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

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

2330102833

CHEMISTRY **9701/32**

Paper 32 Advanced Practical Skills **May/June 2008**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Instructions to Supervisors

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.
You are advised to show all working in calculations.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 11 and 12.

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 **12** printed pages.

SP (SM/CGW) T58776/3

UNIVERSITY *of* CAMBRIDGE International Examinations

For Examiner's Use

1 You are provided with the following.

FB 1, 3.00 mol dm^{-3} hydrochloric acid, HCl
Three tubes containing different mixtures of sodium carbonate, Na_2CO_3, and sodium hydrogencarbonate, $NaHCO_3$, each with a total mass of 5.00 g of mixture.

tube labelled	mass of Na_2CO_3 / g	mass of $NaHCO_3$ / g	% by mass of Na_2CO_3
FB 2	1.00	4.00	20.0
FB 3	2.50	2.50	50.0
FB 4	4.00	1.00	80.0

You are to determine the temperature change, ΔT, when the contents of each of the tubes **FB 2**, **FB 3** and **FB 4** react with an excess of hydrochloric acid, **FB 1**.

(a) (i) Calculate the volume of 3.00 mol dm^{-3} hydrochloric acid required to react with 5.00 g of sodium carbonate, Na_2CO_3. Show your working.

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

[M_r: Na_2CO_3, 106.0]

(ii) Calculate the volume of 3.00 mol dm^{-3} hydrochloric acid required to react with 5.00 g of sodium hydrogencarbonate, $NaHCO_3$. Show your working.

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

[M_r: $NaHCO_3$, 84.0]

[2]

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$35.00\,cm^3$ of $3.00\,mol\,dm^{-3}$ HCl will be used in each experiment – an excess of hydrochloric acid.

(b) **Read the following instructions before starting this section.**

- Fill a burette with **FB 1**, $3.00\,mol\,dm^{-3}$ HCl.
- Support the plastic cup in a $250\,cm^3$ beaker.
- Run $35.00\,cm^3$ of acid from the burette into the cup.
- Measure the steady temperature of the acid in the plastic cup.
- Tip the contents of the tube labelled **FB 2** into the acid as quickly as possible but take care to avoid overflow or acid spray. Stir with the thermometer, measure and record the highest **or** lowest temperature reached in the reaction.
- Make certain that all of the solid has been transferred from the tube to the cup. Tap the tube if necessary to dislodge any residual solid.
- Empty and rinse the plastic cup with water. Shake out any residual drops of water.
- Repeat the experiment for each of the tubes **FB 3** and **FB 4**.

Record all measurements of temperature and the temperature changes, ΔT, in an appropriate form in the space below. Indicate clearly whether the temperature has increased or decreased in the reaction.

[4]

(c) Select masses of Na_2CO_3 and $NaHCO_3$ which can be used to prepare two further tubes, each containing a mixture which can be used in the same experiment as described above. The temperature change when each of these mixtures reacts with hydrochloric acid will be used with those above to plot five points on a graph.

tube labelled	mass of Na_2CO_3 / g	mass of $NaHCO_3$ / g
FB 5		
FB 6		

[1]

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(d) Preparation of the tubes **FB 5** and **FB 6**

You are provided with

- empty tubes labelled **FB 5** and **FB 6**,
- sodium carbonate and sodium hydrogencarbonate.

Prepare each tube and record in an appropriate form in the space below

- all of your weighings,
- the mass of sodium carbonate in the mixture,
- the mass of sodium hydrogencarbonate in the mixture,
- the % by mass of sodium carbonate in the mixture.

[4]

(e) Carry out the same experiment as in **(b)** for each of the tubes **FB 5** and **FB 6**.

Record all temperature readings and the temperature change, ΔT, for each of the tubes.

[2]

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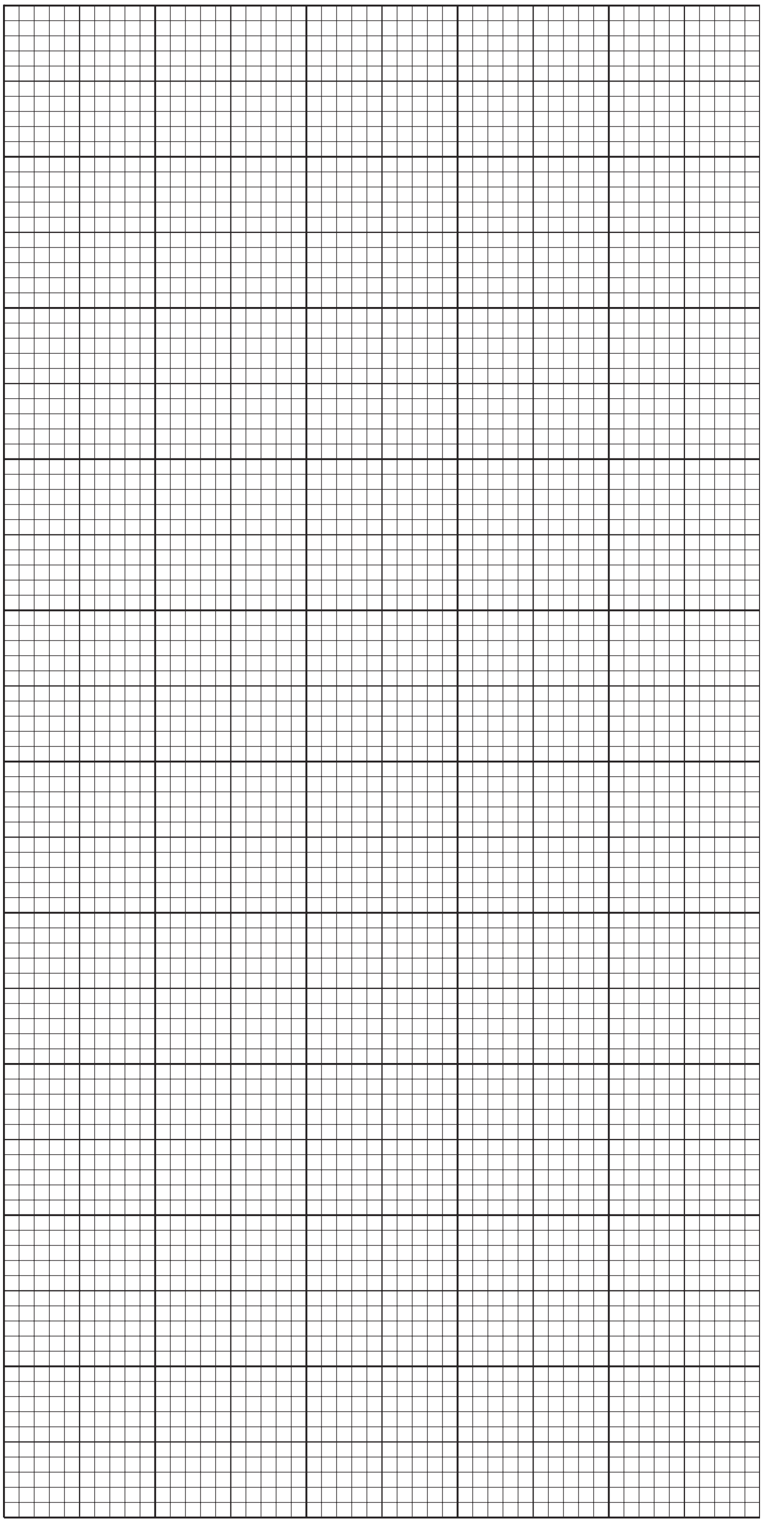
(f) Plot ΔT (*y*-axis, starting at –10 °C) against the % by mass of Na_2CO_3 in the mixture (*x*-axis, starting at 0%).
Remember – the temperature has increased in some experiments and decreased in others.

Draw the most appropriate straight line through the five plotted points. Extend this line until it crosses the y-axis.



[4]

(g) Record from the graph the temperature change when the mixture contains no sodium carbonate. This represents the temperature change for 5.00 g of sodium hydrogencarbonate.

ΔT, read from the graph for 0% sodium carbonate is .... °C. [1]

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(h) You are to use the value in **(g)**, obtained from the graph, to calculate the enthalpy change for the reaction between sodium hydrogencarbonate and hydrochloric acid.

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

(i) Calculate the energy change in the plastic cup when 5.00 g of $NaHCO_3$ reacts with excess hydrochloric acid.
[4.3 J are absorbed or released when the temperature of 1.0 cm^3 of solution changes by 1 °C.]

(ii) Calculate the enthalpy change, ΔH, for the reaction

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

Give your answer in $kJ\,mol^{-1}$, correct to **3 significant figures.**
Include the appropriate sign.

[M_r: $NaHCO_3$, 84.0]

ΔH = ………………………………… $kJ\,mol^{-1}$
[4]

For Examiner's Use

(i) Suggest the most significant source of error in this experiment.

....

....

.... [1]

(j) Suggest a modification to the experimental procedure that would reduce the error described in **(i)**.

....

....

....

....

.... [1]

(k) Do you think the method used is capable of producing an accurate value for the enthalpy change for the reaction of sodium hydrogencarbonate and hydrochloric acid?

Justify your answer by referring to the results of your experiment.

....

....

....

....

....

....

.... [1]

[Total: 25]

2 The three solutions **FB 7**, **FB 8**, and **FB 9** each contain one of the following.

a cation and the chloride ion
manganese(II) sulphate, $MnSO_4$
magnesium sulphate, $MgSO_4$

For Examiner's Use

(a) Using the information on page 12 select **two** suitable reagents and use them to carry out a test to determine which solutions contain the sulphate ion.

In the space below, record details of the test performed and the observations made.

From this test, solutions **FB** .... and **FB** .... contain the sulphate ion.

[2]

(b) By selecting a further **two** reagents, carry out a test to confirm the presence of the chloride ion in the remaining solution.

In the space below, record details of the test performed and the observations made.

[2]

You are to perform the tests given in the table opposite on each of **FB 7**, **FB 8** and **FB 9** to identify and confirm the cation present in the solution.

Record details of colour changes seen, the formation of any precipitate and the solubility of any such precipitate in an excess of the reagent added.

Where gases are released they should be identified by a test, described in an appropriate place in the table.

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.

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test	observations with **FB 7**	observations with **FB 8**	observations with **FB 9**
(c) To 1 cm depth of solution in a test-tube, add aqueous sodium hydroxide drop-by-drop until it is in excess.			
(d) To 1 cm depth of solution in a test-tube, add aqueous ammonia drop-by-drop until it is in excess.			

[4]

(e) Observations made with aqueous sodium hydroxide should have indicated that one of the solutions contains either of two cations. Identify this solution and the **two** possible cations.

Solution .... could contain .... or ....

Make use of the Qualitative Analysis Notes on page 11 to suggest what further test you could do to identify which of the two ions was present.

....

....

....

Carry out your suggestion using a boiling-tube. Record the results below and explain how this enables you to identify the ion present.

....

....

....

[3]

For Examiner's Use

(f) For each of the solutions **FB 7**, **FB 8**, and **FB 9**, identify the cation present and give supporting evidence from the observations made.

FB 7 contains ....

supporting evidence

....

....

....

FB 8 contains ....

supporting evidence

....

....

....

FB 9 contains ....

supporting evidence

....

....

....

[3]

(g) Carry out the tests below on **FB 7**.

test	observations
To 1 cm depth of solution in a boiling-tube, add 2 cm depth of aqueous ammonia, then slowly add 2 cm depth of aqueous hydrogen peroxide.	
To 1 cm depth of solution in a boiling-tube, add 2 cm depth of aqueous hydrogen peroxide, then slowly add 2 cm depth of aqueous ammonia.	

[1]

[Total: 15]

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)	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. insoluble in excess	green ppt. 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. insoluble in excess	off-white ppt. 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 pale 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 A*l* foil
nitrite, NO_2^- (aq)	NH_3 liberated on heating with OH^-(aq) and A*l* foil; NO liberated by dilute acids (colourless NO $\rightarrow$ (pale) brown NO_2 in air)
sulphate, SO_4^{2-} (aq)	gives white ppt. with Ba^{2+}(aq) or with Pb^{2+}(aq) (insoluble in excess dilute strong acids)
sulphite, 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
sulphur dioxide, SO_2	turns potassium dichromate(VI) (aq) from orange to green