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

CANDIDATE NAME	

CENTRE NUMBER							CANDIDATE NUMBER					

4827396477

CHEMISTRY **9701/35**

Advanced Practical Skills **October/November 2010**

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 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 13 and 14.

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 **13** printed pages and **3** blank pages.

DC (NF) 28264/3

UNIVERSITY *of* CAMBRIDGE International Examinations

For Examiner's Use

1 **FA 1** is an aqueous solution of hydrochloric acid, HCl.
FA 2 is aqueous sodium hydroxide containing 10.00 g dm^{-3} NaOH.

You are to determine the concentration, in mol dm^{-3}, of the hydrochloric acid in **FA 1**.

(a) **Method**

- Fill a burette with **FA 2**.
- Pipette 10.0 cm^3 of **FA 1** into a conical flask.
- Add to the flask a few drops of the acid-base indicator provided.
- Place the flask on a white tile.
- Titrate the acid in the flask with **FA 2**.

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 **FA 2** added in each accurate titration.
- Make certain any recorded results show the precision of your practical work.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

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

10.0 cm^3 of **FA 1** required .... cm^3 of **FA 2**.
[1]

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Calculations

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

(c) **(i)** Calculate the concentration, in mol dm^{-3}, of the sodium hydroxide in **FA 2**.
FA 2 contains 10.00 g dm^{-3} NaOH.
[A_r: H, 1.0; O, 16.0; Na, 23.0]

The concentration of sodium hydroxide in **FA 2** is .... mol dm^{-3}.

(ii) Calculate how many moles of sodium hydroxide are contained in the volume recorded in **(b)**.

.... mol of NaOH.

(iii) Deduce how many moles of hydrochloric acid were pipetted into the conical flask and calculate the concentration, in mol dm^{-3}, of the hydrochloric acid in **FA 1**.

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

I	
II	

The concentration of the hydrochloric acid in **FA 1** is .... mol dm^{-3}.
[2]

[Total: 10]

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2 **FA 3** is crushed impure calcium carbonate, $CaCO_3$.
FA 4 is 0.500 mol dm^{-3} hydrochloric acid
FA 5 is 0.280 mol dm^{-3} sodium hydroxide.

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You are to determine the percentage purity of calcium carbonate by dissolving a measured mass of **FA 3** in a known volume of hydrochloric acid, which is in excess.
The hydrochloric acid remaining after all the calcium carbonate has dissolved can be determined by titration with aqueous sodium hydroxide, **FA 4**.
You may assume that any impurity present in the calcium carbonate does **not** react with hydrochloric acid.

(a) **Method – Read through the instructions before starting any practical work**.

- Weigh and record the mass of an empty boiling-tube.
- Add to the boiling-tube between 2.60 g and 2.80 g of **FA 3**.
- Reweigh the tube and its contents.
- In part **(b)** of the method you will tip the **FA 3** into hydrochloric acid, then re-weigh the tube and any residual **FA 3**.

In the space below record, in an appropriate form, all of the balance readings and the mass of **FA 3** used in the experiment.

I	
II	

[2]

(b) **Method – Read through the instructions before starting any practical work**.

- Pour approximately 150 cm^3 of **FA 4** into a 250 cm^3 beaker.
- Add, a little at a time with constant stirring, the weighed **FA 3** to the acid in the beaker.
- After each small addition stir until the effervescence has ceased and all the solid has dissolved.
- Reweigh the tube and any residual **FA 3**. Record the mass in **(a)**.
- Transfer the solution in the beaker to the 250 cm^3 graduated (volumetric) flask labelled **FA 6**.
- Rinse the beaker several times with **a small amount of FA 4** and add the rinsings to the graduated flask.
- Make up the solution to the 250 cm^3 mark by **adding FA 4**, **not water**.
- Shake the flask to obtain a uniform solution.

For Examiner's Use

Titration

- Fill a burette with **FA 5**.
- Pipette 25.0 cm^3 of **FA 6** from the graduated flask into a conical flask.
- Add to the flask a few drops of the acid-base indicator provided.
- Place the flask on a white tile.
- Titrate the acid in the flask with **FA 5**.

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 **FA 5** added in each titration.
- Make certain any recorded results show the precision of your practical work.

I	
II	

[2]

(c) 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 **FA 6** required .... cm^3 of **FA 5**.

For Examiner's Use

(d) Calculations

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

Remember – **FA 4** is 0.500 mol dm^{-3} hydrochloric acid
FA 5 is 0.280 mol dm^{-3} sodium hydroxide.

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

.... mol of NaOH

(ii) Deduce how many moles of hydrochloric acid reacted with the sodium hydroxide in **(i)** and calculate how many moles of hydrochloric acid were present in the 250 cm^3 graduated flask labelled **FA 6**.

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

.... mol of HC*l* were present in the graduated flask.

(iii) Calculate how many moles of hydrochloric acid were present in 250 cm^3 of **FA 4**.

250 cm^3 of **FA 4** contained .... mol HC*l*.

(iv) Calculate the following.

(answer to **(d)(iii)** – answer to **(d)(ii)**)

This is the amount of hydrochloric acid that reacted with the calcium carbonate in the weighed sample of **FA 3**.

.... mol of HC*l* reacted with the calcium carbonate in .... g **FA 3**.

I	
II	

For Examiner's Use

(v) Use your answer to **(iv)** to calculate the mass of calcium carbonate that reacted with hydrochloric acid.
This is the mass of pure $CaCO_3$ in the weighed sample of **FA 3**.

$$CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

[A_r: Ca, 40.0; C, 12.0; O, 16.0]

The weighed sample of **FA 3** contains .... g of $CaCO_3$.

(vi) Calculate the percentage of calcium carbonate, $CaCO_3$, in **FA 3** by evaluating the following expression.

$$\frac{\text{mass of } CaCO_3 \text{ from } \textbf{(d)(v)}}{\text{mass of } \textbf{FA 3} \text{ used, from } \textbf{(a)}} \times 100$$

Complete your evaluation even if your answer is greater than 100%

FA 3 contains .... % calcium carbonate.
[5]

III	
IV	
V	

(e) 6.25 g of pure calcium carbonate are required to neutralise all the hydrochloric acid in 250 cm^3 of **FA 4**.

You were instructed to measure a mass between 2.60 g and 2.80 g of **FA 3** in this experiment.

What difficulties might you encounter if you used a mass of about 5.50 g of **FA 3** in this experiment?

....

....

....
[1]

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

The balance used in the experiment displays the mass to	....	decimal places.
The maximum error in a single balance reading is	±	g.
The maximum error in measuring the mass of **FA 3** is	±	g.

(ii) Calculate the maximum percentage error in the mass of **FA 3** measured in **(a)**.

The maximum error in the mass of **FA 3** is .... %.
[2]

(g) **(i)** The percentage of calcium carbonate in the weighed sample of **FA 3** can also be found by investigating the thermal decomposition of the compound into calcium oxide and carbon dioxide.
Write a balanced equation, including state symbols, for this thermal decomposition.

(ii) **Briefly outline** the key measurements to be made in order to find the percentage of calcium carbonate in **FA 3** by this method.

1. ....

2. ....

3. ....

4. ....

5. ....

6. ....

(You do not have to use all of the numbered steps in your answer)

[2]

[Total: 14]

3 **FA 7**, **FA 8** and **FA 9** are aqueous solutions, each containing one cation and one anion from those listed on pages 13 and 14 in the Qualitative Analysis Notes.

For Examiner's Use

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 wherever possible.

(a) Use aqueous sodium hydroxide and aqueous ammonia, in separate tests, to identify the cation present in **FA 7**, **FA 8** and **FA 9**.

Present your results for each of the solutions in a suitable form below.

I	
II	
III	
IV	
V	
VI	

Conclusion

Complete the following table.

solution	*cation*	*supporting evidence*
FA 7		
FA 8		
FA 9		

[6]

(b) **(i)** **FA 7**, **FA 8** and **FA 9** each contain a single anion which may be Cl^-, I^- or SO_4^{2-}.

For Examiner's Use

Suggest a reagent that would enable you to identify any solutions containing SO_4^{2-}.

Reagent ....

Use this reagent to test each of the solutions. Record your observations in the table below. Indicate, with a tick in the final column, any solution containing SO_4^{2-}.

solution	*observation*	*SO_4^{2-} present*
FA 7		
FA 8		
FA 9		

(ii) Select a further reagent that will enable you to identify the halide ion present in any remaining solution(s).

Reagent ……………………………………………………………………………..

Use this reagent to test the remaining solution(s).
Record your observations and the identity of the halide in a suitable form in the space below.

I	
II	
III	
IV	
V	

[5]

[Turn over

(c) **FA 10** is a white crystalline solid which turns into another white solid, **FA 11**, when heated strongly.
Carry out the tests on **FA 10** and **FA 11** in the table below.
Observe carefully at each stage and record all of your observations in the table.

For Examiner's Use

	test	*observations*
(i)	Place 1 spatula measure of **FA 10** in a hard glass test-tube. Heat the solid **very strongly** until no further change is seen.	
(ii)	Place 1 <u>**small**</u> spatula measure of **FA 11** in a test-tube and add 1 cm depth of dilute hydrochloric acid.	
	As soon as you have completed your observation in **(ii)**, fill the test-tube with water.	

I	
II	
III	
IV	
V	

[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 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 → (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 acid)
sulfite, 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
sulfur dioxide, SO_2	turns acidified aqueous potassium dichromate(VI) from orange to green

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