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

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

4504368604

CHEMISTRY **9701/34**

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 12 and 13.

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	
3	
Total	

This document consists of **12** printed pages and **4** blank pages.

CAMBRIDGE International Examinations

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For Examiner's Use

1 When aqueous hydrochloric acid is mixed with aqueous sodium hydroxide, the neutralisation reaction releases heat causing a rise in the temperature of the solution.

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

In this experiment you will mix different volumes of hydrochloric acid and sodium hydroxide but the total volume will be kept constant. For each mixture you will record the temperature rise. Since the combined volume remains the same, the temperature rise is a direct measure of the heat given out by the reaction. The maximum heat given out occurs when all the acid present is exactly neutralised by all the alkali present. By determining the volumes when this occurs you can work out the concentration of the sodium hydroxide.

FB 1 is 2.00 mol dm^{-3} hydrochloric acid, HC*l*.
FB 2 is aqueous sodium hydroxide, NaOH.

Read through the instructions carefully and prepare a table for your results in the space on page 4 before starting any practical work.

(a) Method
Experiment 1

- Support the plastic cup in the 250 cm^3 beaker.
- Fill the unlabelled burette with **FB 1**.
- Run 26.00 cm^3 of **FB 1** from the burette into the plastic cup.
- Record the temperature of **FB 1**, T_1, in the space below.

T_1 = ………… °C

- Fill the burette labelled **FB 2** with **FB 2**.
- Run 4.00 cm^3 of **FB 2** from the burette into the plastic cup.
- Stir the mixture thoroughly and record in your table the maximum temperature of the solution.
- Empty the plastic cup, rinse thoroughly with water and shake dry.

Experiment 2

- Support the plastic cup in the 250 cm^3 beaker.
- Run 22.00 cm^3 of **FB 1** from the burette into the plastic cup.
- Run 8.00 cm^3 of **FB 2** from the burette into the plastic cup.
- Stir the mixture thoroughly and record in your table the maximum temperature of the solution.
- Empty the plastic cup, rinse thoroughly with water and shake dry.

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Experiments 3 – 7

- Repeat the experiment using 18.00, 14.00, 10.00, 6.00 and 2.00 cm^3 of **FB 1** respectively. Add sufficient **FB 2** each time to make sure that the total volume remains 30.00 cm^3.

  For **each** of your **seven** experiments, record in the space below

  - the volume of **FB 1**,
  - the volume of **FB 2**,
  - the maximum temperature of the solution,
  - the temperature rise, ΔT, where ΔT = maximum temperature recorded – T_1.

I	
II	
III	
IV	
V	
VI	

[6]

(b) (i) On the grid opposite, plot the temperature rise, ΔT, on the *y*-axis against the volume of **FB 1** on the *x*-axis.
The scale for ΔT should extend at least 2 °C above your greatest temperature rise.

(ii) Draw a straight line of best fit through the points where the values of ΔT are increasing. Draw a second straight line of best fit through the points where the values of ΔT are decreasing.

(iii) From your graph, determine the value of the volume of **FB 1** where the two lines of best fit intersect.

volume of **FB 1** = ... cm^3

I	
II	
III	
IV	
V	

[5]

For Examiner's Use

For Examiner's Use

(c) Calculations

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

(i) Calculate how many moles of hydrochloric acid are contained in the volume recorded in **(b)(iii)**.

moles of HC*l* = ………………… mol

(ii) Calculate how many moles of sodium hydroxide would react completely with the number of moles of hydrochloric acid in **(c)(i)**.

moles of NaOH = ………………… mol

(iii) Calculate the concentration of **FB 2**. Remember that the combined volume of **FB 1** and **FB 2** in each experiment was 30.00 cm^3.

I	
II	
III	

concentration of **FB 2** = …………………….. mol dm^{-3} [3]

(d) A student decided to modify the experiment. The total volume of the solution was increased to 50 cm^3 and temperature rises were recorded for 5, 10, 15, 20, 25, 30, 35, 40 and 45 cm^3 of **FB 2**. The volumes were measured using a 50 cm^3 measuring cylinder. Discuss how these changes would affect the accuracy with which the concentration of **FB 2** could be determined.

....

....

.... [2]

[Total: 16]

For Examiner's Use

2 A second way to determine the concentration of an alkali is by volumetric titration. In this experiment you will first dilute the sample of **FB 2** that you used in **Question 1** and then titrate the diluted solution using hydrochloric acid.

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

FB 2 is aqueous sodium hydroxide, NaOH.
FB 3 is 0.200 mol dm^{-3} hydrochloric acid, HC*l*.

(a) Method

Dilution of FB 2

- Use the burette labelled **FB 2** to transfer 25.00 cm^3 of **FB 2** into the 250 cm^3 graduated (volumetric) flask, labelled **FB 4**.
- Make up the contents of the flask to the 250 cm^3 mark with distilled water.
- Stopper the flask and mix the contents thoroughly. This solution **FB 4**.

Titration

- Rinse the unlabelled burette thoroughly with distilled water and then with a little **FB 3**. Fill this burette with **FB 3**.
- Use a pipette to transfer 25.0 cm^3 of **FB 4** into a conical flask.
- Add to the flask a few drops of the acid-base indicator provided.
- Titrate the alkali in the flask with the acid, **FB 3**.

You should perform a rough titration.
In the space below record your burette readings for this rough titration.

The rough titre is …………………… cm^3.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Record in a suitable form below all of your burette readings and the volume of **FB 3** added in each accurate titration. Make certain that any recorded results show the precision of your practical work.

I	
II	
III	
IV	
V	

[5]

For Examiner's Use

(b) From your titration results obtain a suitable value to be used in your calculation. Show clearly how you have obtained this value.

25.0 cm^3 of **FB 4** required ………….. cm^3 of **FB 3**.
[1]

(c) (i) Calculate how many moles of HCl are contained in the volume recorded in **(b)**.

moles of HCl = ………………… mol

(ii) Hence, calculate how many moles of NaOH are contained in 25.0 cm^3 of **FB 4**.

moles of NaOH = ………………… mol

(iii) Calculate the concentration of the sodium hydroxide, **FB 2**.

concentration of **FB 2** = …………………….. mol dm^{-3}
[3]

I	
II	
III	

[Total: 9]

For Examiner's Use

3 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 5**, **FB 6**, **FB 7** and **FB 8** are aqueous solutions each of which contains a single cation and a single anion. Some of the ions present are listed below.

Fe^{2+} Pb^{2+} Zn^{2+} I^- OH^- SO_4^{2-}

By observing the reactions that occur when pairs of the solutions are mixed together, you will be able to identify which solution contains which of these ions.

[Turn over

For Examiner's Use

- To a 1 cm depth of **FB 6**, **FB 7** and **FB 8** in separate test-tubes add **FB 5** dropwise until in excess. Leave each test-tube to stand for a few minutes and note any changes.
- Use a 1 cm depth of each solution for the remaining tests.
- Record your observations in the following table.

	FB 6	**FB 7**	**FB 8**
FB 5			
FB 6			
FB 7			

I	
II	
III	
IV	
V	
VI	

[6]

(b) From your observations deduce which solution contains each of the following ions.

ion	Fe^{2+}	Pb^{2+}	Zn^{2+}	I^-	OH^-	SO_4^{2-}
solution						

I	
II	
III	

[3]

For Examiner's Use

(c) **FB 9** is an aqueous solution containing either sulfate, SO_4^{2-}, or sulfite, SO_3^{2-}, ions. Describe how you would determine which ion is present.

....

....

Carry out this test and record your observations and conclusion.

observations ....

....

The anion in **FB 9** is .... [2]

(d) A student is given two **different** samples and told that each contains one of the following organic compounds.

ethanol ethanal ethanoic acid

Describe two chemical tests that the student could carry out on each sample to determine which organic compound is present in each sample. For each test, give the reagent(s) to be used and explain how the different observations would allow the identity of the sample to be determined.

first reagent ....

observations ....

....

explanation ....

....

second reagent ....

observations ....

....

explanation ....

....

[4]

[Total: 15]

I	
II	
III	
IV	

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 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)
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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