Centre Number	Candidate Number	Name

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

CHEMISTRY **9701/05**

Paper 5 Practical Test

October/November 2003

1 hour 30 minutes

Candidates answer on the Question Paper.
Additional materials:
As listed in Instructions to Supervisors

READ THESE INSTRUCTIONS FIRST

Write your details, including practical session and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen in the spaces provided on the Question Paper.
You may use a soft pencil for any diagrams, graphs, or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
The number of marks is given in brackets [ ] at the end of each question or part question.
You are advised to show all working in calculations.
Use of a Data Booklet is unnecessary.
Qualitative Analysis Notes are printed on pages 10 and 11.

SESSION
LABORATORY

If you have been given a label, look at the details. If any details are incorrect or missing, please fill in your correct details in the space given at the top of this page.

Stick your personal label here, if provided.

FOR EXAMINER'S USE	
1	
2	
TOTAL	

This document consists of **11** printed pages and **1** blank page.

University of Cambridge

1 **FB 1** is 2.00 mol dm^{-3} hydrochloric acid, HCl.
FB 2 is solid sodium carbonate, Na_2CO_3.
FB 3 is solid sodium hydrogen carbonate, $NaHCO_3$.

You are to determine, by experiment, the enthalpy change ΔH_1 for the reaction

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

and the enthalpy change ΔH_2 for the reaction

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

You are then to use the results of your experiments to calculate the enthalpy change, ΔH_3 for the reaction

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

Experiment 1

Weigh the tube labelled **Tube 1**, which contains **FB 2**, solid sodium carbonate and record the mass in Table 1.1.

Table 1.1

Mass of tube 1 + **FB 2**	/ g	
Mass of tube 1 + residual **FB 2**	/ g	
Mass of **FB 2** added	/ g	

[1]

Place a plastic (expanded polystyrene) cup inside a 250 cm^3 beaker for stability.

Using a measured cylinder, place 50.0 cm^3 of **FB 1**, aqueous hydrochloric acid, into the plastic cup. Measure and record the temperature of **FB 1** in Table 1.2.

Tip the sodium carbonate from **Tube 1** into the plastic cup, stir carefully and measure the maximum temperature obtained. Record this temperature in Table 1.2 and calculate the temperature rise.

It does not matter if some solid remains in the tube. Reweigh **Tube 1** (and stopper), together with any residual solid. Record the mass in Table 1.1 and calculate the mass of **FB 2** added to the acid.

Table 1.2

Initial temperature of **FB 1**	/ °C	
Maximum temperature after reaction	/ °C	
Temperature rise during reaction	/ °C	

[1] + [3]

For Examiner's Use

(a) Calculate the heat change in the cup during the reaction of solid sodium carbon hydrochloric acid.
[You may assume that 4.3 J are required to raise the temperature of 1 cm^3 of soluti by 1 ^oC]

[1]

(b) By reference to the volume of **FB 1**, the mass of **FB 2** and the equation for the reaction, show which of the reagents **FB 1** or **FB 2** was in excess.
[A_r: Na, 23.0; C, 12.0; 0, 16.0.]

[1]

(c) Calculate ΔH_1 for the following reaction.

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

Give your answer correct to 3 significant figures and include the correct sign and units.

[2]

Experiment 2

Weigh the tube labelled **Tube 2**, which contains **FB 3**, solid sodium hydrogen carbonate and record the mass in Table 1.3.

Table 1.3

Mass of tube 2 + **FB 3**	/ g	
Mass of tube 2 + residual **FB 3**	/ g	
Mass of **FB 3** added	/ g	

[1]

Empty and rinse the plastic cup used in *Experiment 1*. Replace the cup in the 250 cm^3 beaker.

Use the measuring cylinder to place 50.0 cm^3 of **FB 1**, aqueous hydrochloric acid, into the plastic cup. Measure and record the temperature of **FB 1** in Table 1.4.

Tip the sodium carbonate from **Tube 2** into the plastic cup, stir carefully and measure the minimum temperature obtained. Record this temperature in Table 1.4 and calculate the temperature change.

Record the mass of the tube and any residual solid in Table 1.3 and calculate the mass of **FB 3** added to the acid.

Table 1.4

Initial temperature of **FB 1**	/ °C	
Minimum temperature after reaction	/ °C	
Decrease in temperature during reaction	/ °C	

[1] + [3]

(d) Calculate the heat change in the cup during the reaction of solid sodium hydrogen carbonate and hydrochloric acid.
[You may assume that 4.3 J are required to raise the temperature of 1 cm^3 of solution by 1 °C]

[1]

(e) Calculate the number of moles of sodium hydrogen carbonate, $NaHCO_3$, used in the experiment
[A_r: Na, 23.0; C, 12.0; H, 1.0; O, 16.0.]

[1]

(f) Assuming that the hydrochloric acid, **FB 1**, is in excess, calculate ΔH_2 for the following reaction.

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

Give your answer correct to 3 significant figures and include the correct sign and units.

[2]

(g) Use the equations

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

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

and the calculated values of ΔH_1 and ΔH_2 to calculate the enthalpy change, ΔH_3, for the following reaction, where the enthalpy change cannot be measured directly by experiment.

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

[2]

ASSESSMENT OF PLANNING SKILLS

You are provided with **FB 4**, solid sodium hydrogen carbonate, $NaHCO_3$, and distilled water.

Using these materials alone, you are to plan and carry out one experiment to determine a further enthalpy change, ΔH_4, which can be put together with the other enthalpy changes to find the enthalpy change for the following reaction.

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

Give your plan as a series of numbered steps

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For Examiner's Use

Carry out your plan recording all your results in a suitable form.

Show how you can use your results to determine the enthalpy change for the reaction

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

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....[5]

[Total 25]

2 **ASSESSMENT OF PLANNING SKILLS**

Labels have come off three bottles each containing a white solid.

The labels indicate that the solids are

aluminium nitrate
lead nitrate
zinc nitrate

Solutions have been prepared from each of the solids and labelled **FB 5**, **FB 6** and **FB 7**.

You are to plan a way to identify the solid dissolved in each of the solutions. You should then carry out your plan.

MAXIMUM CREDIT will be given for the minimum number of tests to positively identify each of the solutions. Marks will be reduced for additional or unnecessary tests.

Plan

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Results of Tests Carried out

Identity of solids dissolved in the solutions

FB 5	
FB 6	
FB 7	

[Total 5]

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 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)
sulphate, $SO_4^{2-}(aq)$	gives white ppt. with $Ba^{2+}(aq)$ or with $Pb^{2+}(aq)$ (insoluble in excess dilute strong acid)
sulphite, $SO_3^{2-}(aq)$	SO_2 liberated with dilute acids; gives white ppt. with $Ba^{2+}(aq)$ (soluble in excess dilute strong acid)

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

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