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

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER					

CHEMISTRY **9701/34**

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 **12** printed pages and **4** blank pages.

DC (CW) 28188/3

UNIVERSITY *of* CAMBRIDGE
International Examinations

[Turn over

There are three questions on this paper. Question 2 should not be the last question attempted.

1 **FB 1** is an aqueous solution containing 21.50 g dm^{-3} of a mixture of iron(II) sulfate, $FeSO_4$ and iron(III) sulfate, $Fe_2(SO_4)_3$.
FB 2 is an aqueous solution containing 2.00 g dm^{-3} potassium manganate(VII), $KMnO_4$.

In the presence of acid, the iron(II) sulfate is oxidised by potassium manganate(VII).

$$2KMnO_4(aq) + 8H_2SO_4(aq) + 10FeSO_4(aq) \rightarrow 5Fe_2(SO_4)_3(aq) + 2MnSO_4(aq) + K_2SO_4(aq) + 8H_2O(l)$$

(a) Method

- Fill a burette with **FB 2**.
- Pipette 25.0 cm^3 of **FB 1** into the conical flask.
- Use a 25 cm^3 measuring cylinder to add 10 cm^3 of dilute sulfuric acid to the flask.
- Place the flask on a white tile.
- Carefully titrate with **FB 2** until the first permanent pink colour is obtained.

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 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 accurate 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 1** required .... cm^3 of **FB 2**. [1]

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 potassium manganate(VII) in **FB 2**.
FB 2 contains 2.00 g dm^{-3} $KMnO_4$.
[A_r: O, 16.0; K, 39.1; Mn, 54.9]

The concentration of potassium manganate(VII) in **FB 2** is .... mol dm^{-3}.

(ii) Calculate how many moles of $KMnO_4$ were present in the volume calculated in **(b)**.

.... mol of $KMnO_4$.

(iii) Calculate how many moles of iron(II) sulfate, $FeSO_4$, reacted with the potassium manganate(VII) in **(ii)**.

$$2KMnO_4(aq) + 8H_2SO_4(aq) + 10FeSO_4(aq) \rightarrow 5Fe_2(SO_4)_3(aq) + 2MnSO_4(aq) + K_2SO_4(aq) + 8H_2O(l)$$

.... mol of $FeSO_4$ reacted with the potassium manganate(VII).

I	
II	
III	
IV	
V	

(iv) Calculate the concentration, in mol dm^{-3} of $FeSO_4$ in **FB 1**.

The concentration of $FeSO_4$ in **FB 1** is .... mol dm^{-3}.

(v) Calculate the concentration, in g dm^{-3}, of $FeSO_4$ in **FB 1**.
[A_r: O, 16.0; S, 32.1; Fe, 55.8]

FB 1 contains .... g dm^{-3} of $FeSO_4$.

(vi) **FB 1** is an aqueous solution containing 21.50 g dm^{-3} of $FeSO_4$ and $Fe_2(SO_4)_3$.
Calculate the percentage, by mass, of $FeSO_4$ in this mixture.

The mixture contains .... % $FeSO_4$.
[5]

[Total: 13]

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2 **FB 3** is a mixture containing anhydrous sodium carbonate, Na_2CO_3, and sodium hydrogencarbonate, $NaHCO_3$.

When heated, sodium hydrogencarbonate decomposes.

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

Anhydrous sodium carbonate does not decompose when heated.

You are to determine if sodium hydrogencarbonate is the major component, by mass, of the mixture in **FB 3**.

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

- Weigh and record the mass of an empty boiling-tube.
- Tip the contents of the tube labelled **FB 3** into the weighed boiling-tube. Reweigh and record the mass of the boiling-tube and **FB 3**.
- Gently heat the **FB 3** in the boiling-tube for 2 minutes then heat strongly for a further 2 minutes.
  Take care not to lose any solid from the tube during heating.
- Warm the upper parts of the boiling-tube to evaporate any water that may have condensed while heating the solid.
- Place the hot tube on a heat-proof mat and leave to cool.
- **You are advised to continue with part (d) of this question or to start another question while the tube cools.**
- When cool, reweigh the boiling-tube and the residual sodium carbonate.
- Reheat, cool and reweigh the tube until you are satisfied decomposition is complete.

Results

In an appropriate form, in the space below, record all of your balance readings, the mass of **FB 3** heated, the mass of residual sodium carbonate and the mass loss on heating.

I	
II	
III	
IV	
V	
VI	

[6]

Calculations

Do not use your experimental results in part (i)

(b) **(i)** Use the equation for the decomposition of $NaHCO_3$ on heating to calculate the **theoretical** ratio $\frac{\text{mass of } NaHCO_3}{\text{mass loss on heating}}$.

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

[M_r: $NaHCO_3$, 84.0; CO_2, 44.0; H_2O, 18.0]

theoretical ratio = ...

(ii) Use the following expression to calculate the mass of $NaHCO_3$ in the sample of **FB 3** that was heated.

theoretical ratio from **b(i)** × experimental mass loss from **(a)**

mass of $NaHCO_3$ = ... g

(iii) Tick the appropriate box in the table below.

$NaHCO_3$ **<u>is</u>** the major component, by mass, in **FB 3**	
$NaHCO_3$ **<u>is not</u>** the major component, by mass, in **FB 3**	

Justify your answer with supporting evidence.

....

....

[2]

(c) **Do not carry out your suggestions.**

Suggest two ways in which you could show that sodium carbonate does not decompose on heating.

(i) ....

....

(ii) ....

.... [2]

(d) A student is asked to weigh, with maximum precision, a solid.

The three balances available are:

balance A, reading to 1 decimal place,
balance B, reading to 2 decimal places,
balance C, reading to 3 decimal places.

> The smallest division on a burette is 0.1 cm^3.
> The maximum error in a single burette reading is ±0.05 cm^3
>
> Balance readings can be treated in the same way.

Complete the following table.

balance	maximum error for a single balance reading / g	maximum % error when weighing:
A	±	9.0 g of solid =
B	±	4.00 g of solid =
C	±	0.500 g of solid =

[2]

[Total: 12]

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3 **FB 4**, **FB 5**, **FB 6** and **FB 7** are aqueous solutions each containing one of the ions Al^{3+}, NH_4^+, Mg^{2+}, Mn^{2+}.

You will carry out the following tests on each of the solutions.

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.

(a) Carry out the following tests. Record your observations in the spaces provided in the table.

	test	*observations*			
		FB 4	**FB 5**	**FB 6**	**FB 7**
(i)	To 1 cm depth of solution in a test-tube add 1 cm depth of aqueous sodium hydroxide. Swirl the tube, then				
	add a further 2 cm depth of aqueous sodium hydroxide.				
	In tests* (ii) *and* (iii) *put a cross in any boxes where the test is not carried out.				
(ii)	If a precipitate remains at the end of test **(i)** leave the test-tube and contents to stand for a few minutes.				
(iii)	If **no** precipitate formed at all in test **(i)** tip the contents of the tube into a boiling-tube and warm gently. **Care: heated solutions containing sodium hydroxide are liable to be ejected from the tube.**				

<table>
<tr><th colspan="2" rowspan="2">test</th><th colspan="4">observations</th></tr>
<tr><th>FB 4</th><th>FB 5</th><th>FB 6</th><th>FB 7</th></tr>
<tr><td>(iv)</td><td>To 1 cm depth of solution in a test-tube add 1 cm depth of aqueous ammonia.
Swirl the tube, then</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>add a further 2 cm depth of aqueous ammonia.</td><td></td><td></td><td></td><td></td></tr>
</table>

[6]

For Examiner's Use	
I	
II	
III	
IV	
V	
VI	

(b) Use the Qualitative Analysis Notes on page 13 to identify the cation present in each of the solutions.
Complete the table below to identify each ion and to give supporting evidence from your observations.

solution	*cation*	*supporting evidence*
FB 4		
FB 5		
FB 6		
FB 7		

[4]

I	
II	
III	
IV	

Rinse and re-use test-tubes where possible.

[Turn over

(c) Carry out the following tests on the solution you have identified as containing Al^{3+} ions and record your observations in the spaces provided.

		observation
(i)	Add aqueous sodium iodide	
(ii)	Add dilute sulfuric acid	

Explain how your results confirm the presence of Al^{3+} and eliminate any other ion.

....

.... [1]

(d) What other cation listed in the Qualitative Analysis Notes on page 13 would give similar results to Al^{3+} in **(a)**?

.... [1]

(e) Carry out the following tests and make careful observations of all that happens in each experiment. Complete the table.

	test	*observations*
(i)	To 1 cm depth of aqueous silver nitrate in a test-tube add 1 cm depth of aqueous sodium chloride. Keep the tube for comparison with the observations in test **(ii)**.	
(ii)	Repeat test **(i)**. To 1 cm depth of aqueous silver nitrate in a test-tube add 1 cm depth of aqueous sodium chloride, then	*Do not repeat your observations from test* **(i)**
	add 1 cm depth of aqueous sodium iodide and shake the tube.	

[2]

(f) Suggest an explanation for your observations when aqueous sodium iodide is added in test **(e)(ii)**.

....

....

.... [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)	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.]

[Turn over

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 → (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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