

CANDIDATE
NAME

CENTRE
NUMBER

--	--	--	--	--

CANDIDATE
NUMBER

--	--	--	--

CHEMISTRY

9701/31

Paper 3 Advanced Practical Skills 1

May/June 2015

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

MODIFIED LANGUAGE

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 an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 10 and 11.

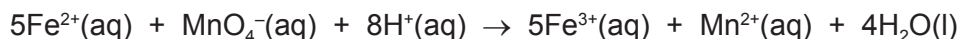
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [] at the end of each question or part question.

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

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

- 1 In this question you will determine the concentration of iron(II) ions in **FA 2**. To do this you will do a titration using potassium manganate(VII) solution. The iron(II) ions, Fe^{2+} , are oxidised by the manganate(VII) ions, MnO_4^- .



When all the Fe^{2+} ions have been oxidised, the presence of unreacted MnO_4^- ions causes the solution to become a permanent pink colour.

FA 1 contains $0.0200 \text{ mol dm}^{-3}$ manganate(VII) ions, MnO_4^- .

FA 2 is a solution containing iron(II) ions, Fe^{2+} .

FA 3 is 1.0 mol dm^{-3} sulfuric acid, H_2SO_4 .

(a) Method

- Fill the burette with **FA 1**.
- Use the pipette to transfer 25.0 cm^3 of **FA 2** into the conical flask.
- Use the 25 cm^3 measuring cylinder to add 10 cm^3 of **FA 3** to the conical flask.
- Add **FA 1** from the burette into the conical flask until the solution becomes a permanent pink colour.
- Perform a **rough titration** and record your burette readings in the space below.

The rough titre is cm^3 .

- Do as many accurate titrations as you think necessary to obtain consistent results.
- Make certain any recorded results show the precision of your practical work.
- Record in a suitable form below all of your burette readings and the volume of **FA 1** added in each accurate titration.

Keep FA 2 to use in Question 3.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

- (b) From your accurate titration results, obtain a suitable value to be used in your calculations. Show clearly how you obtained this value.

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

(c) Calculations

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

- (i) Calculate the number of moles of manganate(VII) ions present in the volume of **FA 1** calculated in (b).

moles of MnO_4^- = ... mol

- (ii) Calculate the number of moles of iron(II) ions present in 25.0 cm³ of **FA 2**.

moles of Fe^{2+} = ... mol

- (iii) Calculate the concentration, in mol dm⁻³, of iron(II) ions in **FA 2**.

concentration of Fe^{2+} in **FA 2** = ... mol dm⁻³

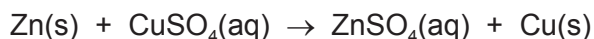
- (iv) **FA 2** was prepared by dissolving hydrated ammonium iron(II) sulfate, $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$ in distilled water. Calculate the mass of salt that would have to be dissolved in 1.00 dm³ of water to prepare **FA 2**.
(*A_r*: H, 1.0; N, 14.0; O, 16.0; S, 32.1; Fe, 55.8)

I	
II	
III	
IV	

mass of $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$ = ... g
[4]

[Total: 12]

- 2 In this experiment you will measure the heat given out by the reaction of excess zinc with copper(II) sulfate solution and use this to estimate the concentration of the copper(II) sulfate.



FA 4 is zinc powder.

FA 5 is aqueous copper(II) sulfate, CuSO_4 .

(a) Method

Read through the instructions carefully and prepare a table below for your results before starting any practical work.

- Support the plastic cup in the 250 cm^3 beaker.
- Use the 50 cm^3 measuring cylinder to transfer 40 cm^3 of **FA 5** into the plastic cup.
- Measure and record the initial temperature of the solution in the plastic cup.
- Start the stopwatch. Measure and record the temperature of the solution every 30 seconds up to and including the temperature at 2 minutes. Stir the solution frequently.
- At time $t = 2\frac{1}{2}$ minutes, add **all** the powdered zinc to the solution in the plastic cup and stir the mixture.
- Record the temperature every 30 seconds from $t = 3$ minutes up to and including $t = 9$ minutes. Stir the solution constantly.

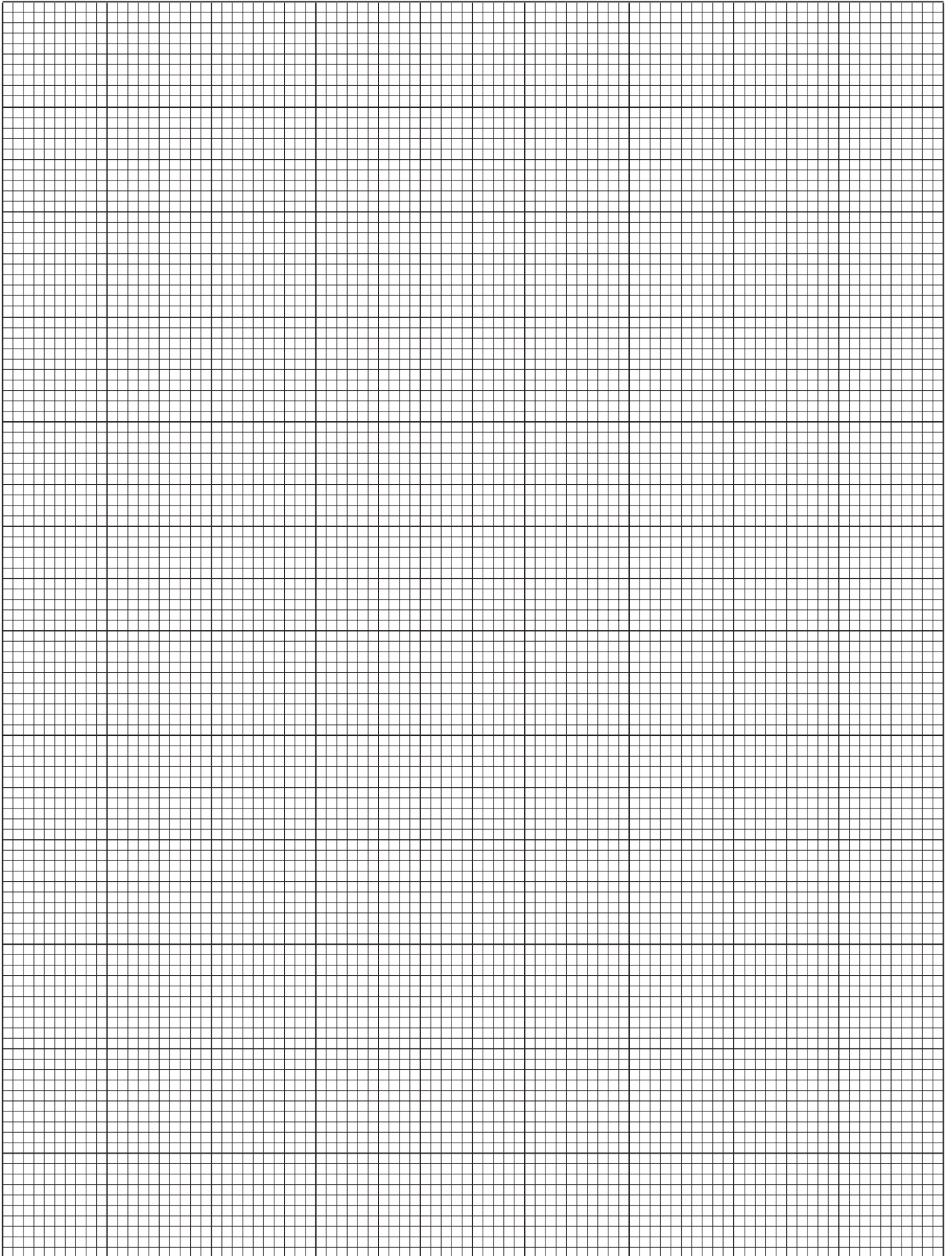
I	
II	
III	
IV	

[4]

- (b) (i)** On the grid opposite, plot the temperature (y-axis) against the time (x-axis). The scale for the temperature axis must allow you to plot a point with a temperature 5°C greater than the maximum temperature you recorded.
- (ii)** Draw the following best-fit **straight** lines on the graph.
- a line through the points between time $t = 0$ minutes and time $t = 2$ minutes
 - a line through the points between time $t = 5$ minutes and time $t = 9$ minutes
 - a vertical line at time $t = 2\frac{1}{2}$ minutes
- (iii)** Extrapolate the first two straight lines so that they intersect the vertical line at time $t = 2\frac{1}{2}$ minutes.
Use these extrapolated lines to determine the theoretical temperature **change** at time $t = 2\frac{1}{2}$ minutes.

change in temperature = ... $^\circ\text{C}$

[5]



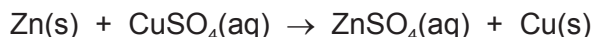
(c) Calculations

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

- (i) Use your answer to **(b)(iii)** to calculate the heat energy produced in the reaction.
(Assume that **4.2 J** are required to increase the temperature of 1 cm³ of solution by 1 °C.)

heat energy produced = ... J

- (ii) The molar enthalpy change, ΔH , for the reaction shown below is -219 kJ mol^{-1} .



Use this value and your answer to **(i)** to calculate the number of moles of copper(II) sulfate in your reaction.

moles of CuSO_4 = ... mol

- (iii) Use your answer to **(ii)**, to calculate the concentration of copper(II) sulfate, in mol dm^{-3} , in **FA 5**.

concentration of CuSO_4 = ... mol dm^{-3}
[3]

- (d) (i) Calculate the maximum percentage error in the highest temperature that you recorded in your results table.

maximum percentage error = ... %

- (ii) A student suggested that the concentration of the copper(II) sulfate could be determined more accurately if a greater mass of zinc had been used.
Explain whether you agree with this student.

.....
.....
.....

- (iii) A second student suggested that the concentration of the copper(II) sulfate could be determined more accurately if a smaller volume of copper(II) sulfate was used.
Explain whether you agree with this student.

.....
.....
.....

[3]

[Total: 15]

3 Qualitative Analysis

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations.**

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

Marks are **not** given for chemical equations.

No additional tests for ions present should be attempted.

If any solution is warmed, a boiling tube MUST be used.

Rinse and reuse test-tubes and boiling tubes where possible.

Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.

(a) In **Question 1** you used **FA 2**. This solution was prepared from hydrated ammonium iron(II) sulfate, $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$.

To a 1 cm depth of **FA 2** in a test-tube, add a small spatula measure of sodium carbonate. Record your observations.

Solutions containing Fe^{2+} ions can quickly be oxidised in air if they are prepared by dissolving the solid in distilled water.

Use your observations to suggest what other substance was added to solid $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$ to prepare **FA 2**.

.....

[2]

- (b) **FA 6** is a mixture of two salts, each of which contains a single cation and a single anion from those listed in the Qualitative Analysis Notes on pages 10 and 11.
Do the following tests and record your observations in the table below.

<i>test</i>	<i>observations</i>
(i) Place a small spatula measure of FA 6 in a hard-glass test-tube and heat strongly.	
(ii) Place a small spatula measure of FA 6 in a test-tube and carefully add dilute sulfuric acid until the reaction is complete, then	
add aqueous sodium hydroxide.	
(iii) To a 3 cm depth of distilled water in a boiling tube, add the remaining sample of FA 6 . Stir and then filter the mixture into a clean boiling tube. You will use this solution for tests (iv)–(vi).	
(iv) To a 1 cm depth of the solution from (iii) in a test-tube, add aqueous sodium hydroxide.	
(v) To a 1 cm depth of the solution from (iii) in a test-tube, add aqueous ammonia.	
(vi) To a 1 cm depth of the solution from (iii) in a test-tube, add aqueous barium chloride or aqueous barium nitrate.	

(vii) Suggest possible identities for the ions present in **FA 6**.

cations

anions

(viii) Describe a further test that would allow you to determine exactly which anions are present. Explain your choice. Do **not** do this test.

.....

.....

.....

[11]

[Total: 13]

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
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

2 Reactions of anions

<i>ion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$)
bromide, $\text{Br}^-(\text{aq})$	gives cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$)
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$)
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 $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)
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 acids)

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 manganate(VII) from purple to colourless

BLANK PAGE

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge International Examinations Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cie.org.uk after the live examination series.

Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

--	--	--	--	--

--	--	--	--

9701/32

May/June 2015

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

MODIFIED LANGUAGE

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 an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 10 and 11.

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 **10** printed pages and **2** blank pages.

- 1 In this question you will determine the percentage purity of a sample of contaminated sodium carbonate. **FB 1** is a solution of the contaminated sodium carbonate. You will first dilute **FB 1** and then titrate the diluted solution using hydrochloric acid.



FB 1 was prepared by dissolving 125 g of contaminated sodium carbonate, Na_2CO_3 , in distilled water and making the solution up to 1 dm^3 .

FB 2 is $0.100 \text{ mol dm}^{-3}$ hydrochloric acid, HCl .
methyl orange indicator

(a) Method

Dilution

- Fill the burette with **FB 1**.
- Run between 13.00 and 13.50 cm^3 of **FB 1** into the 250 cm^3 volumetric (graduated) flask. Record the volume in the space below.

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

- Fill the volumetric flask to the line with distilled water. Stopper the flask and shake it to ensure thorough mixing.
- Label this flask **FB 3**.

Titration

- Rinse the burette thoroughly with distilled water and then with a little of solution **FB 2**.
- Fill the burette with **FB 2**.
- Use the pipette to transfer 25.0 cm^3 of **FB 3** into a conical flask.
- Add 5-10 drops of methyl orange indicator.
- Perform a **rough titration** and record your burette readings in the space below.

The rough titre is cm^3 .

- Do as many accurate titrations as you think necessary to obtain consistent results.
- Make certain any recorded results show the precision of your practical work.
- Record in a suitable form below all of your burette readings and the volume of **FB 2** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	
VIII	

[8]

- (b) From your accurate titration results, obtain a suitable value to be used in your calculations. Show clearly how you obtained this value.

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

(c) Calculations

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

- (i) Calculate the number of moles of hydrochloric acid present in the volume of **FB 2** calculated in (b).

moles of HCl = ... mol

- (ii) Calculate the number of moles of sodium carbonate present in 25.0 cm³ of **FB 3**.

moles of Na₂CO₃ = ... mol

- (iii) Calculate the concentration, in mol dm⁻³, of sodium carbonate in **FB 3**.

concentration of Na₂CO₃ in **FB 3** = ... mol dm⁻³

- (iv) Calculate the concentration, in mol dm⁻³, of sodium carbonate in **FB 1**.

concentration of Na₂CO₃ in **FB 1** = ... mol dm⁻³

- (v) Calculate the percentage purity by mass of the sodium carbonate in the contaminated sample used to prepare solution **FB 1**.
(A_r: C, 12.0; O, 16.0; Na, 23.0)

I	
II	
III	
IV	
V	

percentage purity by mass = ... %
[5]

[Total: 14]

- 2 In this experiment you will determine the percentage by mass of magnesium in a mixture of magnesium and iron. To do this you will measure the heat given out by the reaction of the mixture with excess hydrochloric acid. You should assume that only the magnesium in the mixture will react with the acid.

FB 4 is the mixture of magnesium and iron.

FB 5 is 2.00 mol dm^{-3} hydrochloric acid, HCl .

(a) Method

Read through the instructions carefully and prepare a table below for your results before starting any practical work.

- Support the plastic cup in a 250 cm^3 beaker.
- Use the measuring cylinder to transfer 40 cm^3 of **FB 5** into the plastic cup.
- Weigh the stoppered container with the **FB 4** and record the mass.
- Measure and record the initial temperature of the solution in the plastic cup.
- Add all the sample of **FB 4** to the acid in the plastic cup carefully to minimise acid spray.
- Stir the mixture and record the maximum temperature that is reached.
- Weigh the stoppered container and any residual metal mixture. Record the mass.
- Record the mass of metal added to the acid.

I	
II	
III	
IV	

[4]

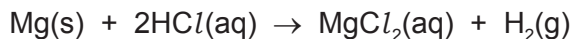
(b) Calculations

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

- (i) Use your value for the maximum temperature rise to calculate the heat energy produced in the reaction.
(Assume that **4.2 J** are required to increase the temperature of 1.0 cm^3 of solution by 1.0°C .)

heat energy produced = ... J

- (ii) The molar enthalpy change, ΔH , for the reaction shown below is -457 kJ mol^{-1} .



Use this value and your answer to (i) to calculate the number of moles of magnesium in your reaction.

moles of Mg = ... mol

- (iii) Use your answer to (ii), to calculate the percentage by mass of magnesium in **FB 4**.
(A_r : Mg, 24.3)

percentage by mass of Mg in **FB 4** = ... %

- (iv) You have assumed that only the magnesium reacts with the acid. What other assumption have you made in using this method to determine the percentage by mass of magnesium in the mixture?

.....

 [4]

- (c) (i) Calculate the maximum percentage error in the temperature rise.

maximum percentage error = ... %

- (ii) Using the same **FB 4**, the same **FB 5** and no additional apparatus, describe how you could modify the experiment to reduce this maximum percentage error in the temperature rise. Explain your answer.

.....

 [3]

[Total: 11]

3 Qualitative Analysis

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations.**

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

Marks are **not** given for chemical equations.

No additional tests for ions present should be attempted.

If any solution is warmed, a boiling tube MUST be used.

Rinse and reuse test-tubes and boiling tubes where possible.

Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.

(a) **FB 6** is a solution containing two cations and one anion. Both of the cations are listed in the Qualitative Analysis Notes on page 10.

- (i) Select reagents to identify the cations in **FB 6**. Do tests using these reagents and record your results in the space below.

The cations in **FB 6** are and

- (ii) The anion in **FB 6** is the nitrate ion, NO_3^- . Explain why it is difficult to confirm the presence of the nitrate ion in **FB 6** using the method outlined in the Qualitative Analysis Notes on page 11.

.....

.....

.....

[6]

Before starting part (b), half fill a 250 cm³ beaker with water and heat with a Bunsen burner to approximately 60 °C. You will use this as a hot water bath. Turn off the Bunsen burner.

- (b) **FB 7** is a halogenoalkane. Do the following test to determine the halogen present in **FB 7**.

<i>test</i>	<i>observations</i>
(i) To a 1 cm depth of ethanol in a test-tube, add a 1 cm depth of silver nitrate followed by 10 drops of FB 7 , then	
place the test-tube in the hot water bath.	

The halogen present in **FB 7** is

- (ii) What type of reaction has the halogenoalkane undergone?

.....

[4]

- (c) **FB 8** and **FB 9** each contain a single cation and a single anion. Do the following tests and record your observations.

<i>test</i>	<i>observations</i>
(i) To a 1 cm depth of FB 8 in a test-tube, add FB 9 until there is no further reaction, then	
add aqueous barium chloride or aqueous barium nitrate.	

- (ii) Suggest possible identities for the ions present. You will only be able to identify one of the cations.

cation

anions

[5]

[Total: 15]

BLANK PAGE

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
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

2 Reactions of anions

<i>ion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$)
bromide, $\text{Br}^-(\text{aq})$	gives cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$)
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$)
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 $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)
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 acids)

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 manganate(VII) from purple to colourless

BLANK PAGE

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge International Examinations Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cie.org.uk after the live examination series.

Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

CANDIDATE
NAME

CENTRE
NUMBER

--	--	--	--	--

CANDIDATE
NUMBER

--	--	--	--

CHEMISTRY

9701/33

Paper 3 Advanced Practical Skills 1

May/June 2015

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Give details of the practical session and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 10 and 11.

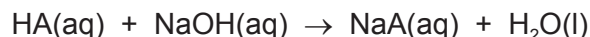
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [] at the end of each question or part question.

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This document consists of **10** printed pages and **2** blank pages.

- 1 HA is an organic acid. Solution **FA 1** was prepared by dissolving 13.1 g of solid HA in each dm³ of solution. You are to determine the relative molecular mass, M_r , of HA by titration with aqueous sodium hydroxide. The equation for the reaction between HA and sodium hydroxide is given below.



FA 1 is a solution containing 13.1 g dm⁻³ of organic acid, HA.

FA 2 is 0.100 mol dm⁻³ sodium hydroxide, NaOH.

bromothymol blue indicator

(a) Method

- Fill the burette with **FA 1**.
- Use the pipette to transfer 25.0 cm³ of **FA 2** into a conical flask.
- Add a few drops of bromothymol blue indicator. This indicator is blue in alkali and yellow in acid solutions.
- Perform a **rough titration** and record your burette readings in the space below.

The rough titre is cm³.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make certain any recorded results show the precision of your practical work.
- Record, in a suitable form below, all of your burette readings and the volume of **FA 1** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

- (b)** From your accurate titration results, obtain a suitable value to be used in your calculations. Show clearly how you obtained this value.

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

(c) Calculations

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

- (i) Calculate the number of moles of sodium hydroxide present in the volume of **FA 2** pipetted into the conical flask.

moles of NaOH = ... mol

- (ii) Use your answer to (c)(i) and the equation on page 2 to determine the number of moles of organic acid, HA, used to neutralise 25.0 cm³ of **FA 2**.

moles of HA = ... mol

- (iii) Use your answers to (b) and (c)(ii) to calculate the number of moles of HA in 1 dm³ of **FA 1**.

moles of HA in 1 dm³ of **FA 1** = ... mol

- (iv) Calculate the relative molecular mass, M_r , of the organic acid, HA.

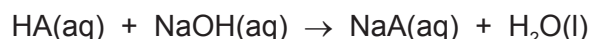
M_r of HA = ...
[4]

- (d) A student carrying out this method correctly with the same concentration of reactants obtained a titre of 28.30 cm³. Would this give a larger or smaller value of M_r than yours?
Explain your answer.

.....
.....
..... [1]

[Total: 13]

- 2 You are to determine the enthalpy change for the neutralisation reaction given below.



You will be using solutions of different concentrations from those in **Question 1**.

FA 3 is 1.80 mol dm^{-3} HA.

FA 4 is aqueous sodium hydroxide, NaOH.

(a) Method

Read through the instructions carefully and prepare a table below for your results before starting any practical work.

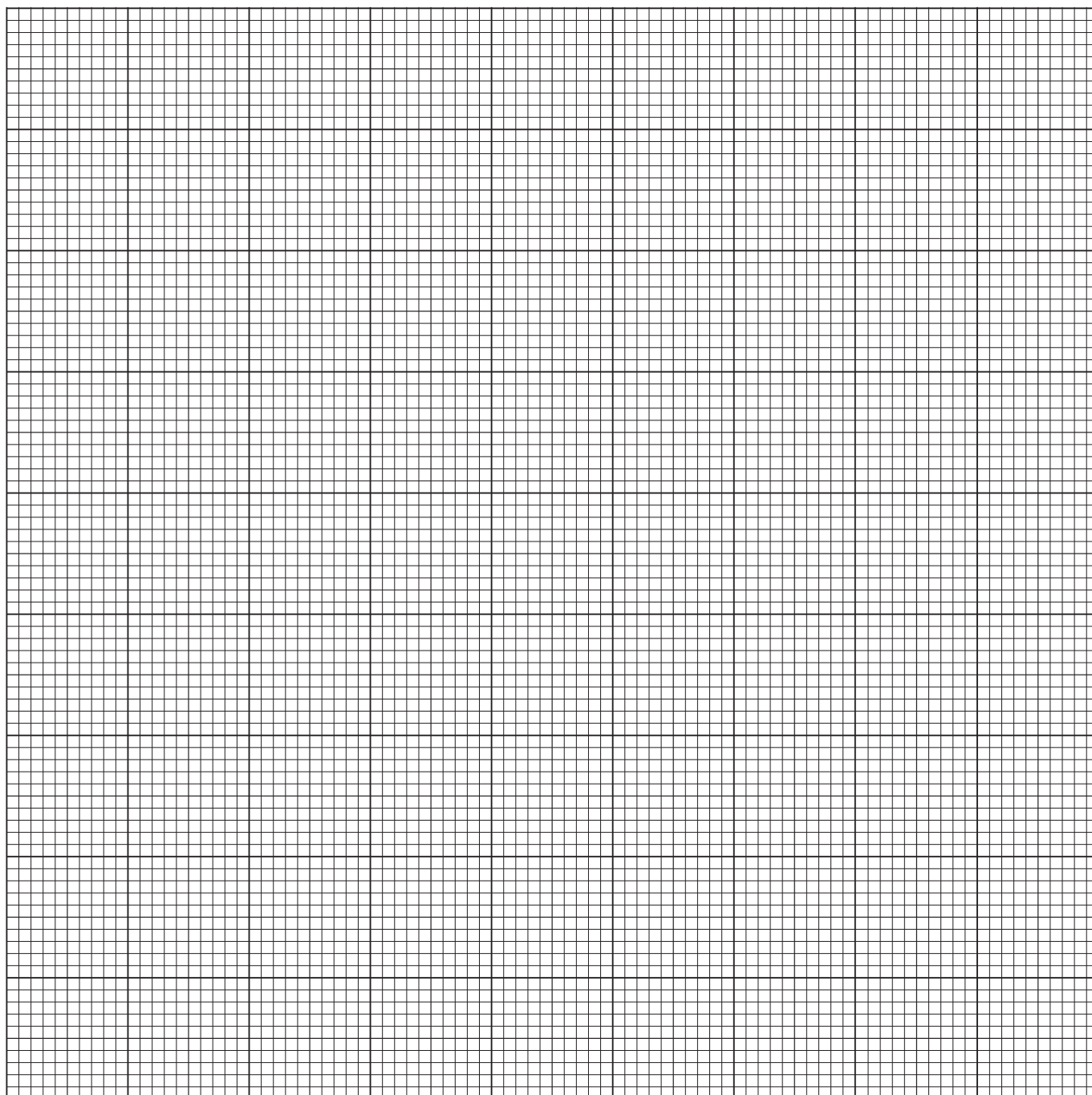
- Support the plastic cup in the 250 cm^3 beaker.
- Rinse and fill the burette with **FA 3**.
- Use the measuring cylinder to transfer 25 cm^3 of **FA 4** into the plastic cup.
- Place the thermometer in the plastic cup and record the temperature of the solution. Tilt the cup if necessary to ensure the thermometer bulb is fully immersed.
- Run 5.00 cm^3 of **FA 3** into the cup. Stir, and record the new temperature of the solution and the volume of **FA 3** added.
- Run a second 5.00 cm^3 of **FA 3** into the cup. Stir and record the new temperature and the total volume of **FA 3** added.
- Continue adding **FA 3** in 5.00 cm^3 portions. Stir and record each new temperature and total volume of **FA 3** until a total of 45.00 cm^3 has been added.

Results

I	
II	
III	
IV	

[4]

- (b)** Plot a graph of temperature (y-axis) against total volume of **FA 3** added (x-axis) on the grid opposite. The temperature axis should allow you to include a point at least 2°C greater than the maximum temperature recorded.



Draw the best fit smooth curve or straight line through the two sets of points, one for the increase in temperature of the mixture and the other for the cooling of the solution once the reaction is complete. Extrapolate the two lines and determine the maximum **increase** in temperature and the corresponding volume of **FA 3** added for this increase in temperature.

I	
II	
III	
IV	

maximum temperature **increase** = ... °C

volume of **FA 3** = ... cm³
[4]

(c) Calculations

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

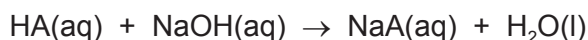
- (i) Calculate the number of moles of HA present in the volume of **FA 3** recorded in **(b)**.

moles of HA = ... mol

- (ii) Using your answers to **(b)**, calculate the heat energy produced when **FA 3** neutralised 25 cm³ of sodium hydroxide.
(Assume that **4.2 J** of heat energy changes the temperature of 1.0 cm³ of solution by 1.0 °C.)

heat energy produced = ... J

- (iii) Calculate the enthalpy change of neutralisation, in kJ mol⁻¹, for the reaction below.



enthalpy change = ... kJ mol⁻¹
(sign) (value)

[4]

- (d) The maximum error in a single thermometer reading is $\pm 0.5^\circ\text{C}$.
Calculate the maximum percentage error in the increase in temperature recorded in **(b)**.

maximum percentage error = ... % [1]

- (e) When carrying out thermochemistry experiments in an A Level laboratory, the plastic cup is usually placed in a glass beaker. Give a reason for the use of the glass beaker.

.....
..... [1]

- (f) Apart from using a thermometer calibrated to a greater level of precision, suggest one improvement that could be made to the **method** carried out in **(a)**.

.....
..... [1]

[Total: 15]

3 Qualitative Analysis

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations.**

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

Marks are **not** given for chemical equations.

No additional tests for ions present should be attempted.

If any solution is warmed, a boiling tube MUST be used.

Rinse and reuse test-tubes and boiling tubes where possible.

Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.

Before starting your practical work, half fill the 250 cm³ beaker with water. Heat it to approximately 80 °C, then turn off the Bunsen burner. This will be used as a hot water bath.

(a) **FA 5** is the salt of another organic acid.

FA 6 is a salt containing two cations and one anion from those listed in the Qualitative Analysis Notes on pages 10 and 11.

Carry out the following tests and record your observations in the table below.

<i>test</i>	<i>observations</i>
(i) To a 1 cm depth of dilute sulfuric acid in a test-tube, add five drops of potassium manganate(VII) then a small spatula measure of FA 5 . Shake the tube then place it in the hot water bath.	
(ii) Place a spatula measure of FA 6 in a hard-glass test-tube. Heat gently and test any gas evolved with litmus paper.	
(iii) To a 4 cm depth of water in a boiling tube, add and dissolve a spatula measure of FA 6 . Use portions of this solution, aqueous FA 6 , for tests (iv) – (vi).	X

<i>test</i>	<i>observations</i>
(iv) To a 1 cm depth of aqueous FA 6 in a test-tube, add aqueous ammonia.	
(v) To a 1 cm depth of aqueous FA 6 in a test-tube, add a 1 cm depth of aqueous barium chloride followed by dilute hydrochloric acid or a 1 cm depth of aqueous barium nitrate followed by dilute nitric acid.	
(vi) To a 1 cm depth of aqueous FA 6 in a test-tube, add a small spatula measure of FA 5 and shake the mixture. Keep this mixture for the test in part (b).	

(vii) Identify as many of the ions in **FA 6** as possible from your observations.

FA 6 contains [9]

(b) A student suggests that one of the cations in **FA 6** was oxidised in test (a)(vi).

(i) Name a reagent you would use to find out whether the student was correct.

reagent

(ii) Use your reagent to carry out a test on the mixture from (a)(vi). Record your observations below. State and explain whether the student was correct.

observations

.....

conclusion

[3]

[Total: 12]

BLANK PAGE

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
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

2 Reactions of anions

<i>ion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$)
bromide, $\text{Br}^-(\text{aq})$	gives cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$)
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$)
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 $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)
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 acids)

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 manganate(VII) from purple to colourless

BLANK PAGE

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge International Examinations Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cie.org.uk after the live examination series.

Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

--

--	--	--	--	--

--	--	--	--

9701/34

May/June 2015

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Give details of the practical session and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 10 and 11.

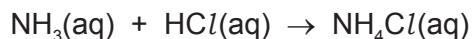
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [] at the end of each question or part question.

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

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

- 1 The concentration of aqueous ammonia used in qualitative analysis is 2 mol dm^{-3} but it is supplied in a much more concentrated form. This is referred to as '.880 ammonia'. You are to determine the concentration of '.880 ammonia' by titration of a solution of ammonia, **FB 1**, with hydrochloric acid of known concentration. The equation for the reaction is given below.



FB 1 is a dilute solution of ammonia, $\text{NH}_3(\text{aq})$. It was prepared by measuring out 5.91 cm^3 of the '.880 ammonia' and then adding distilled water until the solution had a volume of 1 dm^3 .

FB 2 is $0.100 \text{ mol dm}^{-3}$ hydrochloric acid, $\text{HCl}(\text{aq})$.

methyl orange indicator

(a) Method

- Fill the burette with **FB 2**.
- Use the pipette to transfer 25.0 cm^3 of **FB 1** into a conical flask.
- Add a few drops of methyl orange indicator.
- Perform a **rough titration** and record your burette readings in the space below.

The rough titre is cm^3 .

- Carry out as many accurate titrations as you think necessary to achieve consistent results.
- Make certain any recorded results show the precision of your practical work.
- Record, in a suitable form below, all of your burette readings and the volume of **FB 2** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

- (b)** From your accurate titration results, obtain a suitable value to be used in your calculations. Show clearly how you obtained this value.

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

(c) Calculations

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

- (i) Calculate the number of moles of hydrochloric acid present in the volume of **FB 2** calculated in (b).

moles of HCl = ... mol

- (ii) Use your answer to (i) to determine the number of moles of ammonia present in 25.0 cm^3 of **FB 1**, pipetted into the conical flask.

moles of NH_3 = ... mol

- (iii) Use your answer to (ii) to calculate the concentration, in mol dm^{-3} , of the diluted ammonia, **FB 1**.

concentration of NH_3 (diluted) in **FB 1** = ... mol dm^{-3}

- (iv) Use your answer to (iii) and the information on page 2 to calculate the concentration, in mol dm^{-3} , of '.880 ammonia'.

concentration of '.880 ammonia' = ... mol dm^{-3}
[3]

- (d) A student analysed a different sample of concentrated ammonia and determined the concentration to be 15.0 mol dm^{-3} . Calculate the percentage difference in concentration of the '.880 ammonia' you have determined compared with that of the student.
(If you have been unable to complete the calculation, assume the concentration of '.880 ammonia' was 9.35 mol dm^{-3} . This is not the correct value.)

percentage difference in concentration = ... % [1]

[Total: 12]

- 2 You are to determine the enthalpy change of solution, in kJ mol^{-1} , of ammonium chloride.

FB 3 is approximately 9 g of solid ammonium chloride, NH_4Cl .
distilled water

(a) Method

Read through the instructions carefully and prepare a table below for your results before starting any practical work.

- Weigh the plastic cup and record the balance reading.
- Add between 2.9 and 3.1 g of ammonium chloride, **FB 3**, and record the new balance reading.
- Place the plastic cup in the 250 cm^3 beaker.
- Pour 25 cm^3 of distilled water into the measuring cylinder.
- Place the thermometer in the water and record the initial temperature in the table of results.
- Pour the 25 cm^3 of distilled water into the plastic cup.
- Stir the contents of the cup and record the lowest temperature of the solution. Tilt the cup if necessary to ensure the thermometer bulb is fully immersed.
- Repeat the procedure using the other plastic cup. Use between 4.9 and 5.1 g of **FB 3** for this experiment.
- Record the mass of **FB 3** used and the change in temperature for **each** experiment.

Results

I	
II	
III	
IV	
V	

[5]

- (b) (i) Calculate the mean mass of **FB 3** used. Give your answer to **two** decimal places.

mean mass of **FB 3** = ... g

- (ii) Calculate the mean temperature change. Give your answer to **one** decimal place.

mean temperature change = ... °C
[2]

(c) Calculations

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

- (i) Calculate the number of moles of NH_4Cl present in the mass of **FB 3** calculated in (b)(i).
[A_r : H, 1.0; N, 14.0; Cl, 35.5]

moles of NH_4Cl = ... mol

- (ii) Use your answers to (b)(ii) and (c)(i) to calculate the enthalpy change of solution, in kJ mol^{-1} , of NH_4Cl .
(Assume that **4.2 J** of heat energy changes the temperature of 1.0 cm^3 of solution by 1.0°C .)

enthalpy change = ... kJ mol^{-1}
(sign) (value)
[4]

- (d) (i) Which of the two experiments in (a), the first or the second, had the greater percentage error in the value calculated for the temperature change?

.....

- (ii) Given that the error in a single thermometer reading is $\pm 0.5^\circ\text{C}$, calculate the percentage error in the temperature change for the experiment you gave in (d)(i).

percentage error = ... %
[1]

- (e) (i) A student suggested that it would have been better to calculate the enthalpy change for each experiment separately. What would be the advantage of this suggestion? Explain your answer fully.

.....
.....
.....

- (ii) Another student suggested that the procedure would be improved by covering the plastic cup with a lid. Explain whether this would improve the procedure.

.....
.....
[2]

[Total: 14]

3 Qualitative Analysis

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations.**

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

Marks are **not** given for chemical equations.

No additional tests for ions present should be attempted.

If any solution is warmed, a boiling tube MUST be used.

Rinse and reuse test-tubes and boiling tubes where possible.

Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.

- (a) **FB 4** and **FB 5** are solutions of salts each containing one cation and one anion from those listed in the Qualitative Analysis Notes on pages 10 and 11. Carry out the following tests and record your observations in the table below.

<i>test</i>	<i>observations</i>	
	FB 4	FB 5
(i) To a 1 cm depth of solution in a test-tube, add aqueous ammonia.		
(ii) To a 1 cm depth of solution in a test-tube, add a few drops of aqueous silver nitrate.		
(iii) To a 1 cm depth of solution in a test-tube add a few drops of aqueous barium chloride or barium nitrate.		

(iv) Identify both ions in **FB 4**.

cation anion

(v) Suggest the ions which may be present in **FB 5**.

cations anions

(vi) Select a reagent which could be used in a further test on **FB 5** to identify the **cation** present. Carry out your test and record your observations.

<i>test</i>	<i>observations</i>
To a 1 cm depth of FB 5 in a test-tube, add	

The cation in **FB 5** is

[7]

(b) **FB 6** is a pale purple salt containing two cations.

(i) What does this suggest about the identity of one of the cations in **FB 6**?

.....

Carry out the following tests and complete the table below.

<i>test</i>	<i>observations</i>
(ii) Place a spatula measure of FB 6 in a hard-glass test-tube. Heat gently.	
(iii) Dissolve a small spatula measure of FB 6 in a 2 cm depth of distilled water in a test-tube. Use this solution for tests (iv) and (v).	
(iv) Pour about half the solution prepared in (iii) into a boiling tube and add aqueous sodium hydroxide, then	
gently warm the mixture.	
(v) To the remainder of the solution prepared in (iii), add a few drops of aqueous potassium iodide, then	
add a few drops of starch solution.	

(vi) Identify the cations present in **FB 6**.

FB 6 contains and

(vii) What type of reaction occurred when potassium iodide was added to **FB 6** in (v)?

..... [7]

[Total: 14]

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
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

2 Reactions of anions

<i>ion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$)
bromide, $\text{Br}^-(\text{aq})$	gives cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$)
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$)
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 $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)
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 acids)

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 manganate(VII) from purple to colourless

BLANK PAGE

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge International Examinations Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cie.org.uk after the live examination series.

Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

--	--	--	--	--

--	--	--	--

9701/35

May/June 2015

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Give details of the practical session and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 14 and 15.

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 In this experiment you will determine the formula of iron(III) ammonium sulfate, $\text{FeNH}_4(\text{SO}_4)_2 \cdot x\text{H}_2\text{O}$, where x is the number of molecules of water of crystallisation.

A known mass of this iron(III) compound reacted with excess acidified potassium iodide to produce iodine. You will determine the amount of iodine produced by titrating the mixture with sodium thiosulfate.

FA 1 is $0.900 \text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.

FA 2 is a solution of iodine, I_2 , produced as outlined in the paragraph above.
starch indicator

(a) Method

Diluting FA 1

- Pipette 25.0 cm^3 of **FA 1** into the 250 cm^3 volumetric (graduated) flask.
- Make the solution up to the mark using distilled water.
- Shake the flask to mix the solution thoroughly before using it for your titrations.
- Label this diluted solution of sodium thiosulfate **FA 3**.
- Rinse the pipette with distilled water.

Keep FA 1 for use in Question 3.

Titration

- Fill the burette with **FA 3**.
- Use the pipette to transfer 25.0 cm^3 of **FA 2** into a conical flask.
- Add **FA 3** from the burette into the conical flask until the mixture becomes pale yellow.
- Then add 10 drops of starch indicator to give a blue-black colour.
- Continue adding **FA 3** until this blue-black colour disappears. This is the end-point of the titration.
- Perform a **rough titration** and record your burette readings in the space below.

The rough titre is cm^3 .

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

I	
II	
III	
IV	
V	
VI	
VII	

[7]

- (b) From your accurate titration results, obtain a suitable value to be used in your calculations. Show clearly how you obtained this value.

25.0 cm³ of **FA 2** required cm³ of **FA 3**. [1]

(c) Calculations

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

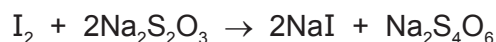
- (i) Using information on page 2, calculate the concentration, in mol dm⁻³, of sodium thiosulfate in **FA 3**.

concentration of Na₂S₂O₃ in **FA 3** = ... mol dm⁻³

- (ii) Calculate the number of moles of sodium thiosulfate present in the volume of **FA 3** calculated in (b).

moles of Na₂S₂O₃ = ... mol

- (iii) Use the equation below to calculate the number of moles of iodine that reacted with the sodium thiosulfate in (ii).

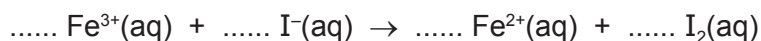


moles of I₂ = ... mol

- (iv) Calculate the concentration of I₂, in mol dm⁻³, in **FA 2**.

concentration of I₂ = ... mol dm⁻³

- (v) The iodine in **FA 2** was produced by the reaction of iron(III) ions with excess potassium iodide. Balance the equation for this reaction.



Use your answer to (iv) and this equation to calculate the number of moles of iron(III) ions that reacted to produce the iodine in 1.00 dm³ of **FA 2**.

moles of Fe³⁺ = ... mol

- (vi) The formula of the iron(III) compound is FeNH₄(SO₄)₂·xH₂O.
38.56 g of this compound was weighed out and added to excess aqueous acidified potassium iodide.
FA 2 was made by making the resulting solution of iodine up to 1.00 dm³ with distilled water.

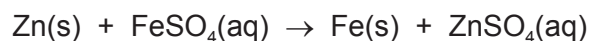
Use this information and your answer to (v) to calculate the number of moles of water of crystallisation, **x**, in one mole of the iron(III) compound.

[A_r: H, 1.0; N, 14.0; O, 16.0; S, 32.1; Fe, 55.8]

x = ...
[6]

[Total: 14]

- 2 In this experiment you will determine the enthalpy change, ΔH , for the reaction of zinc with iron(II) sulfate.



In order to do this, you will determine the enthalpy changes for the reactions of zinc and iron with aqueous copper(II) sulfate. Excess of the two metals will be used during the determinations.

Then you will use Hess' Law to calculate the enthalpy change for the reaction above.

FA 4 is zinc, Zn.

FA 5 is iron, Fe.

FA 6 is 0.500 mol dm⁻³ copper(II) sulfate, CuSO₄.

- (a) Determination of the enthalpy change for the reaction of zinc, **FA 4**, with aqueous copper(II) sulfate, **FA 6**.

Method

- Support a plastic cup inside the 250 cm³ beaker.
- Use the measuring cylinder to transfer 25 cm³ of **FA 6** into the plastic cup.
- Measure and record the initial temperature of the solution in the space below.
- Add all the **FA 4** from the container to the **FA 6** in the plastic cup.
- Stir constantly until the maximum temperature is reached.
- Measure and record the maximum temperature. Tilt the cup if necessary to ensure the thermometer bulb is fully immersed.
- Calculate and record the temperature rise.

- (c) Determination of the enthalpy change for the reaction of iron, FA 5, with aqueous copper(II) sulfate, FA 6.**

Method

- Support the second plastic cup inside the beaker.
- Use the measuring cylinder to transfer 25 cm^3 of **FA 6** into the plastic cup.
- Measure and record the initial temperature of the solution in the space below.
- Add all the **FA 5** from the container to the **FA 6** in the plastic cup.
- Stir constantly until the maximum temperature is reached.
- Measure and record the maximum temperature. Tilt the cup if necessary to ensure the thermometer bulb is fully immersed.
- Calculate and record the temperature rise.

Keep solution FA 6 for use in Question 3.

[2]

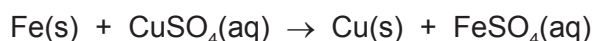
(d) Calculations

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

- (i) Calculate the energy produced during this reaction.
[Assume that **4.2 J** are needed to raise the temperature of 1.0 cm^3 of solution by 1.0°C .]

energy produced = ... J

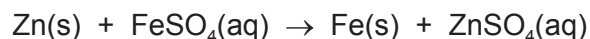
- (ii) Calculate the enthalpy change, in kJ mol^{-1} , for the reaction below.



enthalpy change = ... kJ mol⁻¹
sign value

[2]

- (e) Use your values for the enthalpy changes calculated in (b)(iii) and (d)(ii) to calculate the enthalpy change for the reaction below.



Show clearly how you obtained your answer by drawing a Hess' Law energy cycle.

(If you were unable to calculate the enthalpy changes, assume that the value in **(b)(iii)** is -210 kJ mol^{-1} and the value in **(d)(ii)** is -144 kJ mol^{-1} . Note: these are not the correct values.)

enthalpy change = ... kJ mol⁻¹
 sign *value*

[2]

- (f) (i)** Calculate the maximum percentage error in the temperature **rise** in **(c)**.

percentage error = ... %

- (ii) Apart from using a more accurately calibrated thermometer, suggest **one** improvement that could be made to this experiment that would increase the accuracy.

.....

.....

.....

[2]

[Total: 13]

3 Qualitative Analysis

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations.**

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

No additional tests for ions present should be attempted.

If any solution is warmed, a boiling tube MUST be used.

Rinse and reuse test-tubes and boiling tubes where possible.

Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.

(a) **FA 1**, used in **Question 1**, is an aqueous solution of sodium thiosulfate.

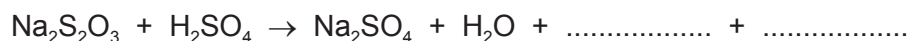
FA 6, used in **Question 2**, is an aqueous solution of copper(II) sulfate.

FA 7 is solid sodium thiosulfate.

Carry out the following tests and record your observations in the table below.

<i>test</i>	<i>observations</i>
(i) Using a spatula, place 2 or 3 crystals of FA 7 into a hard-glass test-tube. Heat gently for several seconds, then	
heat strongly.	
(ii) To a 1 cm depth of dilute sulfuric acid in a boiling tube, add a few crystals of FA 7 . Observe until no further change occurs, then	
warm the mixture, gently and carefully .	
(iii) To a 1 cm depth of aqueous potassium iodide in a test-tube, add a few drops of FA 6 , aqueous copper(II) sulfate, then	
add FA 1 , aqueous sodium thiosulfate, to the mixture until no further change occurs.	

(iv) Using your observations in (ii), complete the equation below by giving the formulae of the other two products.



[5]

(b) **FA 8** and **FA 9** are aqueous solutions.

Each contains **one** cation and **one** anion from those listed on pages 14 and 15.

Carry out the tests and record all your observations in the table.

For each test, use a 1 cm depth of **FA 8** or **FA 9** in a test-tube.

<i>test</i>	<i>observations</i>	
	FA 8	FA 9
(i) Add aqueous sodium hydroxide.		
(ii) Add a few drops of aqueous silver nitrate followed by aqueous ammonia.		
(iii) Add aqueous ammonia.		
(iv) Add an equal depth of dilute sulfuric acid.		
(v) Add an equal depth of FA 9 .		

(vi) Using your observations, identify **three** of the ions present in **FA 8** and **FA 9**.
Write 'unknown' next to the ion that you cannot identify directly from your observations.

ions in **FA 8**: cation anion

ions in **FA 9**: cation anion

(vii) The 'unknown' ion in (vi) can be identified by elimination, using the lists of ions on pages 14 and 15.

Choose **one** positive test that would confirm the identity of this ion. Name the reagent(s) you would use and state what you would observe if the test was positive.

Do not carry out this test.

'unknown' ion tested for

reagent(s)

observation(s)

[8]

[Total: 13]

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
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

2 Reactions of anions

<i>ion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$)
bromide, $\text{Br}^-(\text{aq})$	gives cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$)
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$)
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 $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)
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 acids)

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 manganate(VII) from purple to colourless

BLANK PAGE

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge International Examinations Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cie.org.uk after the live examination series.

Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.