



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

CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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CHEMISTRY

Advanced Practical Skills

9701/31

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 11 and 12.

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

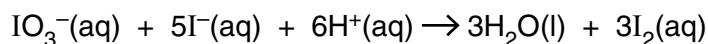
This document consists of **11** printed pages and **1** blank page.



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

For
Examiner's
Use

- 1 You are to determine the concentration of hydrochloric acid, which supplies the H^+ ions in the following reaction.



In the presence of an excess of IO_3^- ions and an excess of I^- ions, the amount of I_2 liberated is directly proportional to the amount of H^+ ions present and can be determined by titration with sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.

You are provided with the following reactants.

FA 1 hydrochloric acid

FA 2 containing 15.0 g dm^{-3} sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$

aqueous potassium iodate(V), KIO_3

aqueous potassium iodide, KI

(a) Method

- Fill a burette with **FA 2**.
- Pipette 25.0 cm^3 of **FA 1** into the conical flask.
- Use a 25 cm^3 measuring cylinder to add to the flask 10 cm^3 of aqueous potassium iodate(V) **and** 10 cm^3 of aqueous potassium iodide. There is an excess of each of these reagents.
- Place the flask on a white tile.
- Titrate the liberated iodine with **FA 2**.
- During the titration the colour of the iodine in the solution will fade from red-brown to orange to yellow. The end-point occurs when the solution just goes colourless with the addition of a single drop of **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.

For
Examiner's
Use

25.0 cm³ of **FA 1** require cm³ of **FA 2**. [1]

Calculations

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

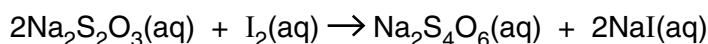
- (c) (i) Calculate the concentration, in mol dm⁻³, of the sodium thiosulfate in **FA 2**.
FA 2 contains 15.0 g dm⁻³ Na₂S₂O₃·5H₂O.
 [A_r: H, 1.0; O, 16.0; Na, 23.0; S, 32.1]

The concentration of sodium thiosulfate in **FA 2** is mol dm⁻³.

- (ii) Calculate how many moles of Na₂S₂O₃ are contained in the volume of **FA 2** recorded in (b).

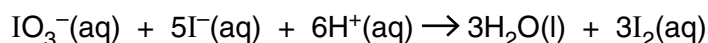
..... mol of Na₂S₂O₃

- (iii) Calculate how many moles of iodine, I₂ reacted with the Na₂S₂O₃ in (ii).



..... mol of iodine reacted with the sodium thiosulfate.

- (iv) Calculate how many moles of hydrochloric acid, HCl, reacted with an excess of potassium iodate(V) and an excess of potassium iodide to produce the amount of iodine calculated in (iii).



..... mol of HCl produced the amount of iodine calculated in (iii).

I	
II	
III	
IV	
V	

- (v) Calculate the concentration, in mol dm^{-3} , of HCl in **FA 1**.

The concentration of HCl in **FA 1** is mol dm^{-3} .
[5]

(d)

Each reading with a burette has a maximum error of $\pm 0.05 \text{ cm}^3$.
Grade B volumetric (bulb) pipettes are calibrated to $\pm 0.06 \text{ cm}^3$.

- (i) Calculate the maximum error in the volume run from the burette recorded in any titration.

The maximum error is cm^3 .

- (ii) Express the maximum error calculated in (i) as a percentage error for the volume calculated in (b).

The maximum error is %.

- (iii) Calculate the percentage error when 25.0 cm^3 of **FA 1** was pipetted into the conical flask.

The error was %.
[2]

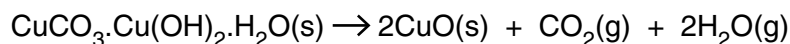
[Total: 15]

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- 2 **FA 3** is powdered basic copper(II) carbonate, a hydrated mixture of copper(II) carbonate and copper(II) hydroxide.

The approximate formula for the basic carbonate is $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2 \cdot \text{H}_2\text{O}$.

When heated, basic copper(II) carbonate decomposes.



You are to determine the change in mass as the solid is heated and decomposed.

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

- Record all weighings in an appropriate form in the space below.
- Weigh and record the mass of an empty boiling-tube.
- Tip the contents of the tube labelled **FA 3** into the weighed boiling-tube. Reweigh and record the total mass of the boiling-tube and **FA 3**.
- Heat **FA 3** in the boiling-tube **very gently** until the vigorous decomposition of the copper carbonate has stopped; then heat more strongly for 1 to 2 minutes. **Take care not to lose any solid from the tube during the initial heating.**
- Warm the upper parts of the boiling-tube to evaporate any water that may have condensed while heating the carbonate.
- 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 copper(II) oxide.
- 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 basic copper(II) carbonate and the mass of residual copper oxide.

I	
II	
III	
IV	
V	
VI	

[6]

Calculations

For
Examiner's
Use

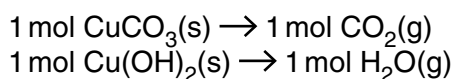
- (b) Calculate the loss in mass during the experiment as a percentage of the mass of solid heated.

[1]

- (c) The theoretical loss in mass is 33.5%.

The proportions of CuCO_3 and Cu(OH)_2 in the basic carbonate can vary from the 1:1 ratio given in the formula.

Make use of the following information to account for the difference between the value you have calculated in (b) and the theoretical percentage loss in mass.



Assume that 1 mol of any sample of the solid basic carbonate contains 1 mol H_2O .

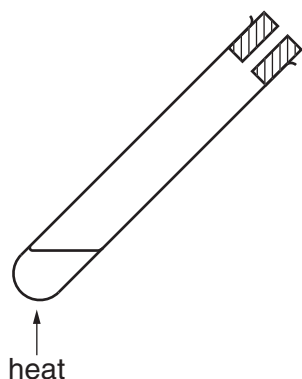
$[M_r: \text{CO}_2, 44.0; \text{H}_2\text{O}, 18.0]$

.....

.....

..... [1]

- (d) Add to the diagram below additional standard laboratory apparatus that would enable you to collect and measure the volume of carbon dioxide evolved in the experiment. Ensure that your apparatus does not also collect and measure any of the water vapour evolved.



[2]

[Total: 10]

- 3 **FA 4, FA 5, FA 6 and FA 7** are aqueous solutions each containing one of the ions Al^{3+} , Mg^{2+} , Pb^{2+} , Zn^{2+} .

For
Examiner's
Use

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.

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

I	
II	
III	
IV	

You should rinse and reuse test-tubes where possible.

test		observations			
		FA 4	FA 5	FA 6	FA 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.				
(ii)	To 1 cm depth of solution in a test-tube add 1 cm depth of aqueous ammonia. Swirl the tube, then				
	add a further 2 cm depth of aqueous ammonia.				
(iii)	To 1 cm depth of solution in a test-tube add 1 cm depth of aqueous potassium iodide.				

[4]

- (b) Use the Qualitative Analysis Notes on page 11 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.

For
Examiner's
Use

<i>solution</i>	<i>cation</i>	<i>supporting evidence</i>
FA 4		
FA 5		
FA 6		
FA 7		

I	
II	
III	
IV	

[4]

Do not carry out the following test.

- (c) Use the Qualitative Analysis Notes on pages 11 and 12 to select a further reagent that could be used to confirm the presence of Pb^{2+} in one of the solutions **FA 4**, **FA 5**, **FA 6** and **FA 7**.

The reagent is [1]

(d) **FA 8** contains aqueous copper(II) ions.

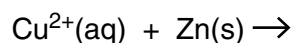
Carry out the following tests and make careful observations of all that happens in each experiment.

For
Examiner's
Use

<i>test</i>		<i>observations</i>
(i)	To 2 cm depth of FA 8 in a boiling-tube add 1 spatula measure of zinc metal powder. Leave to stand for 1 minute, then	
	add 2 cm depth of distilled water and leave to stand for a further 2 minutes.	
(ii)	To 1 cm depth of FA 8 in a test-tube add 1 cm depth of concentrated hydrochloric acid. (Care: corrosive) Retain the mixture for use in (iii).	
(iii)	Using a dropping pipette transfer 1 cm depth of the solution in (ii) into another test-tube. Add 1 cm depth of water and shake the tube.	

[5]

(e) From your observations in (d)(i) complete the equation below:



[1]

[Total: 15]

I	
II	
III	
IV	
V	

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

<i>ion</i>	<i>reaction</i>
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 $\text{NO} \rightarrow$ (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 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

<i>gas</i>	<i>test and test result</i>
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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Advanced Practical Skills

9701/33

October/November 2010

2 hours

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Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

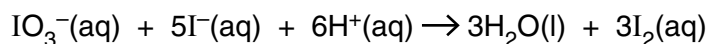
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For
Examiner's
Use

- 1 You are to determine the concentration of hydrochloric acid, which supplies the H^+ ions in the following reaction.



In the presence of an excess of IO_3^- ions and an excess of I^- ions, the amount of I_2 liberated is directly proportional to the amount of H^+ ions present and can be determined by titration with sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.

You are provided with the following reactants.

FA 1 hydrochloric acid

FA 2 containing 15.0 g dm^{-3} sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$

aqueous potassium iodate(V), KIO_3

aqueous potassium iodide, KI

(a) Method

- Fill a burette with **FA 2**.
- Pipette 25.0 cm^3 of **FA 1** into the conical flask.
- Use a 25 cm^3 measuring cylinder to add to the flask 10 cm^3 of aqueous potassium iodate(V) **and** 10 cm^3 of aqueous potassium iodide. There is an excess of each of these reagents.
- Place the flask on a white tile.
- Titrate the liberated iodine with **FA 2**.
- During the titration the colour of the iodine in the solution will fade from red-brown to orange to yellow. The end-point occurs when the solution just goes colourless with the addition of a single drop of **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.

For
Examiner's
Use

25.0 cm³ of **FA 1** require cm³ of **FA 2**. [1]

Calculations

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

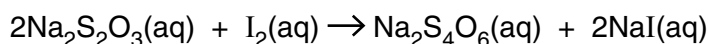
- (c) (i) Calculate the concentration, in mol dm⁻³, of the sodium thiosulfate in **FA 2**.
FA 2 contains 15.0 g dm⁻³ Na₂S₂O₃·5H₂O.
 [A_r: H, 1.0; O, 16.0; Na, 23.0; S, 32.1]

The concentration of sodium thiosulfate in **FA 2** is mol dm⁻³.

- (ii) Calculate how many moles of Na₂S₂O₃ are contained in the volume of **FA 2** recorded in (b).

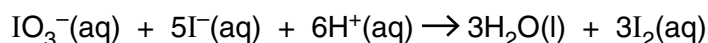
..... mol of Na₂S₂O₃

- (iii) Calculate how many moles of iodine, I₂, reacted with the Na₂S₂O₃ in (ii).



..... mol of iodine reacted with the sodium thiosulfate.

- (iv) Calculate how many moles of hydrochloric acid, HCl, reacted with an excess of potassium iodate(V) and an excess of potassium iodide to produce the amount of iodine calculated in (iii).



..... mol of HCl produced the amount of iodine calculated in (iii).

I	
II	
III	
IV	
V	

- (v) Calculate the concentration, in mol dm^{-3} , of HCl in **FA 1**.

The concentration of HCl in **FA 1** is mol dm^{-3} .
[5]

(d)

Each reading with a burette has a maximum error of $\pm 0.05 \text{ cm}^3$.
Grade B volumetric (bulb) pipettes are calibrated to $\pm 0.06 \text{ cm}^3$.

- (i) Calculate the maximum error in the volume run from the burette recorded in any titration.

The maximum error is cm^3 .

- (ii) Express the maximum error calculated in (i) as a percentage error for the volume calculated in (b).

The maximum error is %.

- (iii) Calculate the percentage error when 25.0 cm^3 of **FA 1** was pipetted into the conical flask.

The error was %.
[2]

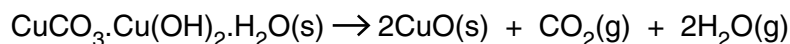
[Total: 15]

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- 2 **FA 3** is powdered basic copper(II) carbonate, a hydrated mixture of copper(II) carbonate and copper(II) hydroxide.

The approximate formula for the basic carbonate is $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2 \cdot \text{H}_2\text{O}$.

When heated, basic copper(II) carbonate decomposes.



You are to determine the change in mass as the solid is heated and decomposed.

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

- Record all weighings in an appropriate form in the space below.
- Weigh and record the mass of an empty boiling-tube.
- Tip the contents of the tube labelled **FA 3** into the weighed boiling-tube. Reweigh and record the total mass of the boiling-tube and **FA 3**.
- Heat **FA 3** in the boiling-tube **very gently** until the vigorous decomposition of the copper carbonate has stopped; then heat more strongly for 1 to 2 minutes. **Take care not to lose any solid from the tube during the initial heating.**
- Warm the upper parts of the boiling-tube to evaporate any water that may have condensed while heating the carbonate.
- 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 copper(II) oxide.
- 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 basic copper(II) carbonate and the mass of residual copper oxide.

I	
II	
III	
IV	
V	
VI	

[6]

Calculations

For
Examiner's
Use

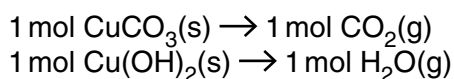
- (b) Calculate the loss in mass during the experiment as a percentage of the mass of solid heated.

[1]

- (c) The theoretical loss in mass is 33.5%.

The proportions of CuCO_3 and Cu(OH)_2 in the basic carbonate can vary from the 1:1 ratio given in the formula.

Make use of the following information to account for the difference between the value you have calculated in (b) and the theoretical percentage loss in mass.



Assume that 1 mol of any sample of the solid basic carbonate contains 1 mol H_2O .

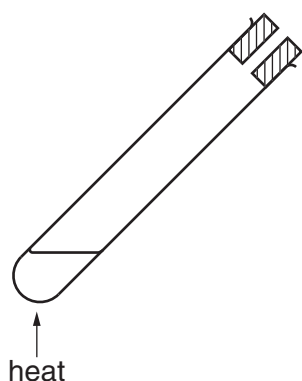
$[M_r: \text{CO}_2, 44.0; \text{H}_2\text{O}, 18.0]$

.....

.....

..... [1]

- (d) Add to the diagram below additional standard laboratory apparatus that would enable you to collect and measure the volume of carbon dioxide evolved in the experiment. Ensure that your apparatus does not also collect and measure any of the water vapour evolved.



[2]

[Total: 10]

- 3 **FA 4, FA 5, FA 6 and FA 7** are aqueous solutions each containing one of the ions Al^{3+} , Mg^{2+} , Pb^{2+} , Zn^{2+} .

For
Examiner's
Use

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.

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

I	
II	
III	
IV	

You should rinse and reuse test-tubes where possible.

test		observations			
		FA 4	FA 5	FA 6	FA 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.				
(ii)	To 1 cm depth of solution in a test-tube add 1 cm depth of aqueous ammonia. Swirl the tube, then				
	add a further 2 cm depth of aqueous ammonia.				
(iii)	To 1 cm depth of solution in a test-tube add 1 cm depth of aqueous potassium iodide.				

[4]

- (b) Use the Qualitative Analysis Notes on page 11 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.

For
Examiner's
Use

<i>solution</i>	<i>cation</i>	<i>supporting evidence</i>
FA 4		
FA 5		
FA 6		
FA 7		

I	
II	
III	
IV	

[4]

Do not carry out the following test.

- (c) Use the Qualitative Analysis Notes on pages 11 and 12 to select a further reagent that could be used to confirm the presence of Pb^{2+} in one of the solutions **FA 4**, **FA 5**, **FA 6** and **FA 7**.

The reagent is [1]

(d) **FA 8** contains aqueous copper(II) ions.

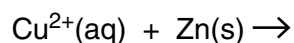
Carry out the following tests and make careful observations of all that happens in each experiment.

For
Examiner's
Use

<i>test</i>		<i>observations</i>
(i)	To 2 cm depth of FA 8 in a boiling-tube add 1 spatula measure of zinc metal powder. Leave to stand for 1 minute, then	
	add 2 cm depth of distilled water and leave to stand for a further 2 minutes.	
(ii)	To 1 cm depth of FA 8 in a test-tube add 1 cm depth of concentrated hydrochloric acid. (Care: corrosive) Retain the mixture for use in (iii).	
(iii)	Using a dropping pipette transfer 1 cm depth of the solution in (ii) into another test-tube. Add 1 cm depth of water and shake the tube.	

[5]

(e) From your observations in (d)(i) complete the equation below:



[1]

[Total: 15]

I	
II	
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IV	
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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

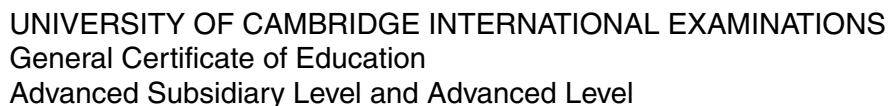
<i>ion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chromate(VI), $\text{CrO}_4^{2-}(\text{aq})$	yellow solution turns orange with $\text{H}^+(\text{aq})$; gives yellow ppt. with $\text{Ba}^{2+}(\text{aq})$; gives bright yellow ppt. with $\text{Pb}^{2+}(\text{aq})$
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$); gives white ppt. with $\text{Pb}^{2+}(\text{aq})$
bromide, $\text{Br}^-(\text{aq})$	gives cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$); gives white ppt. with $\text{Pb}^{2+}(\text{aq})$
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$); gives yellow ppt. with $\text{Pb}^{2+}(\text{aq})$
nitrate, $\text{NO}_3^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
nitrite, $\text{NO}_2^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil; NO liberated by dilute acids (colourless $\text{NO} \rightarrow$ (pale) brown NO_2 in air)
sulfate, $\text{SO}_4^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ or with $\text{Pb}^{2+}(\text{aq})$ (insoluble in excess dilute strong acid)
sulfite, $\text{SO}_3^{2-}(\text{aq})$	SO_2 liberated with dilute acids; gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in excess dilute strong acid)

3 Tests for gases

<i>gas</i>	<i>test and test result</i>
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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9701/34

October/November 2010

2 hours

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	
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3	
Total	

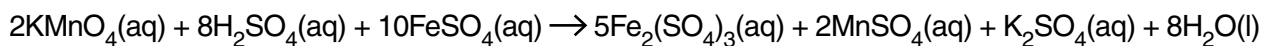
This document consists of **12** printed pages and **4** blank pages.

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

For
Examiner's
Use

- 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, $\text{Fe}_2(\text{SO}_4)_3$.
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).



(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.

For
Examiner's
Use

25.0 cm³ of **FB 1** required cm³ 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 KMnO₄.

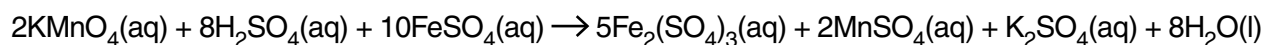
[A_r: O, 16.0; K, 39.1; Mn, 54.9]

The concentration of potassium manganate(VII) in **FB 2** is mol dm⁻³.

- (ii) Calculate how many moles of KMnO₄ were present in the volume calculated in (b).

..... mol of KMnO₄.

- (iii) Calculate how many moles of iron(II) sulfate, FeSO₄, reacted with the potassium manganate(VII) in (ii).



..... mol of FeSO₄ 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 $\text{Fe}_2(\text{SO}_4)_3$.
Calculate the percentage, by mass, of FeSO_4 in this mixture.

The mixture contains % FeSO_4 .
[5]

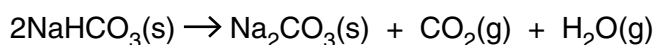
[Total: 13]

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

For
Examiner's
Use

When heated, sodium hydrogencarbonate decomposes.



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

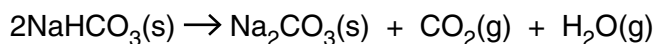
In an appropriate form, in the space below, record all of your balance readings, the mass of **FB 3** heated, the mass of residual sodium carbonate and the mass loss on heating.

I	
II	
III	
IV	
V	
VI	

[6]

CalculationsFor
Examiner's
Use**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 $\frac{\text{mass of NaHCO}_3}{\text{mass loss on heating}}$.



$[M_r: \text{NaHCO}_3, 84.0; \text{CO}_2, 44.0; \text{H}_2\text{O}, 18.0]$

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)** $\times$ experimental mass loss from **(a)**

mass of NaHCO_3 = ... g

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

NaHCO_3 is the major component, by mass, in FB 3	
NaHCO_3 is not 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 $\pm 0.05 \text{ cm}^3$

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	$\pm$	9.0 g of solid =
B	$\pm$	4.00 g of solid =
C	$\pm$	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+} .

For
Examiner's
Use

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.				
<i>In tests (ii) and (iii) put a cross in any boxes where the test is not carried out.</i>					
(ii)	<u>If a precipitate remains at the end of test (i)</u> leave the test-tube and contents to stand for a few minutes.				
(iii)	<u>If no precipitate formed at all in test (i)</u> 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.				

<i>test</i>		<i>observations</i>			
		FB 4	FB 5	FB 6	FB 7
(iv)	To 1 cm depth of solution in a test-tube add 1 cm depth of aqueous ammonia. Swirl the tube, then				
	add a further 2 cm depth of aqueous ammonia.				

[6]

- (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.

<i>solution</i>	<i>cation</i>	<i>supporting evidence</i>
FB 4		
FB 5		
FB 6		
FB 7		

[4]

Rinse and re-use test-tubes where possible.

For
Examiner's
Use

I	
II	
III	
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V	
VI	

I	
II	
III	
IV	

- (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.

For
Examiner's
Use

		<i>observation</i>
(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.

	<i>test</i>	<i>observations</i>
(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 add 1 cm depth of aqueous sodium iodide and shake the tube.	<i>Do not repeat your observations from test (i)</i>

[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.]

2 Reactions of anions

<i>ion</i>	<i>reaction</i>
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 $\text{NO} \rightarrow$ (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 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

<i>gas</i>	<i>test and test result</i>
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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General Certificate of Education
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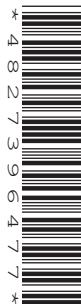
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CENTRE
NUMBER

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CANDIDATE
NUMBER

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CHEMISTRY

Advanced Practical Skills

9701/35

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.
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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.



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

For
Examiner's
Use

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 10.0cm^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.

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

CalculationsFor
Examiner's
Use

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

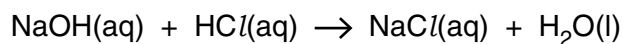
- (c) (i) Calculate the concentration, in mol dm^{-3} , of the sodium hydroxide in **FA 2**.
FA 2 contains 10.00 g dm^{-3} NaOH.
 $[A_r: \text{H}, 1.0; \text{O}, 16.0; \text{Na}, 23.0]$

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**.



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 $0.500 \text{ mol dm}^{-3}$ hydrochloric acid
FA 5 is $0.280 \text{ mol dm}^{-3}$ sodium hydroxide.

For
Examiner's
Use

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.

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**.

(d) CalculationsFor
Examiner's
Use

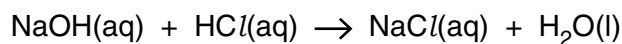
Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

Remember – **FA 4** is $0.500 \text{ mol dm}^{-3}$ hydrochloric acid
FA 5 is $0.280 \text{ mol dm}^{-3}$ 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**.



..... mol of HCl 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 HCl.

- (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 HCl reacted with the calcium carbonate in g **FA 3**.

I	
II	

- (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**.



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

For
Examiner's
Use

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.

$$\frac{\text{mass of CaCO}_3 \text{ from (d)(v)}}{\text{mass of FA 3 used, from (a)}} \times 100$$

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

III	
IV	
V	

FA 3 contains % calcium carbonate.
[5]

- (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]

(f) (i) Complete the following table.

For
Examiner's
Use

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

Conclusion

Complete the following table.

<i>solution</i>	<i>cation</i>	<i>supporting evidence</i>
FA 7		
FA 8		
FA 9		

I	
II	
III	
IV	
V	
VI	

[6]

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

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-} .

<i>solution</i>	<i>observation</i>	<i>SO_4^{2-} present</i>
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]

(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

<i>test</i>		<i>observations</i>
(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 small 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

<i>ion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chromate(VI), $\text{CrO}_4^{2-}(\text{aq})$	yellow solution turns orange with $\text{H}^+(\text{aq})$; gives yellow ppt. with $\text{Ba}^{2+}(\text{aq})$; gives bright yellow ppt. with $\text{Pb}^{2+}(\text{aq})$
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$); gives white ppt. with $\text{Pb}^{2+}(\text{aq})$
bromide, $\text{Br}^-(\text{aq})$	gives cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$); gives white ppt. with $\text{Pb}^{2+}(\text{aq})$
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$); gives yellow ppt. with $\text{Pb}^{2+}(\text{aq})$
nitrate, $\text{NO}_3^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
nitrite, $\text{NO}_2^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil, NO liberated by dilute acids (colourless $\text{NO} \rightarrow$ (pale) brown NO_2 in air)
sulfate, $\text{SO}_4^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ or with $\text{Pb}^{2+}(\text{aq})$ (insoluble in excess dilute strong acid)
sulfite, $\text{SO}_3^{2-}(\text{aq})$	SO_2 liberated with dilute acids; gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in excess dilute strong acid)

3 Tests for gases

<i>gas</i>	<i>test and test result</i>
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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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

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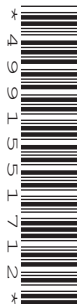
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CHEMISTRY

9701/36

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 11 and 12.

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.



You must prepare Flask A and Flask B in Question 2 before starting Question 1. Shake each flask periodically during the time you spend on Question 1.

- 1 **FB 1** is $0.125 \text{ mol dm}^{-3}$ sulfuric acid, H_2SO_4 .
FB 2 is an aqueous solution of sodium hydroxide, NaOH .

You are to determine the concentration, in mol dm^{-3} , of the sodium hydroxide in **FB 2**.

(a) Method

- Fill a burette with **FB 1**.
- Run between 45.50 cm^3 and 46.50 cm^3 of **FB 1** from the burette into the 250 cm^3 graduated (volumetric) flask, labelled **FB 3**.
- Make up to the mark with distilled water.
- Shake the flask to mix the solution.

In the space below record your burette readings and the volume of **FB 1** added to the graduated flask.

You are reminded to shake Flask A and Flask B periodically.

Titration

- Fill a second burette with **FB 2**.
- Pipette 25.0 cm^3 of **FB 3**, the diluted acid, into a conical flask.
- Add to the flask a few drops of phenolphthalein indicator.
- Place the flask on a white tile.
- Titrate the acid in the flask with **FB 2**.
 At the end-point a "permanent" pink colour will remain in the solution.
- **Note:** The "permanent" pink colour will fade over several minutes as carbon dioxide is absorbed from the atmosphere.

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 on page 3 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.

You will require the burette containing FB 2 for Question 2.

[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 cm³ of **FB 3** required cm³ of **FB 2**.
[1]

Calculations

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

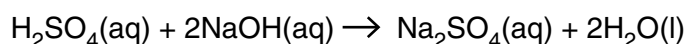
- (c) (i) Calculate how many moles of H₂SO₄ in **FB 1** were run from the burette into the 250 cm³ graduated, (volumetric) flask.

..... mol of H₂SO₄ were run from the burette into the graduated flask.

- (ii) Calculate how many moles of H₂SO₄ in **FB 3** were pipetted from the graduated flask into the conical flask in each titration.

..... mol of H₂SO₄ were pipetted into the conical flask.

- (iii) Calculate how many moles of NaOH reacted with the H₂SO₄ in (ii).



The H₂SO₄ in the titration flask reacted with mol of NaOH.

I	
II	
III	
IV	
V	
VI	
VII	

I	
II	
III	
IV	
V	

- (iv) Calculate the concentration, in mol dm^{-3} , of NaOH in **FB 2**.

For
Examiner's
Use

The concentration of NaOH in **FB 2** is mol dm^{-3} .
[5]

- (d) The individual error in any burette reading is $\pm 0.05 \text{ cm}^3$.
Two students, A and B, record identical burette readings.

final burette reading	25.60 cm^3
initial burette reading	1.35 cm^3
volume added	24.25 cm^3

Explain the following.

- (i) The initial burette reading made by student A was 0.05 cm^3 greater than the true value but the volume added was exactly 24.25 cm^3 .

.....
.....

- (ii) The initial burette reading made by student B was 0.05 cm^3 less than the true value and the actual volume added was exactly 24.15 cm^3 .

.....
.....

[2]

- (e) In the instructions for the experiment you were told that the “permanent” pink colour at the end-point would fade over a few minutes as carbon dioxide is absorbed from the atmosphere.

- (i) Explain why absorption of carbon dioxide at the end-point would reverse the indicator colour change seen in the titration.

.....
.....

- (ii) Suggest a modification to the titration method, using the same indicator, that would overcome this problem.

.....
.....

[2]

[Total: 17]

- 2 **FB 4** is $0.050 \text{ mol dm}^{-3}$ sodium hydroxide solution.
FB 5 is $0.200 \text{ mol dm}^{-3}$ propanoic acid, $\text{C}_2\text{H}_5\text{CO}_2\text{H}$.
FB 6 is an organic liquid that does not mix with water.

For
Examiner's
Use

Propanoic acid dissolves both in water and in the organic layer, **FB 6**.

When an aqueous solution of the acid is shaken with **FB 6**, some of the acid transfers to the organic layer.

The amount of acid remaining in the aqueous layer can be determined by titration with aqueous sodium hydroxide.

Preparation of the mixture in Flask A and in Flask B.

Flask A

- Use a measuring cylinder to place 50 cm^3 of **FB 5** into the stoppered flask labelled **Flask A**.
- Use a second measuring cylinder to add to the flask 40 cm^3 of **FB 6**, the organic liquid.
- Replace the stopper in the flask.

Flask B

- Use the first measuring cylinder to place 50 cm^3 of **FB 5** into the stoppered flask labelled **Flask B**.
- Use the second measuring cylinder to add to the flask 60 cm^3 of **FB 6**, the organic liquid.
- Replace the stopper in the flask.
- Shake both flasks vigorously for about 1 minute.
- **Leave the flasks on the workbench and start Question 1.**
- Shake the flasks for a further minute at intervals during the course of your work on another question.

(a) Titrations

For each flask follow the same procedure.

- Empty the burette containing **FB 2**.
- Rinse the burette thoroughly with **FB 4**.
- Fill the burette with **FB 4**.
- Ensure the two layers have separated – this should take no longer than 1 minute after shaking the flask.
- Pipette 10.0 cm^3 of the **lower** (aqueous) layer into a conical flask. Attach the pipette filler to the pipette before inserting it into the mixture, in order to close the top of the pipette to prevent any of the top (organic) layer from entering the pipette.
- Replace the stopper in the flask.
- Titrate the acid in the conical flask with **FB 4**, using phenolphthalein indicator, as in Question 1.
- **One titration will be sufficient for each experiment but take care to ensure that no errors are made during the procedure.**

I	
II	
III	
IV	

Results

Record, in a single table below, the burette readings and volume of **FB 4** added, for each of **Flask A** and **Flask B**.

For
Examiner's
Use

[4]

(b) Calculations

In these calculations make use of the following.

- The concentration of NaOH in **FB 4** is $0.050 \text{ mol dm}^{-3}$.
- 50 cm^3 of $0.200 \text{ mol dm}^{-3}$ propanoic acid, the volume of acid added to each flask, contains $0.010 \text{ mol C}_2\text{H}_5\text{CO}_2\text{H}$.
- $1 \text{ mol C}_2\text{H}_5\text{CO}_2\text{H}$ reacts with 1 mol NaOH .

- (i) Calculate the volume of **FB 4** that contains 0.010 mol NaOH .
This is the volume of **FB 4** that would have reacted with the propanoic acid in the 50 cm^3 of the aqueous layer, **before** shaking with the organic liquid.

Volume of **FB 4** = ... cm^3

- (ii) For each flask, use your titration result in (a) to calculate the volume of **FB 4** needed to react with the acid remaining in 50 cm^3 of the aqueous layer, **after** shaking with the organic liquid.

Flask A	Flask B
volume of FB 4 = ... cm^3	volume of FB 4 = ... cm^3

- (iii) The amount of propanoic acid transferred to the organic layer can be represented by the following.

(answer to (i) – answer to (ii))

For each flask evaluate this expression.

Flask A (answer to (i) – answer to (ii)) = ... cm^3

Flask B (answer to (i) – answer to (ii)) = ... cm^3

[2]

- (c) In which flask was most propanoic acid transferred to the organic layer?

Justify your answer.

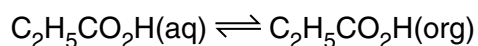
.....

.....

.....

[1]

- (d) It is suggested that shaking the mixture leads to the following equilibrium being established.



Determine the equilibrium constant by evaluating the expressions in the following table.

- (i) Determine the equilibrium constant by evaluating the expressions in the following table. **Ignore units.**

Flask A	Flask B
$K_c = \frac{\text{answer (b)(iii)}}{\text{answer (b)(ii)}} \times 1.25$	$K_c = \frac{\text{answer (b)(iii)}}{\text{answer (b)(ii)}} \times 0.83$
$K_c = \dots\dots\dots$	$K_c = \dots\dots\dots$

- (ii) Explain whether or not your results support the idea that equilibrium has been established in each flask.

.....

.....

.....

[1]

[Total: 8]

- 3 **FB 7, FB 8 and FB 9** are aqueous solutions, each containing cations and anions from those listed on pages 11 and 12 in the Qualitative Analysis Notes.

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.

- (a) (i) One or more of the solutions **FB 7, FB 8 and FB 9** are believed to contain the ammonium ion, NH_4^+ .

Suggest a reagent that would enable you to identify the presence of NH_4^+ and describe how you would use the reagent in an appropriate test.

reagent

test

.....

Use this reagent to test each of the solutions. Record your observations in the table below.

<i>solution</i>	<i>observation</i>
FB 7	
FB 8	
FB 9	

I	
II	

- (ii) One or more of the solutions contains the sulfate ion, SO_4^{2-} .
 Select reagents that would enable you to identify the presence of SO_4^{2-} .
 Show clearly, by describing how the reagents will be used, how you would distinguish SO_4^{2-} from the sulfite ion, SO_3^{2-} .

For
Examiner's
Use

reagents

test

Use these reagents to test each of the solutions. Record your observations in the table below.

<i>solution</i>	<i>observation</i>
FB 7	
FB 8	
FB 9	

III	
IV	
V	

(iii) **Conclusions**

The ammonium ion, NH_4^+ , is present in

The sulfate ion, SO_4^{2-} , is present in [5]

- (b) Use aqueous sodium hydroxide and aqueous ammonia in separate tests to identify any cation (apart from NH_4^+) present in **FB 7**, **FB 8** and **FB 9**.

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

I	
II	
III	
IV	

[4]

(c) Conclusion

Complete the following table.

Place a cross in any box where no cation has been identified.

<i>solution</i>	<i>cation</i>	<i>supporting evidence</i>
FB 7		
FB 8		
FB 9		

[1]

(d) Carry out the following tests on FB 10.

Observe carefully at each stage and record all of your observations in the table.

<i>test</i>		<i>observations</i>
(i)	Place 2 spatula measures of FB 10 in a dry, hard glass boiling-tube. Heat the solid gently at first, then strongly until no further change is seen. Retain the solid for use in (ii) .	
(ii)	Tip the contents of the tube in (i) into a second boiling-tube. Add 2 cm depth of dilute hydrochloric acid a little at a time . Warm the tube and leave to stand.	

[5]

[Total: 15]

For
Examiner's
Use

I	
II	
III	
IV	
V	

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

<i>ion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chromate(VI), $\text{CrO}_4^{2-}(\text{aq})$	yellow solution turns orange with $\text{H}^+(\text{aq})$; gives yellow ppt. with $\text{Ba}^{2+}(\text{aq})$; gives bright yellow ppt. with $\text{Pb}^{2+}(\text{aq})$
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$); gives white ppt. with $\text{Pb}^{2+}(\text{aq})$
bromide, $\text{Br}^-(\text{aq})$	gives cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$); gives white ppt. with $\text{Pb}^{2+}(\text{aq})$
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$); gives yellow ppt. with $\text{Pb}^{2+}(\text{aq})$
nitrate, $\text{NO}_3^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
nitrite, $\text{NO}_2^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil, NO liberated by dilute acids (colourless $\text{NO} \rightarrow$ (pale) brown NO_2 in air)
sulfate, $\text{SO}_4^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ or with $\text{Pb}^{2+}(\text{aq})$ (insoluble in excess dilute strong acid)
sulfite, $\text{SO}_3^{2-}(\text{aq})$	SO_2 liberated with dilute acids; gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in excess dilute strong acid)

3 Tests for gases

<i>gas</i>	<i>test and test result</i>
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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