Centre Number	Candidate Number	Name

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

CHEMISTRY **9701/03**

Paper 3 Practical Test

October/November 2005

1 hour 15 minutes

Candidates answer on the Question Paper.
Additional Materials: as listed in the 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 6 and 7.

SESSION
LABORATORY

For Examiner's Use	
1	
2	
TOTAL	

This document consists of **7** printed pages and **1** blank page.

UNIVERSITY of CAMBRIDGE International Examinations

1 **FA 1** is an aqueous solution containing 38.10 g dm^{-3} of borax crystals.
Borax is disodium tetraborate-***x***-water, $Na_2B_4O_7.\boldsymbol{x}H_2O$.
FA 2 is 1.00 mol dm^{-3} HC*l*.

You are required to find the number of moles of water of crystallisation, ***x***, in the borax crystals.
Disodium tetraborate reacts with hydrochloric acid according to the equation below.

$$Na_2B_4O_7(aq) + 2HCl(aq) + 5H_2O(l) \rightarrow 2NaCl(aq) + 4H_3BO_3(aq)$$

(a) Use a burette to measure between 44.50 cm^3 and 45.50 cm^3 of **FA 2** into the 250 cm^3 volumetric (graduated) flask labelled **FA 3**.
Record your burette readings in Table 1.1.

Table 1.1 Dilution of FA 2

final burette reading	/ cm^3	
initial burette reading	/ cm^3	
volume of **FA 2** used	/ cm^3	

Fill the flask to the 250 cm^3 mark with distilled or deionised water and mix the contents thoroughly by shaking. This solution is **FA 3.**

Fill the second burette with the **diluted hydrochloric acid**, **FA 3**.

(b) Pipette 25.0 cm^3 of **FA 1** into a conical flask and add a few drops of the indicator provided. Titrate the contents of the conical flask with **FA 3** until the appropriate colour change is observed at the end-point.

Repeat the titration as many times as you think necessary to obtain accurate results.
Make certain that the recorded results show the precision of your practical work.

Table 1.2 Titration of FA 1 with FA 3

The indicator used was ....

final burette reading / cm^3				
initial burette reading / cm^3				
volume of **FA 3** used / cm^3				

Summary

25.0 cm^3 of **FA 1** reacted with ………………. cm^3 of **FA 3.**

Show which results you used to obtain this volume of **FA 3** by placing a tick (✓) under the readings in Table 1.2.

[6]

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You are advised to show full working in all parts of the calculations.

(c) Calculate the concentration, in mol dm^{-3}, of hydrochloric acid in the diluted solution **FA 3**.

[1]

(d) Calculate how many moles of hydrochloric acid were run from the burette into the conical flask during the titration of **FA 1** with **FA 3**.

[1]

(e) Calculate the concentration, in mol dm^{-3}, of the disodium tetraborate in **FA 1**.

$$Na_2B_4O_7(aq) + 2HCl(aq) + 5H_2O(l) \rightarrow 2NaCl(aq) + 4H_3BO_3(aq)$$

[2]

(f) Calculate the concentration, in g dm^{-3}, of disodium tetraborate, $Na_2B_4O_7$, in **FA 1**.
[A_r: Na, 23.0; B, 10.8; O, 16.0.]

[2]

(g) **FA 1** contains 38.10 g dm^{-3} of borax crystals, $Na_2B_4O_7.\boldsymbol{x}H_2O$. Use this information and your answer to **(f)** to calculate the mass of water present in the dissolved crystals.

[1]

(h) Calculate the number of moles of water present in 38.10 g of borax crystals.

Use this answer and the answer to **(e)** to calculate the value of ***x*** in $Na_2B_4O_7.\boldsymbol{x}H_2O$.

[2]
[Total:15]

2 **FA 4** contains **one cation** from those listed on page 6.
FA 4 also contains **one anion** but this is not an ion listed on page 7.

By performing the tests below, you should be able to identify the cation and to draw a further conclusion as to the nature of **FA 4**.

In all tests, the reagent should be added gradually until no further change is observed, with shaking after each addition.
Record your observations in the spaces provided.
Your answers should include

- details of colour changes and precipitates formed,
- the names of gases evolved and details of the test used to identify each one.

You should indicate clearly at what stage in a test a change occurs.

Marks are **not** given for chemical equations.
No additional or confirmatory tests for ions present should be attempted.

Candidates are reminded that definite deductions may be made from tests where there appears to be no reaction.

Test	*Observations [6]*
(a) Transfer two thirds of the solid **FA 4** to a boiling-tube and add about 7 cm depth of dilute nitric acid. **Cautiously warm** the tube until the orange colour of the solid is no longer visible. Filter the mixture and retain filtrate for further tests. Wash the residue with water and retain residue for further tests.	
(b) Transfer the remaining solid **FA 4** to a hard glass test-tube and heat strongly. Identify, with a suitable test, the gas evolved.	
Tests on the filtrate **(c)** To 1 cm depth of the filtrate from **(a)** in a test-tube, add aqueous sodium hydroxide until there is no further change.	
(d) To 1 cm depth of the filtrate from **(a)** in a test-tube, add aqueous ammonia until there is no further change.	

Test	*Observations*
(e) To 1 cm depth of the filtrate from **(a)** in a test-tube, add aqueous potassium iodide.	
Tests on residue **(f)** Cautiously place 1 cm depth of concentrated hydrochloric acid into a boiling-tube and add an equal volume of water. Add to the tube some of the residue from **(a)** and warm gently. Identify, with a suitable test, the gas evolved. Immediately the gas is identified rinse the contents of the tube into the sink.	

Use the information in the Qualitative Analysis Tables on pages 6 and 7 to identify the cation present in **FA 4**.

The **cation** present in **FA 4** is ....

Give two pieces of evidence that support your choice of this ion.

....

....

.... [2]

FA 4 behaves as ....

Give one piece of evidence that supports this behaviour.

....

....

....

.... [2]

[Total: 10]

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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