FB 1** and the other for the warming 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	

(c) Method

Step 2

$$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$$

- 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 the acid, **FB 3**, into the plastic cup. The acid is in excess.
- Weigh the container with **FB 2** and record the balance reading.
- Place the thermometer in the acid and record the initial temperature. Tilt the cup if necessary so that the bulb of the thermometer is fully covered.
- Carefully tip all the **FB 2**, in small portions to avoid spray, into the acid and stir to dissolve it.
- Record the highest temperature.
- Reweigh the container with any residual **FB 2** and record the balance reading and the mass of **FB 2** used.

Results

I	
II	
III	

[3]

(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 absorbed when **FB 1** was added to the acid 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 absorbed = ... J

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(ii) Calculate the enthalpy change, in kJ mol^{-1}, when 1 mole of **FB 1**, $NaHCO_3$, reacts with acid. (A_r: H, 1.0; C, 12.0; O, 16.0; Na, 23.0)

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

(iii) Using your results from **(c)**, calculate the heat energy produced when **FB 2** was added to the acid 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 produced = ... J

(iv) Calculate the enthalpy change, in kJ mol^{-1}, when 1 mole of **FB 2**, Na_2CO_3, reacts with acid. (A_r: C, 12.0; O, 16.0; Na, 23.0)

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

I	
II	
III	
IV	
V	
VI	
VII	

(v) Use your answers to parts **(ii)** and **(iv)** and the equations for **steps 1** and **2** to determine the enthalpy change for the reaction below.

$$Na_2CO_3(s) + H_2O(l) + CO_2(g) \rightarrow 2NaHCO_3(s)$$

enthalpy change, ΔH = ... kJ mol^{-1}
(sign) (value) [7]

For Examiner's Use

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

The balance used in the experiment reads to .... decimal place(s).
The maximum error in a single balance reading is .... g.
The maximum error in measuring the recorded mass of **FB 2** in **(c)** would be .... g.

(ii) Calculate the maximum percentage error in the mass of **FB 2** in **step 2**.

maximum percentage error in the mass of **FB 2** in **step 2** = ... %

[2]

(f) **(i)** A student stated that the experiment could be made more accurate by using twice the volume of acid in **step 1** and **step 2**. Suggest whether the student is correct or incorrect and justify your answer.

The student is ....

because ....

....

....

[1]

(ii) Another student carried out **step 2** twice using the carbonate of a different metal and obtained the following results.

First result: mass used = 2.96 g; increase in temperature = 4.0 °C
Second result: mass used = 3.65 g; increase in temperature = 5.0 °C

The student then used the mean mass and the mean temperature increase 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: 24]

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.

(a) **FB 4**, **FB 5** and **FB 6** are aqueous solutions of salts. Each contains a different anion which is either 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)	FB 4	FB 5	FB 6

I	
II	
III	
IV	
V	

[5]

For Examiner's Use

(b) 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 provided below.

test	*observations*		
	FB 4	**FB 5**	**FB 6**
(i) To 1 cm depth of salt solution in a test-tube, add a few drops of aqueous sodium hydroxide,			
then add excess.			
(ii) To 1 cm depth of salt solution in a test-tube, add a few drops of aqueous ammonia,			
then add excess.			

[3]

(c) From your observations in **(a)** and **(b)**, identify as many of the ions present as possible.

	FB 4	**FB 5**	**FB 6**
cation			
anion			

[3]

For Examiner's Use

(d) One or more of the solutions contain(s) a second cation, the hydrogen ion, H^+.

(i) State two tests that can be used to show whether H^+ is present.

test 1 ....

test 2 ....

(ii) Carry out your tests and record your observations in a suitable form in the space below.

I	
II	
III	
IV	
V	

(iii) Identify which of the solutions **FB 4**, **FB 5** and **FB 6** contain(s) the hydrogen ion, H^+.

H^+ is present in ....

[5]

[Total: 16]

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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