



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

9701/31

Paper 31 Advanced Practical Skills

October/November 2009

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 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 are advised to show all working in calculations.
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	
Total	

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

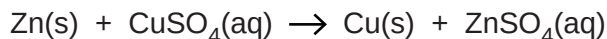


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1 You are provided with the following reagents.

- two weighing bottles labelled **FA 1**, each containing between 2.90 g and 3.00 g of zinc powder
- **FA 2**, 0.80 mol dm⁻³ copper sulfate, CuSO₄

You are to determine the enthalpy change, ΔH , for the following reaction.



You will carry out the experimental procedure twice.

Read through the instructions below before starting the experiment.

- (a) You will weigh each bottle and later in the experiment weigh it again after the zinc powder has been tipped into copper sulfate solution.
In the space below prepare a table to record the weighings and the mass of zinc powder used in **each** experiment.

Weigh accurately, to at least one decimal place, one of the weighing bottles labelled **FA 1**.

Record this mass in the table you have prepared. [1]

(b) Procedure

- Support the plastic cup in the 250 cm³ beaker and, using a pipette, place 25.0 cm³ of **FA 2** into the plastic cup.
- Stir gently, taking a temperature reading every ½ minute until a steady temperature has been obtained for a period of at least 2 minutes. You may need to tilt the beaker in order to cover the bulb of the thermometer with solution.
- On a precise minute reading tip the zinc powder from the weighing bottle into the plastic cup.
Do not read the temperature at this time or at the following ½ minute.
- Continue to stir the mixture thoroughly. Starting 1 minute after the addition of the zinc powder, record the temperature every ½ minute until the temperature has reached a maximum value and then decreased steadily for at least 5 minutes.
- Reweigh the empty weighing bottle. Record the mass of the bottle + any residual zinc powder and the mass of zinc powder used in the experiment in the table you prepared in (a).
- Record your results in an appropriate form in the space on the following page.

Repeat the experiment using the contents of the second weighing bottle and 25.0 cm³ copper sulfate solution pipetted into a clean plastic cup.

(b) continued

For
Examiner's
Use

Results Make certain your readings of temperature display the precision of the apparatus used.

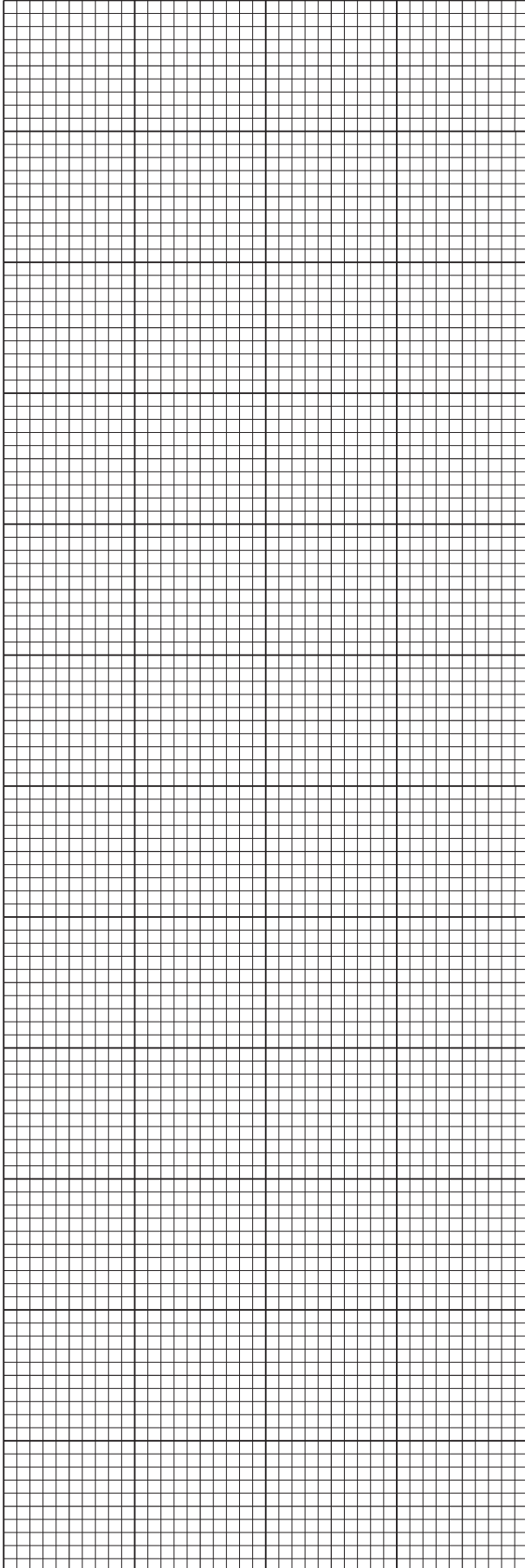
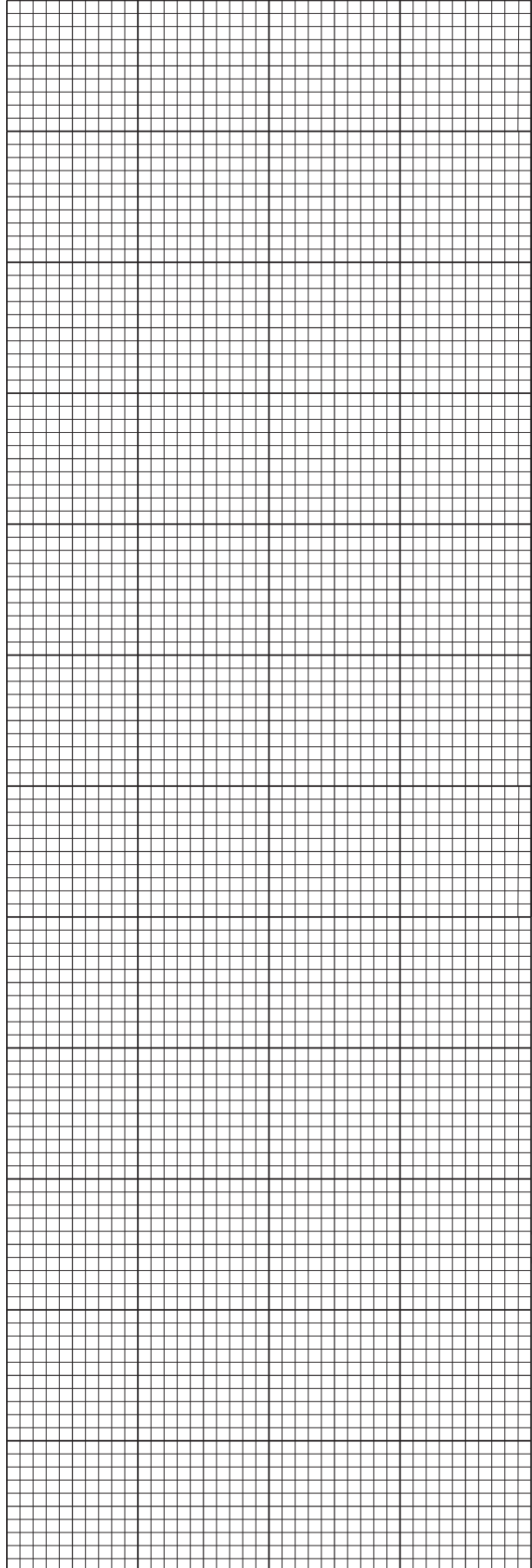
[11]

- (c)** Plot your temperature and time readings separately for each experiment on the grids on the next page. Your temperature axis should extend 10°C **above** the highest temperature you recorded.
Draw lines as instructed below.

On each graph draw a horizontal straight line through the steady initial temperature.

Extrapolate the cooling section of each graph back to the time when you added the zinc powder.

Draw construction lines on the graphs to deduce the “theoretical” **temperature rise** at the moment of mixing the reagents.

experiment 1**experiment 2**

For
Examiner's
Use

[4]

- (d) The “theoretical” **temperature rises** are °C and °C.

The mean “theoretical” **temperature rise** is °C. [1]

Calculations

Show working and appropriate significant figures in **all** of your calculations. [2]

- (e) Calculate how many moles of copper sulfate, CuSO_4 , were pipetted into the plastic cup.

..... mol of CuSO_4 were pipetted into the cup

For each experiment calculate how many moles of zinc powder were added to the plastic cup.

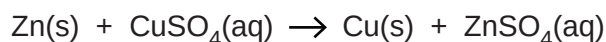
[A_r : Zn, 65.4]

1 st experiment	2 nd experiment

In the 1st experiment mol of zinc powder were added to the plastic cup.

In the 2nd experiment mol of zinc powder were added to the plastic cup. [1]

- (f) Use your answers to (e) and the equation for the reaction to determine which reagent was in excess and which was the limiting reagent. Explain your answer.



.....

 [1]

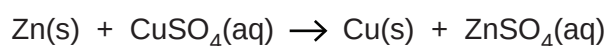
For
Examiner's
Use

- (g) From your mean “theoretical” temperature rise at the time of mixing, calculate the heat energy released in the plastic cup by the reaction of zinc powder with copper sulfate solution.

[You may assume that 4.3 J are required to raise the temperature of 1 cm³ of any solution by 1 °C and that the mass of any solid may be ignored.]

..... of heat energy are released. [1]

- (h) Calculate, correct to 3 significant figures, the enthalpy change in kJ mol⁻¹ for the following reaction.



$\Delta H =$ kJ mol⁻¹
[2]

- (i) Identify and explain **one** source of error in the experiment you have carried out.

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

- (j) Suggest a way in which the experimental method you used could be improved in a school or college laboratory in order to minimise this error.

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

[Total: 26]

- 2 The three boiling-tubes, labelled **FA 3**, **FA 4**, and **FA 5**, each contain a solid with one cation and one anion from those listed on pages 11 and 12.

For
Examiner's
Use

You will carry out specified tests to deduce the cations and anions present in **FA 3**, **FA 4** and **FA 5**.

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) Heat the boiling-tube containing **FA 5** gently at first then more strongly.
Record your observations in the space below.

[2]

- (b) In their boiling-tubes, dissolve **FA 3**, **FA 4** and the **cold** residue after heating **FA 5** in a minimum of dilute nitric acid and then add distilled water so that each boiling-tube is approximately $\frac{2}{3}$ full. Warm to dissolve if necessary.

Record your observations in the space below.

Use these solutions for tests **(d)**, **(e)** and **(f)**.

[1]

- (c) Which anion can be identified from your observations in (a) and (b)?
Explain your answer.

For
Examiner's
Use

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

- (d) The cations present in **FA 3**, **FA 4** and **FA 5** can be identified by reaction of each solution with aqueous sodium hydroxide and with aqueous ammonia.
React 1cm depth of each of the solutions prepared in (b) with each of these two reagents.

Record, in an appropriate form in the space below, your observations for these reactions.

i	
ii	
iii	
iv	
v	
vi	

Conclusions

Using your observations you should be able to identify the cation present in two of the solutions. For the remaining solution you should be able to identify two possible cations.

FA 3 contains the cation(s)

FA 4 contains the cation(s)

FA 5 contains the cation(s)

[6]

- (e) Use the information on pages 11 and 12 to select a reagent to distinguish between the two possible cations identified as present in one of the solutions in (d).

For
Examiner's
Use

Carry out the test with the selected reagent.

reagent

observation

conclusion

[2]

- (f) Carry out the following tests.

<i>test</i>	<i>observations</i>		
	FA 3	FA 4	FA 5
To 1 cm depth of solution in a test-tube, add 1 cm depth of aqueous barium nitrate, then			
add 2 cm depth of dilute nitric acid.			
To 1 cm depth of solution in a test-tube, add 1 cm depth of aqueous silver nitrate, then			
allow any precipitate formed to settle, pour off the solution and add aqueous ammonia to the precipitate.			

What conclusions can be made from the observations above?

.....

 [2]

[Total: 14]

Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

	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 pale cream ppt. with Ag^+ (aq) (partially soluble in NH_3 (aq)); gives white ppt. with Pb^{2+} (aq)
iodide, I^- (aq)	gives yellow ppt. with Ag^+ (aq) (insoluble in NH_3 (aq)); gives yellow ppt. with Pb^{2+} (aq)
nitrate, NO_3^- (aq)	NH_3 liberated on heating with OH^- (aq) and Al foil
nitrite, NO_2^- (aq)	NH_3 liberated on heating with OH^- (aq) and Al foil, NO liberated by dilute acids (colourless NO $\rightarrow$ (pale) brown NO_2 in air)
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) (aq) from orange to green

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General Certificate of Education Advanced Subsidiary Level and Advanced Level

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CHEMISTRY

9701/32

Paper 32 Advanced Practical Skills

October/November 2009

2 hours

Candidates answer on the Question Paper.

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Session
Laboratory

For Examiner's Use	
1	
2	
Total	

This document consists of **12** printed pages.



- 1 This question concerns the **solubility** of **FB 1**, potassium nitrate, in water.

For
Examiner's
Use

The **solubility** of a substance in water is defined as:
the mass of substance that will dissolve in and just saturate 100 g of water at a particular temperature.
When a solution is saturated the dissolved solid is in equilibrium with undissolved solid.
When a solution of potassium nitrate is cooled it becomes saturated when crystals form in the solution.

You are to investigate how the **solubility** of **FB 1** in water varies with temperature.

You are provided with the following materials.

weighing bottle, labelled **FB 1**, containing potassium nitrate
distilled water

Read through the instructions before starting any practical work.

Method

- Weigh an empty boiling-tube.
- Add the contents of the weighing bottle labelled **FB 1** to the weighed boiling-tube.
- Reweigh the boiling-tube and its contents.
- Record, in an appropriate form below, your weighings and the mass of **FB 1** used.

(a) Weighings

[2]

(b) Preparing a saturated solution

- Fill the burette with distilled water.
- Add 14.00 cm^3 of distilled water from the burette to the weighed boiling-tube containing **FB 1**.
- Use the clamp as a holder for the boiling-tube. Take care not to break the tube by clamping it too tightly.
- Warm the tube carefully, while stirring the contents with a thermometer, until all the solid has dissolved. (Take care that you do not break the thermometer bulb or the tube while stirring.)
- Keeping the tube in the clamp attach the clamp to a stand.
- Let the tube cool and continue to stir gently with the thermometer.
- Watch the solution carefully. Note and record (**on the next page**) the temperature at which you **first** notice crystals forming in the solution.
- If you are uncertain about the temperature when crystals first form, warm the tube again for a few moments and repeat the cooling.
- As soon as you have recorded the temperature add a further 2.00 cm^3 of distilled water to the tube from the burette.
- Warm to redissolve the solid and cool as before.
- Note and record (**on the next page**) the temperature at which crystals now form in the solution. This will be lower than the temperature obtained with 14.00 cm^3 of water.
- Repeat the addition of 2.00 cm^3 of distilled water, the heating and the cooling, until you have four readings in total.

(c) In an appropriate form in the space below, record the following.

- the total volume of distilled water in the boiling-tube
- the temperature at which crystals first appeared for each solution

Make certain that your results show the precision of your working.

For
Examiner's
Use

i	
ii	
iii	
iv	
v	
vi	
vii	
viii	

[8]

(d) For each solution, calculate the **solubility** (in grams of solid per 100g of water) using the following formula.

$$\text{solubility} = \frac{100}{\text{volume of water}} \times \text{mass of FB 1 dissolved}$$

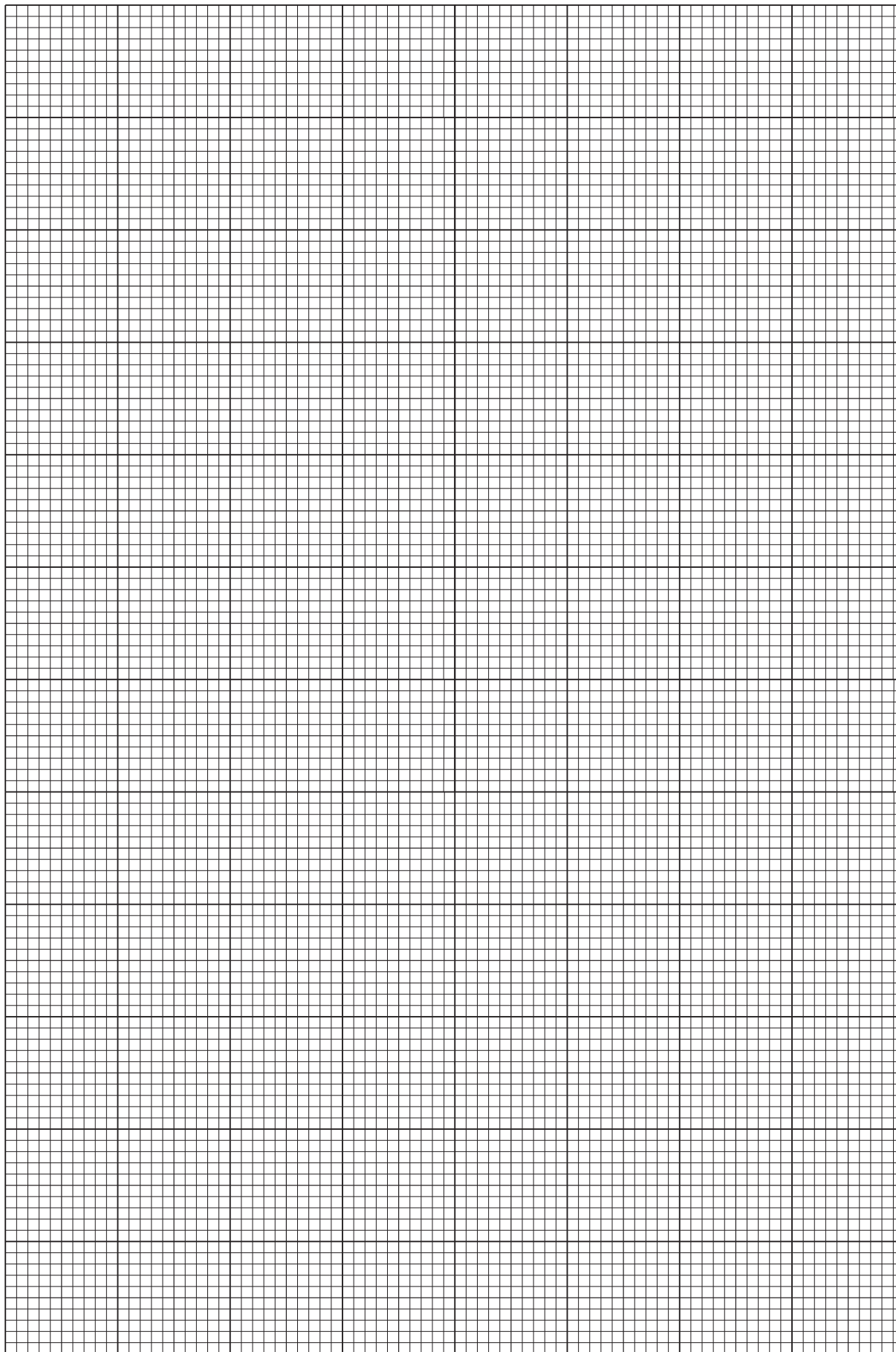
Complete the table below to show the **solubility** at different temperatures.
In all calculated values show appropriate significant figures.

solubility (in grams of solid per 100 g of water)	temperature / °C

[3]

- (e) Plot **solubility** against temperature and draw an appropriate line through the points plotted. Do **not** start at zero on either axis. You will need to be able to find the solubility of **FB1** at 42.5°C.

For
Examiner's
Use



From the graph plotted the **solubility** of **FB 1** in water at 42.5 °C is

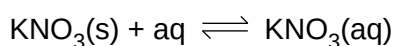
..... g of solid per 100 g of water.
[6]

For
Examiner's
Use

- (f) Describe how the **solubility** of **FB 1** changes with temperature.

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

- (g) Use your answer to (f) and your understanding of equilibrium systems to explain if dissolving **FB 1**, KNO_3 , under equilibrium conditions is exothermic or endothermic.



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

- (h) Suggest **two** possible sources of inaccuracy, other than poor experimental technique, in this experiment.

1
.....
.....
2
.....
.....

[2]

- (i) A solution of KNO_3 , saturated at 60°C , is prepared in a thermostatically controlled water bath.

For
Examiner's
Use

The **solubility** of KNO_3 at 60°C can be calculated if the mass of the solution and the mass of solid dissolved in the solution can be determined.

Suggest steps to enable you to find these masses.

You may not need all of these numbered steps.

1

2

3

4

5

6

7

Show how you would calculate the **solubility** of KNO_3 at 60°C from the mass of the solution and the mass of solid dissolved in the solution.

[2]

[Total: 26]

2 You are provided with three solids, **FB 2**, **FB 3**, and **FB 4**.

Each of the solids contains one cation from those on page 11 and a sulfite or sulfate anion.

You will carry out specified tests to identify the cations and anions present in **FB 2**, **FB 3** and **FB 4**. Use the data on pages 11 and 12.

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)** In separate boiling-tubes, dissolve half of each of the solids **FB 2**, **FB 3** and **FB 4** in a minimum volume of dilute hydrochloric acid.

Gently warm each of the boiling-tubes.

Add distilled water so that each boiling-tube is approximately $\frac{2}{3}$ full.

Record your observations in an appropriate form in the space below.

[2]

- (b)** The cations present in **FB 2**, **FB 3** and **FB 4** can be identified by reaction of each solution, with aqueous sodium hydroxide and with aqueous ammonia.

React 1cm depth of each of the solutions prepared in **(a)** with each of these two reagents.

Record, in an appropriate form, in the space below your observations for these reactions.

i	
ii	
iii	
iv	
v	

For
Examiner's
Use

Conclusions

Using your observations you should be able to identify the cation in two of the solutions. For the remaining solution you should be able to identify two possible cations.

FB 2 contains the cation(s)

FB 3 contains the cation(s)

FB 4 contains the cation(s) [5]

- (c) Use the information on pages 11 and 12 to select a reagent to distinguish between the two possible cations identified as present in one of the solutions in (b).

.....

Carry out the test with the selected reagent.

observation

conclusion [1]

- (d) In separate boiling-tubes shake the remaining half of each solid with 3 cm depth of distilled water.

If any solid does not readily dissolve in water filter the mixture and retain the solution formed.

You will need to keep some of the **FB 2** solution for test (f).

Carry out the following tests.

test	observations		
	FB 2	FB 3	FB 4
To 1 cm depth of the solution in a test-tube, add 1 cm depth of aqueous barium chloride,			
then,			
add 2 cm depth of dilute hydrochloric acid.			

Draw appropriate conclusions as to the identity of the anion in each solution.

FB 2 contains the anion

FB 3 contains the anion

FB 4 contains the anion [3]

- (e) Explain why aqueous barium chloride must be added before hydrochloric acid when distinguishing between a sulfite and a sulfate.

.....

.....

.....

..... [1]

- (f) Carry out the following test with the solution of **FB 2** prepared in (d).

<i>test</i>	<i>observation</i>
To 1 cm depth of the solution of FB 2 in a test-tube add 1 cm depth of aqueous potassium iodide,	
then	
add a few drops of starch solution.	

What is the nature of the reaction taking place between **FB 2** and potassium iodide?

.....

.....

..... [2]

[Total: 14]

Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

	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

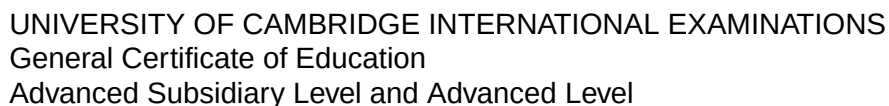
<i>ion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chromate(VI), CrO_4^{2-} (aq)	yellow solution turns orange with H^+ (aq); gives yellow ppt. with Ba^{2+} (aq); gives bright yellow ppt. with Pb^{2+} (aq)
chloride, Cl^- (aq)	gives white ppt. with Ag^+ (aq) (soluble in NH_3 (aq)); gives white ppt. with Pb^{2+} (aq)
bromide, Br^- (aq)	gives pale cream ppt. with Ag^+ (aq) (partially soluble in NH_3 (aq)); gives white ppt. with Pb^{2+} (aq)
iodide, I^- (aq)	gives yellow ppt. with Ag^+ (aq) (insoluble in NH_3 (aq)); gives yellow ppt. with Pb^{2+} (aq)
nitrate, NO_3^- (aq)	NH_3 liberated on heating with OH^- (aq) and Al foil
nitrite, NO_2^- (aq)	NH_3 liberated on heating with OH^- (aq) and Al foil, NO liberated by dilute acids (colourless NO $\rightarrow$ (pale) brown NO_2 in air)
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) (aq) from orange to green

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9701/33

October/November 2009

2 hours

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1	
2	
3	
Total	

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

BLANK PAGE

1 Read through question 1 before starting any practical work.For
Examiner's
Use

You are provided with the following reagents.

- **FA 1**, hydrated iron(II) sulfate
- **FA 2**, aqueous iron(II) sulfate
- **FA 3**, aqueous potassium manganate(VII)
- **FA 4**, sulfuric acid

The formula of hydrated iron(II) sulfate is $\text{FeSO}_4 \cdot x\text{H}_2\text{O}$ where **x** shows the number of molecules of water of crystallisation present.

The value of **x** can be found by two different methods.

Method 1 involves heating to drive off water of crystallisation while **Method 2** uses a titration to determine the concentration of $\text{Fe}^{2+}(\text{aq})$.

(a) Method 1

- Weigh a crucible and record the mass.
- Add between 1.80 g and 2.00 g of **FA 1** and record the new mass.
- Place the crucible containing **FA 1** on a pipe clay triangle and heat gently for about four minutes with a Bunsen burner.
- Allow the crucible to cool. You should continue with **Method 2** while the crucible is cooling.
- Weigh the crucible and its contents.

Record all masses in the space below.

[3]

- (b)** Calculate the mass of water lost and the mass of iron(II) sulfate that remained after heating.

mass of water lost = ... g

mass of iron(II) sulfate remaining = ... g

[1]

- (c) Use your answer to (b) to calculate how many moles of water were lost and the moles of iron(II) sulfate, FeSO_4 , remaining after heating.

Show all of your working.

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

For
Examiner's
Use

The hydrated iron(II) sulfate contained mol of water

and mol of FeSO_4 . [2]

- (d) Use your answer to (c) to determine the value of x in the formula of hydrated iron(II) sulfate, $\text{FeSO}_4 \cdot x\text{H}_2\text{O}$.

$x =$ [2]

(e) Method 2

- Fill the burette with **FA 3**, aqueous potassium manganate(VII).
- Pipette 25.0 cm^3 of **FA 2** into a conical flask and use a measuring cylinder to add approximately 20 cm^3 of **FA 4**.
- Titrate this solution with **FA 3** from the burette until the first permanent pink colour remains in the solution.
- Perform sufficient further titrations to obtain accurate results.
- Record your titration results in the space below. Make certain that your recorded results show the precision of your working.

i	
ii	
iii	
iv	
v	
vi	
vii	
viii	
ix	
x	
xi	

Summary

25.0 cm^3 of **FA 2** reacted with cm^3 of **FA 3**.

Show which results you used to obtain the value of the volume of **FA 3** by placing a tick (✓) under the readings used in your results. [11]

- (f) All experimental methods contain errors, some of which are concerned with uncertainty of measurements.

Complete the table below to show the uncertainties in measuring the volume of potassium manganate(VII) used in **Method 2**.

maximum uncertainty in a single reading with a burette	$\pm \dots\dots\dots \text{cm}^3$
volume of potassium manganate(VII), FA 3 , from the summary in (e)	$\dots\dots\dots \text{cm}^3$
maximum percentage error in the volume of potassium manganate(VII) used	$\dots\dots\dots \%$

[2]

- (g) **Method 1** is usually less accurate than **Method 2** for finding the value of x in the formula of hydrated iron(II) sulfate, $\text{FeSO}_4 \cdot x\text{H}_2\text{O}$.

A group of students carried out **Method 1** correctly but calculated a value of 9 for x . The true value for x is 7.

Suggest an error in the practical procedure of the experiment that could account for this difference.

.....
 [1]

- (h) Suggest a modification that could be made to the practical procedure in **Method 1** to reduce this error.

Explain why this modification should give an answer nearer to 7.

modification

 explanation
 [2]

[Total: 24]

BEFORE STARTING QUESTION 2, heat a half-full 250cm^3 beaker of water for use as a hot water-bath in question 3.

2 The four solutions **FA 5**, **FA 6**, **FA 7** and **FA 8** each contain one of the following anions.

- chloride, Cl^-
- iodide, I^-
- nitrate, NO_3^-
- nitrite, NO_2^-

For
Examiner's
Use

Use information from the Qualitative Analysis Notes on page 11 to answer the following questions.

(a) Which single reagent could you use to identify the solution containing the nitrite ion?

.....

Which single reagent could you use to identify the solutions containing the chloride and the iodide ion?

..... [1]

(b) Use the reagents selected in (a) to test each of the solutions.

Rinse and reuse test-tubes where possible.

Record in an appropriate form in the space below, the reagents used and the observations made.

i	
ii	
iii	
iv	
v	
vi	
vii	

From your observations identify the solutions containing chloride, iodide and nitrite ions. In each case give evidence to support your answer.

solution contains the chloride ion.

supporting evidence

solution contains the iodide ion.

supporting evidence

solution contains the nitrite ion.

supporting evidence [7]

(c) Do not carry out this test.

State another test that you could use to confirm the presence of chloride and iodide ions.

.....

.....[1]

[Total: 9]

For
Examiner's
Use

- 3 (a) You are to carry out the tests given in the table below on solutions **FA 9** and **FA 10**. You should record details of colour changes seen and the formation of any precipitate.

For
Examiner's
Use

No additional tests should be attempted.

Reheat your water bath until the water boils. Turn off the Bunsen burner.

	<i>test</i>	<i>observations</i>
(i)	To 1 cm depth of FA 9 in a test-tube, add 1 cm depth of dilute hydrochloric acid.	
(ii)	To 1 cm depth of FA 9 in a test-tube, add 1 cm depth of dilute sulfuric acid.	
(iii)	To 1 cm depth of FA 10 in a boiling-tube, add dilute sulfuric acid until no further change occurs. Use this solution for test (iv).	
(iv)	To the solution left after test (iii) add 1 cm depth of ethanol. Place the mixture in your hot water bath and leave for approximately 3 minutes.	
(v)	To 1 cm depth of FA 9 in a test-tube add 1 cm depth of FA 10 .	

[4]

- (b) From your observations in (a) identify the cation present in **FA 9**. Give evidence to support your answer.

Solution **FA 9** contains the ion.

supporting evidence

.....[2]

- (c) What chemical change, involving ethanol, takes place in reaction (iv)? Give evidence to support your answer.

chemical change

supporting evidence

.....[1]

[Total: 7]

Qualitative Analysis Notes

Key: [ppt. = precipitate.]

1 Reactions of aqueous cations

	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 soln 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 $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acid); gives white ppt. with $\text{Pb}^{2+}(\text{aq})$
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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CHEMISTRY

9701/34

Paper 34 Advanced Practical Skills

October/November 2009

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 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 are advised to show all working in calculations.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 9 and 10.

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 **9** printed pages and **3** blank pages.



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1 Read through question 1 before starting any practical work.For
Examiner's
Use

You are provided with the following reagents.

- **FB 1**, hydrated copper(II) sulfate
- **FB 2**, aqueous copper(II) sulfate
- **FB 3**, aqueous sodium thiosulfate
- **FB 4**, aqueous potassium iodide
- **FB 5**, starch indicator solution

The formula of hydrated copper(II) sulfate is $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$ where **x** shows the number of molecules of water of crystallisation present.

The value of **x** can be found by two different methods.

Method 1 involves heating to drive off water of crystallisation while **Method 2** uses a titration to determine the concentration of $\text{Cu}^{2+}(\text{aq})$.

(a) Method 1

- Weigh a crucible and record the mass.
- Add between 2.50g and 2.70g of **FB 1** and record the new mass.
- Place the crucible containing **FB 1** on a pipe clay triangle and heat gently for about four minutes with a Bunsen burner.
- Allow the crucible to cool. You should continue with **Method 2** while the crucible is cooling.
- Weigh the crucible and its contents.

Record all masses in the space below.

[3]

- (b)** Calculate the mass of water lost and the mass of copper(II) sulfate that remained after heating.

mass of water lost = ... g

mass of copper(II) sulfate remaining = ... g

[1]

- (c) Use your answer to (b) to calculate how many moles of water were lost and the moles of copper(II) sulfate, CuSO_4 , remaining after heating.

Show all of your working.

[A_r : Cu, 63.5; H, 1.0; O, 16.0; S, 32.1]

For
Examiner's
Use

The hydrated copper(II) sulfate contained mol of water

and mol of CuSO_4 . [2]

- (d) Use your answer to (c) to determine the value of x in the formula of hydrated copper(II) sulfate, $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$.

$x = \dots\dots\dots$ [2]

(e) Method 2

- Fill the burette with **FB 3**, aqueous sodium thiosulfate.
- Pipette 25.0 cm^3 of **FB 2** into a conical flask and use a measuring cylinder to add 10 cm^3 of **FB 4**.
- Titrate this solution with **FB 3** from the burette until the mixture becomes yellow-brown. Do **not** add too much **FB 3** at this stage.
- An off-white precipitate is also present in the flask and this will mask the colour of the solution.
- Add approximately 1 cm^3 of **FB 5**. The solution will become blue-black as a starch iodine complex is formed.
- Continue the titration until the blue-black colour of the complex just disappears leaving the off-white precipitate.
- Perform sufficient further titrations to obtain accurate results.
- Record your titration results in the space below. Make certain that your recorded results show the precision of your working.

i	
ii	
iii	
iv	
v	
vi	
vii	
viii	
ix	
x	
xi	

Summary

25.0 cm^3 of **FB 2** reacted with cm^3 of **FB 3**.

Show which results you used to obtain the value of the volume of **FB 3** by placing a tick (✓) under the readings used in your results. [11]

- (f) (i) In **Method 1** a student was advised to carry out all weighings using the same balance. What type of error might be introduced if more than one balance was used?

.....
[1]

- (ii) In **Method 2**, 10 cm^3 of **FB 4** was added during the titration process. Assume that the measuring cylinder used could be read to $\pm 0.5\text{ cm}^3$. Calculate the percentage error in the measurement of this volume.

..... % error [1]

- (g) **Method 1** is usually less accurate than **Method 2** for finding the value of x in the formula of hydrated copper(II) sulfate, $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$.

A group of students carried out **Method 1** correctly but calculated a value of 4 for x . The true value for x is 5.

Suggest an error in the practical procedure of the experiment that could account for this difference.

.....
 [1]

- (h) Suggest a modification that could be made to the practical procedure in **Method 1** to reduce this error.

Explain why this modification should give an answer nearer to 5.

modification

.....

explanation

..... [2]

[Total: 24]

- 2 In this question you should use information from the Qualitative Analysis Notes on pages 9 and 10.

For
Examiner's
Use

- (a) Solutions **FB 6**, **FB 7** and **FB 8** are known to be either chlorides or sulfates of aluminium, magnesium or calcium. The addition of aqueous sodium hydroxide and aqueous ammonia can be used to give information about the cation present. Add NaOH(aq) and NH₃(aq) separately to each of the solutions **FB 6**, **FB 7** and **FB 8**.

Rinse and reuse test-tubes where possible.

Record both the tests and your observations in an appropriate form in the space below.

i	
ii	
iii	
iv	
v	
vi	
vii	

From your observations identify the solutions containing aluminium, magnesium and calcium ions. In each case give evidence to support your answer.

Solution contains the aluminium ion.

supporting evidence

Solution contains the magnesium ion.

supporting evidence

Solution contains the calcium ion.

supporting evidence [7]

- (b) Choose a pair of reagents that, used together, would identify which solution or solutions contain(s) the sulfate ion.

For
Examiner's
Use

Carry out the tests and record, in the space below, the reagents used and the observations made.

The sulfate ion is present in [2]

[Total: 9]

- 3 (a) You are to carry out the tests given in the table below on solid **FB 9**.

Record details of any gases that are released in the reactions. These gases should be identified by a test, **described in the appropriate part of the table**.

No additional tests should be attempted.

For
Examiner's
Use

	<i>test</i>	<i>observations</i>
(i)	Place a spatula measure of FB 9 in the small hard-glass test-tube labelled FB 9 and heat the solid strongly.	
(ii)	To 1 cm depth of aqueous sodium hydroxide in a boiling-tube, add 1 spatula measure of FB 9 , then	
	gently heat the mixture, do not boil Care is needed when heating aqueous sodium hydroxide.	
(iii)	To 1 cm depth of aqueous sodium hydroxide in a boiling-tube, add 1 spatula measure of FB 9 and a piece of aluminium foil, then	
	gently heat the mixture. Care is needed when heating aqueous sodium hydroxide.	

[4]

- (b) What elements **must** be present in **FB 9** to give the results you have obtained in test (i) and test (iii)?

..... [1]

- (c) What is the function of the aluminium foil in test (iii)?

..... [1]

- (d) **Do not carry out this test**

What would you expect to see if 1 cm depth of dilute hydrochloric acid was added to a spatula measure of **FB 9**?

.....

..... [1]

[Total: 7]

Qualitative Analysis Notes

Key: [ppt. = precipitate.]

1 Reactions of aqueous cations

	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 soln 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 $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acid); gives white ppt. with $\text{Pb}^{2+}(\text{aq})$
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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