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9701/31

May/June 2011

2 hours

Additional Materials: As listed in the Instructions to Supervisors

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.

You may lose marks if you do not show your working or if you do not use appropriate units.

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

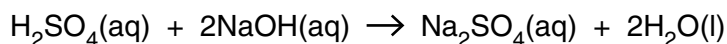
For Examiner's Use	
1	
2	
3	
Total	

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

- 1 **FA 1** is sulfuric acid, H_2SO_4 , of approximate concentration 0.7 mol dm^{-3} .
FA 2 is $0.150 \text{ mol dm}^{-3}$ sodium hydroxide.
 You are also provided with phenolphthalein (indicator).

For
Examiner's
Use

You will determine the exact concentration of **FA 1** by titration.



(a) Method

Dilution

- Pipette 25.0 cm^3 of **FA 1** into the 250 cm^3 graduated (volumetric) flask labelled **FA 3**.
- Make the solution up to the mark using distilled water.
- Shake the flask to mix the solution of **FA 3**.

Titration

- Rinse out the pipette with distilled water and then with **FA 3**.
- Pipette 25.0 cm^3 of **FA 3** into a conical flask.
- Add 5 drops of phenolphthalein indicator to the flask. The indicator should remain colourless.
- Fill the burette with **FA 2**.
- Titrate **FA 3** with **FA 2**, until a permanent pale pink colour is obtained.

You should perform a **rough titration**.

In the space below record your burette readings for this rough titration.

The rough titre is cm^3 .

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

I	
II	
III	
IV	
V	
VI	
VII	

[7]

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

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

(c) Calculations

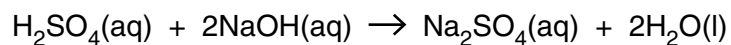
Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

For
Examiner's
Use

- (i) Calculate how many moles of NaOH were present in the volume of **FA 2** calculated in (b).

..... mol of NaOH

- (ii) Calculate how many moles of H_2SO_4 were present in 25.0 cm^3 of **FA 3**.



..... mol of H_2SO_4

- (iii) Calculate how many moles of H_2SO_4 were present in 25.0 cm^3 of the undiluted solution **FA 1**.

..... mol of H_2SO_4

- (iv) Calculate the concentration, in mol dm^{-3} , of H_2SO_4 in **FA 1**.

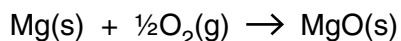
The concentration of H_2SO_4 in **FA 1** was mol dm^{-3} . [4]

[Total: 12]

I	
II	
III	
IV	

- 2 You will determine, using Hess' Law, the enthalpy change, ΔH_1 , for the reaction of magnesium with oxygen to form magnesium oxide.

For
Examiner's
Use



(a) Reaction of magnesium with sulfuric acid

Method

FA 4 is 0.64 mol dm^{-3} sulfuric acid.

FA 5 is magnesium turnings. This is supplied in two containers.

You will carry out the experiment **twice**.

- Support the plastic cup in a 250 cm^3 beaker.
- Using a measuring cylinder, transfer 25 cm^3 of **FA 4** into the plastic cup.
- Tilt the beaker so that the bulb of the thermometer is covered by the solution. Measure and record the initial temperature of the solution.
- **Carefully**, add all the **FA 5** from one of the containers into the plastic cup.
- Stir the mixture constantly with the thermometer.
- Record the highest temperature obtained.
- Empty and rinse the plastic cup and dry it with a paper towel.
- Repeat the experiment using the second portion of **FA 5**.

In the space below, record all your readings in an appropriate form.
Calculate the mean temperature rise.

I	
II	
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mean temperature rise = ... °C [5]

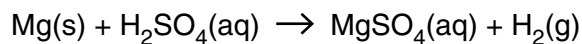
Calculation

Show your working and express your answers to **three** significant figures.

- (i) Using the mean temperature rise above, calculate the mean heat energy produced in the reaction.
(You may assume that 4.3 J are required to raise the temperature of 1.0 cm^3 of any solution by 1.0°C .)

heat energy produced = ...
value unit

(ii) Calculate the enthalpy change, ΔH_2 , in kJ mol^{-1} , for the following reaction.



You should assume that the magnesium in your reaction is in excess.

For
Examiner's
Use

$$\Delta H_2 = \underset{\text{sign}}{\dots\dots\dots} \underset{\text{value}}{\dots\dots\dots} \text{kJ mol}^{-1} \quad [2]$$

(b) Reaction of magnesium oxide with sulfuric acid

Method

FA 4 is 0.64 mol dm^{-3} sulfuric acid.

FA 6 is magnesium oxide.

- Using a measuring cylinder, transfer 50 cm^3 of **FA 4** into a 250 cm^3 beaker.
- Place the beaker on a tripod and gauze, and heat gently until the temperature of the acid reaches 45°C – 60°C .
- Support a plastic cup in a 250 cm^3 beaker.
- Transfer all the solution of hot **FA 4** into the plastic cup.
- Stir and record the temperature of hot **FA 4**.
- **Immediately** add all the **FA 6** to the **FA 4** in the plastic cup.
- Stir the mixture constantly with the thermometer.
- Record the highest temperature obtained.

In the space below, record all your readings in an appropriate form.

[3]

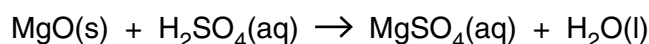
CalculationFor
Examiner's
Use

Show your working and express your answers to **three** significant figures.

- (i) Calculate the heat energy produced in the reaction.
(You may assume that 4.3 J are required to raise the temperature of 1.0 cm³ of any solution by 1.0 °C.)

heat energy produced = ...
value unit

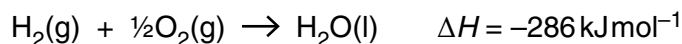
- (ii) Calculate the enthalpy change, ΔH_3 , in kJ mol⁻¹, for the following reaction.



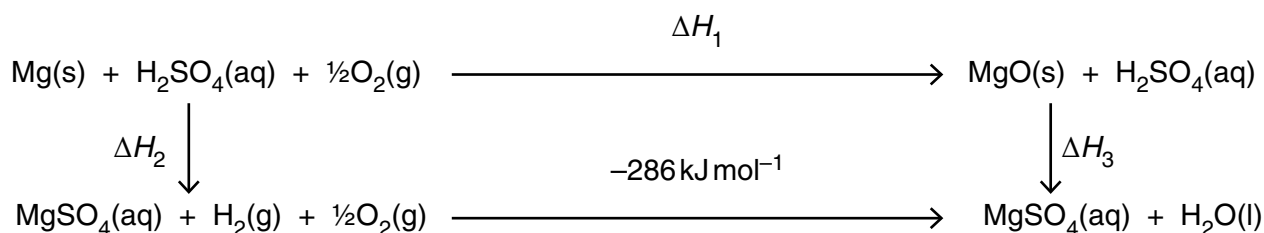
You should assume that the magnesium oxide in your reaction is in excess.

$\Delta H_3 = \dots\dots\dots$ kJ mol⁻¹
sign value

- (iii) The enthalpy change for the following reaction is -286 kJ mol⁻¹.



Use the Hess' Law cycle given below to calculate ΔH_1 , the enthalpy change for the reaction of magnesium with oxygen.



$\Delta H_1 = \dots\dots\dots$ kJ mol⁻¹ [3]
sign value

- (c) Suggest **one** improvement to the method by which heat losses from your apparatus could have been reduced.

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

[Total: 14]

3 Qualitative Analysis

For
Examiner's
Use

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

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

When 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 should be attempted.

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

Rinse and re-use test-tubes and boiling tubes where possible.

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

- (a) **FA 7** contains one cation and one anion from those listed in the Qualitative Analysis Notes on pages 10 and 11.

Put two spatula measures of **FA 7** into a test-tube.

Add about two-thirds of a test-tube of distilled water and dissolve the solid.

For each test that you carry out, use 1 cm depth of the solution of **FA 7**.

- (i) Carry out the following tests and complete the table below.

<i>test</i>	<i>observation(s)</i>
Add 5 drops of aqueous barium chloride (or barium nitrate) to your solution of FA 7 .	
Add 5 drops of aqueous silver nitrate to your solution of FA 7 .	

I	
II	
III	

- (ii) Put a **very small** spatula measure of solid **FA 7** into a hard glass test-tube. Hold the test-tube horizontally and heat it gently for a few seconds, then heat it strongly until no further change takes place. Leave the test-tube to cool to room temperature. *While cooling takes place, move on to (iv).* In the space below record the observations made at each stage in an appropriate form.

- (iii) State what deductions you can make about the identity of the anion in **FA 7** from the tests above.

.....

- (iv) Use the information in the Qualitative Analysis Notes on pages 10 and 11 to select a further test to confirm the identity of the anion in **FA 7**.

test

Carry out **this test** and, in the space below, record the observation(s) made in an appropriate form. State your conclusion.

IV	
V	
VI	
VII	
VIII	
IX	

- (v) The cation in **FA 7** is aluminium ion, calcium ion or zinc ion. Select **one reagent** to identify the cation in **FA 7**.

reagent

Use this reagent to carry out a test.
 Record the observation(s) made and identify the cation.

.....

 [9]

- (b) **FA 8** contains one cation from those listed on page 10 and 11.

Put all of the **FA 8** into a test-tube.

Half fill the test-tube with distilled water and dissolve the solid.

- (i) To 1 cm depth of the solution of **FA 8** in a test-tube, add aqueous potassium iodide until the test-tube is half full. Allow the mixture to stand for two minutes.

Use a dropping pipette to transfer about 1 cm³ of the mixture from the top of the test-tube to another test-tube. Add 5 drops of starch solution.

Record all of your observations.

- (ii) State what **type** of chemical behaviour has been shown by potassium iodide in this reaction. Give an ionic equation to justify your answer.

.....

- (iii) To another 1 cm depth of solution of **FA 8** in a test-tube, add aqueous sodium hydroxide.

Record the observation(s) made.

Give the **ionic** equation for the reaction taking place.

.....

 [5]

[Total: 14]

For
Examiner's
Use

I	
II	
III	
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Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

ion	reaction with	
	NaOH(aq)	NH ₃ (aq)
aluminium, Al ³⁺ (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH ₄ ⁺ (aq)	no ppt. ammonia produced on heating	–
barium, Ba ²⁺ (aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca ²⁺ (aq)	white ppt. with high [Ca ²⁺ (aq)]	no ppt.
chromium(III), Cr ³⁺ (aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu ²⁺ (aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe ²⁺ (aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe ³⁺ (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
lead(II), Pb ²⁺ (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
magnesium, Mg ²⁺ (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn ²⁺ (aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn ²⁺ (aq)	white ppt. soluble in excess	white ppt. soluble in excess

[Lead(II) ions can be distinguished from aluminium ions by the insolubility of lead(II) chloride.]

2 Reactions of anions

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

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CANDIDATE
NUMBER

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CHEMISTRY

Advanced Practical Skills

9701/32

May/June 2011

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Instructions to Supervisors

READ THESE INSTRUCTIONS FIRST

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

Answer **all** questions.

You may lose marks if you do not show your working or if you do not use appropriate units.

Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 11 and 12.

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

Session

Laboratory

For Examiner's Use

1

2

3

Total

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



- 1 Many solid salts exist as hydrates. One example is washing soda – hydrated sodium carbonate, $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$.

For
Examiner's
Use

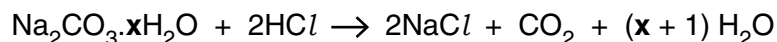
You are to determine the value of x in $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$ by titration with hydrochloric acid.

FB 1 is hydrated sodium carbonate, $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$.

FB 2 is $0.200 \text{ mol dm}^{-3}$ hydrochloric acid, HCl .

methyl orange indicator

The equation for the reaction between hydrated sodium carbonate and hydrochloric acid is shown below.



(a) Method

- Weigh the tube containing **FB 1**, the hydrated sodium carbonate. Record the mass in the space below.
- Add all the **FB 1** into a 250 cm^3 glass beaker. Reweigh the tube containing any residual **FB 1**. Record the mass in the space below.
- Calculate and record the mass of **FB 1** used.

mass of **FB 1** used = ... g

- Use the 50 cm^3 measuring cylinder to add, in total, about 100 cm^3 of distilled water to the beaker.
- Stir with a glass rod until all the solid has dissolved.
- Pour the solution from the beaker into the 250 cm^3 graduated (volumetric) flask.
- Wash out the beaker thoroughly with distilled water and add the washings to the graduated flask.
- Make up the contents of the graduated flask to the 250 cm^3 mark with distilled water.
- Shake the flask to mix the solution of **FB 1**.
- Pipette 25.0 cm^3 of your solution of **FB 1** into a conical flask.
- Add to the flask a few drops of methyl orange indicator and place the flask on a white tile.
- Fill the burette with hydrochloric acid, **FB 2**.
- Titrate the solution of **FB 1** with the acid until the end-point is reached.

You should perform a **rough titration**.

In the space below record your burette readings for this rough titration.

For
Examiner's
Use

The rough titre is cm^3 .

- 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 an appropriate form below, all your burette readings and the volume of **FB 2** added in each accurate titration.

I	
II	
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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]

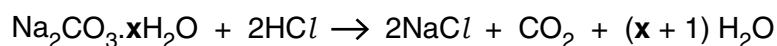
(c) CalculationsFor
Examiner's
Use

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

- (i) Calculate how many moles of HCl were present in the volume of **FB 2** calculated in (b).

..... mol of HCl

- (ii) Calculate how many moles of $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$ were present in 25.0cm^3 of the solution of **FB 1**.



..... mol of $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$

- (iii) Calculate how many moles of $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$ were present in 250cm^3 of the solution of **FB 1**.

..... mol of $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$

- (iv) Use the mass of **FB 1** that you weighed out to calculate the relative formula mass of $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$.

relative formula mass = ...

I	
II	
III	
IV	
V	
VI	

- (v) Calculate the value of **x** in $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$.
[A_r : H, 1.0; C, 12.0; O, 16.0; Na, 23.0]

For
Examiner's
Use

x = ... [6]

- (d) The error in a single burette reading is $\pm 0.05\text{cm}^3$.

What is the percentage error in the titre volume calculated in (b)?

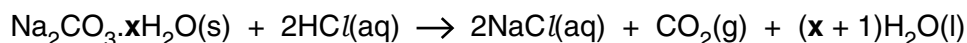
percentage error = ... % [1]

[Total: 15]

- 2 You are to determine the enthalpy change for the reaction of hydrated sodium carbonate, $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$, with hydrochloric acid, $\text{HCl}(\text{aq})$.

For
Examiner's
Use

The equation for this reaction is shown below.



FB 3 is hydrated sodium carbonate, $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$.

FB 4 is 4.00 mol dm^{-3} hydrochloric acid, HCl .

Make sure that in this experiment you use the hydrochloric acid labelled FA 4.

(a) Method

- Support the plastic cup in a 250 cm^3 beaker.
- Use a measuring cylinder to transfer 25 cm^3 of **FB 4** into the plastic cup.
- Tilt the beaker so that the bulb of the thermometer is covered by the solution.
- Measure and record the temperature of the solution.
- Measure and record the mass of the tube containing **FB 3**.
- **Carefully** tip all the hydrated sodium carbonate from the weighed tube into the plastic cup.
- **There will be effervescence. Add the solid in small portions with constant stirring using the thermometer.**
- Record the lowest temperature obtained.
- Reweigh the tube containing any residual **FB 3**.

In the space below, record, in an appropriate form,

- both balance readings,
- both temperature measurements,
- the mass of **FB 3** used in the experiment,
- the fall in temperature.

[5]

I	
II	
III	
IV	
V	

(b) Calculation

Show your working and express your answers to **three** significant figures.

- (i) Calculate the heat energy change involved in the reaction.
(You may assume that 4.3 J are required to change the temperature of 1.0 cm^3 of any solution by 1.0°C .)

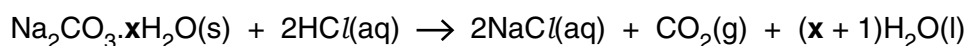
heat energy produced = ... J

- (ii) Calculate the number of moles of $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$ you used in **2(a)**.
 You will need to use the relative formula mass you calculated in **1(c)(v)**.
 If you were unable to calculate the relative formula mass in **1(c)**, assume it is 259
 but note that this is **not** the correct value.

For
Examiner's
Use

..... mol of $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$

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



I	
II	
III	
IV	

enthalpy change = ... kJ mol^{-1}

sign *value*

[4]

- (c) In experiments carried out to determine enthalpy changes, heat transfer between the surroundings and the reactants is a significant source of error. This problem can be limited by improved insulation.

Apart from modifications made to minimise heat transfer, suggest **one** possible improvement you could make to the apparatus or procedure to make the determination of the enthalpy change more accurate.

.....

.....

..... [1]

[Total: 10]

3 Qualitative Analysis

For
Examiner's
Use

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

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

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

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

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

No additional tests for ions present should be attempted.

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

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

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

- (a) (i) You are provided with three solutions **FB 5**, **FB 6** and **FB 7**, each of which contains a single cation. One of these cations is aluminium, one is magnesium and the other is lead.

Use the information in the Qualitative Analysis Notes on page 11 to select reagents that would enable you to determine the cation in **FB 5**, **FB 6** and **FB 7**.

reagents

Carry out suitable tests and record the results of your experiments in an appropriate form in the space below.

[4]

I	
II	
III	
IV	

(ii) Complete the table below.

	FB 5	FB 6	FB 7
<i>cation</i>			

What is the **minimum** evidence from your observations, that enables you to identify these cations?

The minimum evidence for the cation in **FB 5** is

.....

The minimum evidence for the cation in **FB 6** is

.....

The minimum evidence for the cation in **FB 7** is

.....

[4]

I	
II	
III	
IV	

Carry out the tests and complete the following table.

<i>test</i>	<i>observations</i>
(i) To a spatula measure of FB 8, in a test-tube, add about a 1 cm depth of distilled water to make a solution. To this solution add 4 pieces of magnesium ribbon.	
(ii) To a small spatula measure of FB 8, in a boiling tube, add 3 cm depth of aqueous sodium hydroxide. Warm gently and carefully.	
(iii) To a spatula measure of FB 8, in a test-tube, add about a 1 cm depth of distilled water to make a solution. To this solution add an equal volume of aqueous sodium hydroxide. To this mixture add a small volume of hydrogen peroxide.	

I	
II	
III	
IV	
V	
VI	
VII	

metal ion = ...

oxidation number (state) changes from to

oxidation number (state) changes from to

[7]

[Total: 15]

Qualitative Analysis Notes

Key: [ppt. = precipitate.]

1 Reactions of aqueous cations

ion	reaction with	
	NaOH(aq)	NH ₃ (aq)
aluminium, Al ³⁺ (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH ₄ ⁺ (aq)	no ppt. ammonia produced on heating	—
barium, Ba ²⁺ (aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca ²⁺ (aq)	white ppt. with high [Ca ²⁺ (aq)]	no ppt.
chromium(III), Cr ³⁺ (aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu ²⁺ (aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe ²⁺ (aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe ³⁺ (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
lead(II), Pb ²⁺ (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
magnesium, Mg ²⁺ (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn ²⁺ (aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn ²⁺ (aq)	white ppt. soluble in excess	white ppt. soluble in excess

[Lead(II) ions can be distinguished from aluminium ions by the insolubility of lead(II) chloride.]

2 Reactions of anions

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

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General Certificate of Education
Advanced Subsidiary Level and Advanced Level

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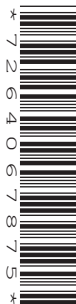
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NUMBER

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CHEMISTRY

Advanced Practical Skills

9701/33

May/June 2011

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Instructions to Supervisors

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

Answer **all** questions.

You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 11 and 12.

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

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

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



- 1 **FA 1** is an iron salt in which all the iron is present as Fe^{2+} cations. You will work out the percentage of iron in this salt by titrating a solution of this salt with a standard solution aqueous potassium manganate(VII).

FA 1 is an unknown iron(II) salt.

FA 2 is 1.00 mol dm^{-3} sulfuric acid.

FA 3 is $0.0100 \text{ mol dm}^{-3}$ potassium manganate(VII).

(a) Method

Weighing out the salt

- Weigh the tube containing **FA 1**.
- Tip the contents of the tube into a 250 cm^3 beaker.
- Re-weigh the empty tube.
- Record all your readings in a suitable form in the space below.

Preparing the solution

- To the salt in the beaker use a measuring cylinder to add approximately 200 cm^3 of **FA 2** and stir until the salt has dissolved.
- Pour the contents of the beaker carefully into the 250 cm^3 graduated (volumetric) flask using the small funnel.
- Rinse the contents of the beaker twice with a little distilled water and add these washings to the graduated flask.
- Fill the graduated flask to the line with distilled water. Shake carefully to ensure adequate mixing.

Titration

- Fill the burette with **FA 3**.
- Pipette 25.0 cm^3 of the solution of **FA 1** from the graduated flask into a conical flask.
- Titrate the solution of **FA 1** in the flask with **FA 3** until the first appearance of a permanent pink colour.

You should perform a **rough titration**.

In the space below record your burette readings for this rough titration.

The rough titre is cm^3 .

- Carry out as many accurate titrations as you think are necessary to obtain consistent results.
- Make certain any recorded results show the precision of your practical work.
- Record in an appropriate form below all of your burette readings and the volume of **FA 3** added in each accurate titration.

For
Examiner's
Use

I	
II	
III	
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V	
VI	
VII	

[7]

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

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

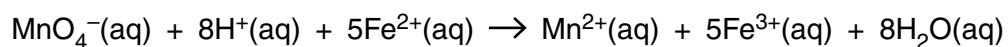
(c) CalculationsFor
Examiner's
Use

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

- (i) Calculate how many moles of MnO_4^- (aq) were present in the volume of **FA 3** calculated in **(b)**.

moles of MnO_4^- (aq) = ... mol

- (ii) Use the following equation to calculate how many moles of Fe^{2+} (aq) were present in the conical flask.



moles of Fe^{2+} (aq) in the conical flask = ... mol

- (iii) Calculate the number of moles of Fe^{2+} in your weighed sample of **FA 1**.

moles of Fe^{2+} in the weighed sample = ... mol

I	
II	
III	
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V	

- (iv) Calculate the percentage of iron in **FA 1**.
[A_r : Fe, 55.8]

For
Examiner's
Use

the percentage of iron in **FA 1** = ... %
[5]

- (d) There are a number of sources of potential error in this experiment. One of these involves the readings taken using the balance.

- (i) State the maximum individual error in any single balance reading.

maximum individual error = ... g

- (ii) Calculate the maximum percentage error in the mass of **FA 1** used in your experiment.

maximum percentage error = ... % [2]

[Total: 16]

- 2 **FA 4** is an **impure** sample of hydrated magnesium sulfate, $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$. When heated the water of crystallisation is driven off to leave anhydrous magnesium sulfate, MgSO_4 . The impurity does not give off water when heated. By determining how much water is present in the impure sample, the percentage purity can be calculated.

For
Examiner's
Use

(a) Method

- Weigh a clean dry crucible.
- Empty all of the **FA 4** into the crucible.
- Reweigh the crucible and its contents.
- Support the crucible in the pipe-clay triangle on top of a tripod.
- Heat the crucible gently for about 1 minute and then more strongly for a further 4 minutes.
- Allow the crucible to cool. You should start question 3 while cooling is taking place.
- When the crucible is cool enough to handle, reweigh the crucible and its contents.
- Repeat the cycle of heating and weighing as many times as you think necessary.

In the space below, record, in an appropriate form, all your weighings and include the mass of **FA 4** used and the mass of water that was lost.

I	
II	
III	
IV	
V	

[5]

(b) CalculationsFor
Examiner's
Use

Show your working and express your answers to **three** significant figures.

- (i) Using the mass of water that was lost on heating, calculate the mass of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ that was present in the initial sample of **FA 4**.
[A_r : H, 1.0; O, 16.0; Mg, 24.3; S, 32.1]

mass of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ = ... g [1]

- (ii) Calculate the percentage by mass of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ in **FA 4**.

percentage by mass of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ in **FA 4** = ... % [1]

- (c) Suggest an improvement to the practical procedure that would give a more accurate value for the percentage by mass of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ in **FA 4**.

.....

 [1]

[Total: 8]

Qualitative Analysis*For
Examiner's
Use*

- 3 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 full name or correct formula of the reagents must be given.

FA 5 is a sodium salt.

FA 6 is a salt containing a single cation and a single anion from those listed in the Qualitative Analysis Notes on pages 11 and 12.

FA 7 is an aqueous solution of an unknown compound.

By carrying out specific tests you will identify some of the ions in these.

- (a) Put a spatula measure of **FA 5** into a boiling tube. Heat it gently for a few minutes and then strongly until no further changes are seen.
Record your observations at each stage, in the space below.

[2]

Leave the boiling tube to cool. Do not discard the contents as they will be used later in the question.

- (b) Put a spatula measure of **FA 6** into a test-tube. Half fill the test-tube with distilled water and dissolve the solid. You will use this solution to carry out the following tests.
- To a 1 cm depth of a solution of **FA 6** in a boiling tube, add 0.5 cm depth of aqueous sodium hydroxide using a teat pipette. Heat the mixture carefully.
 - To a 1 cm depth of a solution of **FA 6** in a test-tube, add aqueous ammonia.
 - To a 1 cm depth of a solution of **FA 6** in a test-tube, add aqueous barium chloride or barium nitrate.
 - To a 1 cm depth of a solution of **FA 6** in a test-tube, add aqueous silver nitrate, followed by aqueous ammonia.

Record your observations for each of the tests in the space below.
Identify the ions present in **FA 6**.

For
Examiner's
Use

FA 6 contains and [6]

- (c) Put a small spatula measure of **FA 6** into a boiling tube. Taking great care, add **5 drops** of concentrated sulfuric acid.

CARE: Concentrated sulfuric acid is very corrosive.

Once you have made your observations fill the boiling tube with water.

Record your observations in the space below.

What type of chemical reaction occurs between **FA 6** and sulfuric acid?
Justify your answer.

.....

..... [3]

- (d) To the residue in the boiling tube from (a), slowly and carefully add **FA 7** to a depth of about 5 cm.

Divide this solution equally into two test-tubes.

- To one test-tube add 5 drops of aqueous lead nitrate.
- To the other test-tube add 5 drops of aqueous silver nitrate.

Record your observations for each test in the space below.

[2]

- (e) Use the information in the Qualitative Analysis Notes on pages 11 and 12 to select one test to confirm the identity of the cation in **FA 7** and one test to confirm the identity of the anion in **FA 7**.

Carry out both tests and record your observations for each of the tests in the space below.

Identify the ions present in **FA 7**.

FA 7 contains and [3]

[Total: 16]

Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

ion	reaction with	
	NaOH(aq)	NH ₃ (aq)
aluminium, Al ³⁺ (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH ₄ ⁺ (aq)	no ppt. ammonia produced on heating	—
barium, Ba ²⁺ (aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca ²⁺ (aq)	white ppt. with high [Ca ²⁺ (aq)]	no ppt.
chromium(III), Cr ³⁺ (aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu ²⁺ (aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe ²⁺ (aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe ³⁺ (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
lead(II), Pb ²⁺ (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
magnesium, Mg ²⁺ (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn ²⁺ (aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn ²⁺ (aq)	white ppt. soluble in excess	white ppt. soluble in excess

[Lead(II) ions can be distinguished from aluminium ions by the insolubility of lead(II) chloride.]

2 Reactions of anions

<i>ion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chromate(VI), CrO_4^{2-} (aq)	yellow solution turns orange with H^+ (aq); gives yellow ppt. with Ba^{2+} (aq); gives bright yellow ppt. with Pb^{2+} (aq)
chloride, Cl^- (aq)	gives white ppt. with Ag^+ (aq) (soluble in NH_3 (aq)); gives white ppt. with Pb^{2+} (aq)
bromide, Br^- (aq)	gives cream ppt. with Ag^+ (aq) (partially soluble in NH_3 (aq)); gives white ppt. with Pb^{2+} (aq)
iodide, I^- (aq)	gives yellow ppt. with Ag^+ (aq) (insoluble in NH_3 (aq)); gives yellow ppt. with Pb^{2+} (aq)
nitrate, NO_3^- (aq)	NH_3 liberated on heating with OH^- (aq) and Al foil
nitrite, NO_2^- (aq)	NH_3 liberated on heating with OH^- (aq) and Al foil; NO liberated by dilute acids (colourless NO $\rightarrow$ (pale) brown NO_2 in air)
sulfate, SO_4^{2-} (aq)	gives white ppt. with Ba^{2+} (aq) or with Pb^{2+} (aq) (insoluble in excess dilute strong acids)
sulfite, SO_3^{2-} (aq)	SO_2 liberated with dilute acids; gives white ppt. with Ba^{2+} (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 dichromate(VI) from orange to green

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CHEMISTRY

Advanced Practical Skills

9701/34

May/June 2011

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Instructions to Supervisors

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Answer **all** questions.

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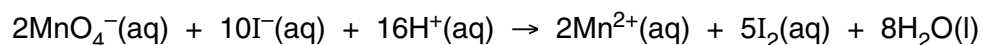
Session
Laboratory

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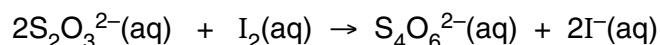
This document consists of **12** printed pages and **1** insert.



- 1 You are to determine the concentration, in mol dm^{-3} , of the aqueous sodium thiosulfate. To do this you will first produce iodine solution by reacting aqueous potassium iodide with aqueous potassium manganate(VII). In this reaction iodide ions are oxidised to iodine by manganate(VII) ions in acidic solution.



You will then titrate the iodine with aqueous thiosulfate ions, in **FB 1**.



You are provided with the following.

FB 1 is a solution of sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$, of unknown concentration.

FB 3 is $0.0050 \text{ mol dm}^{-3}$ potassium manganate(VII), KMnO_4 .

FB 4 is 0.10 mol dm^{-3} potassium iodide, KI .

FB 5 is 1.0 mol dm^{-3} sulfuric acid, H_2SO_4 .

starch indicator

(a) Method

Dilution

- Fill the burette with **FB 1**.
- Run between 45.50 cm^3 and 46.50 cm^3 of **FB 1** from the burette into the 250 cm^3 graduated (volumetric) flask, labelled **FB 2**.
- Make the solution up to the mark with distilled water.
- Shake the flask to mix the solution of **FB 2**.

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

TitrationFor
Examiner's
Use

- Fill a second burette with **FB 2**, the diluted sodium thiosulfate.
- Pipette 25.0 cm³ of **FB 3** into a conical flask.
- Using a 25 cm³ measuring cylinder, add about 10 cm³ of **FB 4**.
- Using the same measuring cylinder, add about 10 cm³ of **FB 5**.
- Titrate the mixture in the flask with **FB 2** until the colour is pale yellow.
- Add about 10 drops of starch indicator. A blue-black colour should be seen as the starch reacts with the remaining iodine.
- Continue to add **FB 2** until the blue-black colour just disappears leaving a colourless solution.

You should perform a **rough titration**.

In the space below record your burette readings for this rough titration.

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 an appropriate form below all of your burette readings and the volume of **FB 2** added in each accurate titration.

I	
II	
III	
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VII	

[7]

- (b) From your accurate titration results obtain a suitable value to be used in your calculations.

Show clearly how you have obtained this value.

The iodine produced by 25.0 cm³ of **FB 3** required cm³ of **FB 2**. [1]

(c) Calculations

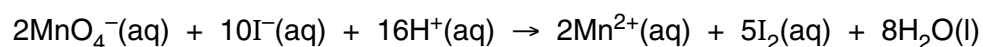
Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

For
Examiner's
Use

- (i) Calculate how many moles of MnO_4^- were pipetted into the conical flask.

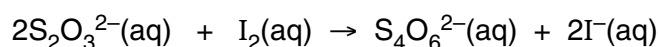
..... mol of MnO_4^-

- (ii) Calculate how many moles of I_2 were produced from the number of moles of MnO_4^- calculated in (i).



..... mol of I_2

- (iii) Calculate how many moles of $\text{S}_2\text{O}_3^{2-}$ reacted with the I_2 in (ii).



..... mol of $\text{S}_2\text{O}_3^{2-}$

- (iv) Calculate how many moles of $\text{S}_2\text{O}_3^{2-}$ were present in the 250cm^3 graduated (volumetric) flask.

..... mol of $\text{S}_2\text{O}_3^{2-}$

- (v) Use your answer to (iv) and the volume of **FB 1** that was diluted to calculate the concentration, in mol dm^{-3} , of the original solution of sodium thiosulfate, **FB 1**.

The concentration of $\text{Na}_2\text{S}_2\text{O}_3$ in **FB 1** was mol dm^{-3} .
[6]

I	
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VI	

- (d) The maximum error for a 25 cm^3 pipette commonly used in schools is $\pm 0.06\text{ cm}^3$.
The maximum individual error in any single burette reading is $\pm 0.05\text{ cm}^3$.

For
Examiner's
Use

Calculate each of the following.

The maximum percentage error in the volume of **FB 3** pipetted into the conical flask

maximum percentage error in the pipetted volume of **FB 3** = ... %

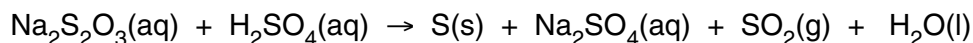
The maximum percentage error in the titre calculated in (b)

maximum percentage error in the titre volume = ... %
[1]

[Total: 15]

- 2 You are to investigate how the rate of the following reaction varies with the concentration of sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.

For
Examiner's
Use



The rate can be found by measuring how long it takes for the solid sulfur formed to obscure the printing on the insert provided.

Care should be taken to avoid inhalation of $\text{SO}_2(\text{g})$ that is given off during this reaction.

FB 5 is 1.0 mol dm^{-3} sulfuric acid, H_2SO_4 .

FB 6 is 0.10 mol dm^{-3} sodium thiosulfate $\text{Na}_2\text{S}_2\text{O}_3$.

Read through the instructions carefully and prepare a table for your results on page 7 before starting any practical work.

(a) Method

- Using the 50 cm^3 measuring cylinder transfer 45 cm^3 of **FB 6** into a 100 cm^3 beaker.
- Using the 25 cm^3 measuring cylinder measure 10 cm^3 of **FB 5**.
- Tip the **FB 5** into the **FB 6** in the beaker and **immediately** start timing.
- Stir the mixture once with a glass rod and place it on top of the printed insert.
- View the printed insert from above so that it is seen through the mixture.
- Record the time, to the nearest second, when the printing on the insert **just** disappears.
- Empty and rinse the beaker. Shake out as much of the water as possible and dry the outside of the beaker.
- You will repeat the experiment to find out how the time for the printing on the insert to disappear changes when a different volume of **FB 6** is used.
- Using the 50 cm^3 measuring cylinder transfer 20 cm^3 of **FB 6** and 25 cm^3 of distilled water into the 100 cm^3 beaker.
- Using the 25 cm^3 measuring cylinder add 10 cm^3 of **FB 5** to the mixture and **immediately** start timing.
- Stir the mixture once with a glass rod and place it on top of the printed insert.
- View the printed insert from above so that it is seen through the mixture.
- Record the time, to the nearest second, when the printing on the insert **just** disappears.
- Select suitable volumes of **FB 6** and distilled water for **two** further experiments to investigate the effect of volume of sodium thiosulfate on the time taken for the printing on the insert to **just** disappear.

Calculate the values of $1/\text{time}$, where time is in seconds, to an appropriate number of significant figures.

In the space below, record, in an appropriate form, all measurements of volume, time, and your calculated values of $1/\text{time}$.

For
Examiner's
Use

I	
II	
III	
IV	
V	

[5]

- (b) Why was the **total** volume of solution kept constant in the experiments?

.....

..... [1]

- (c) It may be assumed that the rate of reaction is proportional to $1/\text{time}$.
Draw a conclusion from your results about the relationship between the concentration of sodium thiosulfate used and the rate of reaction.
Explain your answer.

.....

.....

..... [1]

- (d) In the four experiments, which value of the time measured had the greatest error?
Explain your answer.

.....

.....

..... [1]

- (e) How could the procedure be adapted to find the effect of changing the concentration of acid on the rate of reaction?

.....

.....

..... [1]

[Total: 9]

3 Qualitative Analysis

For
Examiner's
Use

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

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

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

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

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

No additional tests for ions present should be attempted.

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

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

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

There are two parts to this question. In the first part you will analyse three metal salts, **FB 7**, **FB 8** and **FB 9**, to identify the cation in each. In the second part you will carry out a series of tests on a different salt, **FB 10**, to identify the anion.

(a) **FB 7**, **FB 8** and **FB 9** each contain one of aluminium ions, lead ions or zinc ions.

By reference to the Qualitative Analysis Notes on pages 11 and 12, select **two** appropriate reagents to perform tests to identify the cations present.

reagent

Record the tests performed and the results of those tests in an appropriate form in the space below.

I	
II	
III	
IV	
V	

[5]

(b) From your observations, identify the cations present in **FB 7**, **FB 8** and **FB 9**. State the **minimum** evidence to support each of your choices.

FB 7 contains cations.

evidence

.....

FB 8 contains cations.

evidence

.....

FB 9 contains cations.

evidence

.....

[3]

- (c) You are provided with a solid sample of **FB 10** which is a metal salt. Use this sample to perform the experiments described below. Record all your observations in the table.

<i>test</i>	<i>observations</i>
(i) Place a spatula measure of solid FB 10 into a dry hard-glass tube. Hold the test-tube in a holder. Heat the test-tube gently at first	
and then very strongly for several minutes.	
Allow the test-tube to cool, and then half fill it with distilled water. Dissolve the solid residue. This is FB 11. Retain this for tests (iv) and (v). While you are waiting for the test-tube to cool, continue with experiment (c)(ii) and (iii).	
(ii) Pour a 2 cm depth of aqueous copper(II) sulfate in a test-tube. Add a spatula measure of solid FB 10.	
(iii) Pour a 2 cm depth of aqueous aluminium sulfate into a test-tube. Add a spatula measure of solid FB 10.	

I	
II	
III	
IV	
V	

<i>test</i>	<i>observations</i>
(iv) Pour a 2 cm depth of solution FB 11 into a test-tube. Add the same volume of aqueous barium chloride.	
Then, using a dropping pipette, add dilute hydrochloric acid until no further change is seen.	
(v) Pour 1 cm depth of FB 11 into a test-tube and add an equal depth of aqueous copper(II) sulfate.	
Transfer the contents of the test-tube into an evaporating dish and place it over a Bunsen burner on a tripod and gauze. Heat strongly until all the water has been driven off and no further change is seen.	

[5]

(d) Consider your observations in **(c)** and answer the following questions. In each case, provide evidence from your observations to support your conclusions.

(i) Identify the anion present in **FB 11** and state evidence to support your choice.

FB 11 contains the anion.

evidence

.....

(ii) Suggest what type of reaction occurs as **FB 10** is converted into **FB 11**.

.....

.....

(iii) Suggest an explanation for what you observed in **(c)(iii)**.

.....

.....

[3]

[Total: 16]

Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

ion	reaction with	
	NaOH(aq)	NH ₃ (aq)
aluminium, Al ³⁺ (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH ₄ ⁺ (aq)	no ppt. ammonia produced on heating	—
barium, Ba ²⁺ (aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca ²⁺ (aq)	white ppt. with high [Ca ²⁺ (aq)]	no ppt.
chromium(III), Cr ³⁺ (aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu ²⁺ (aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe ²⁺ (aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe ³⁺ (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
lead(II), Pb ²⁺ (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
magnesium, Mg ²⁺ (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn ²⁺ (aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn ²⁺ (aq)	white ppt. soluble in excess	white ppt. soluble in excess

[Lead(II) ions can be distinguished from aluminium ions by the insolubility of lead(II) chloride.]

2 Reactions of anions

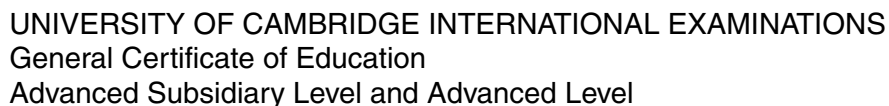
<i>ion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chromate(VI), CrO_4^{2-} (aq)	yellow solution turns orange with H^+ (aq); gives yellow ppt. with Ba^{2+} (aq); gives bright yellow ppt. with Pb^{2+} (aq)
chloride, Cl^- (aq)	gives white ppt. with Ag^+ (aq) (soluble in NH_3 (aq)); gives white ppt. with Pb^{2+} (aq)
bromide, Br^- (aq)	gives cream ppt. with Ag^+ (aq) (partially soluble in NH_3 (aq)); gives white ppt. with Pb^{2+} (aq)
iodide, I^- (aq)	gives yellow ppt. with Ag^+ (aq) (insoluble in NH_3 (aq)); gives yellow ppt. with Pb^{2+} (aq)
nitrate, NO_3^- (aq)	NH_3 liberated on heating with OH^- (aq) and Al foil
nitrite, NO_2^- (aq)	NH_3 liberated on heating with OH^- (aq) and Al foil; NO liberated by dilute acids (colourless $\text{NO} \rightarrow$ (pale) brown NO_2 in air)
sulfate, SO_4^{2-} (aq)	gives white ppt. with Ba^{2+} (aq) or with Pb^{2+} (aq) (insoluble in excess dilute strong acids)
sulfite, SO_3^{2-} (aq)	SO_2 liberated with dilute acids; gives white ppt. with Ba^{2+} (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 dichromate(VI) from orange to green

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9701/35

May/June 2011

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Instructions to Supervisors

READ THESE INSTRUCTIONS FIRST

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

Answer **all** questions.

You may lose marks if you do not show your working or if you do not use appropriate units.

Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 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.

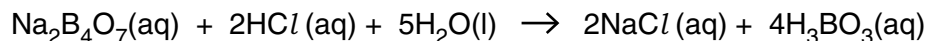
Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This document consists of **15** printed pages and **1** blank page.

You are to determine the percentage by mass of water in the borax crystals.

Borax reacts with hydrochloric acid according to the equation.



- 1 **FA 1** is an aqueous solution containing 38.10 g dm^{-3} of **borax** crystals. **Borax** has the formula, $\text{Na}_2\text{B}_4\text{O}_7 \cdot x\text{H}_2\text{O}$.
FA 2 is 1.00 mol dm^{-3} hydrochloric acid, HCl .

You are also provided with an indicator suitable for the titration of a strong acid and a weak base.

The indicator provided is

(a) Method

Dilution

- Fill the burette with **FA 2**.
- Run between 44.50 cm^3 and 45.50 cm^3 of **FA 2** from the burette into the 250 cm^3 graduated (volumetric) flask, labelled **FA 3**.
- Make the solution up to the mark with distilled water.
- Shake the flask to mix the solution of **FA 3**.

In the space below record your burette readings and the volume of **FA 2** added to the graduated flask.

Titration

- Fill a second burette with **FA 3**, the diluted hydrochloric acid.
- Pipette 25.0 cm^3 of **FA 1** into a conical flask.
- Add to the flask a few drops of the indicator provided.
- Titrate the borax in the flask with **FA 3** until the appropriate colour change is observed for the end-point.

You should perform a **rough titration**.

In the space below record your burette readings for this rough titration.

The rough titre is cm^3 .

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- 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 3** added in each accurate titration.

For
Examiner's
Use

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 have obtained this value.

25.0 cm³ of **FA 1** 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.

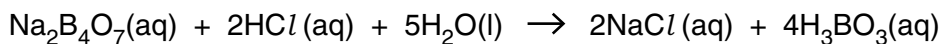
- (i) Calculate the concentration of hydrochloric acid, in mol dm⁻³, in the diluted solution, **FA 3**.

The concentration of HCl in **FA 3** was mol dm⁻³.

- (ii) Calculate how many moles of HCl were present in the volume of **FA 3** calculated in (b).

..... mol of HCl

- (iii) Calculate how many moles of $\text{Na}_2\text{B}_4\text{O}_7$ reacted with the HCl in (ii).



For
Examiner's
Use

The HCl run from the burette reacted with mol of $\text{Na}_2\text{B}_4\text{O}_7$.

- (iv) Calculate the concentration, in g dm^{-3} , of $\text{Na}_2\text{B}_4\text{O}_7$ in **FA 1**.
[A_r : B, 10.8; O, 16.0; Na, 23.0]

The concentration of $\text{Na}_2\text{B}_4\text{O}_7$ in **FA 1** is g dm^{-3} .

- (v) Use your answer to (iv) and the information at the start of question 1 to calculate the percentage by mass of water in the borax crystals, $\text{Na}_2\text{B}_4\text{O}_7 \cdot x\text{H}_2\text{O}$.
[A_r : H, 1.0; B, 10.8; O, 16.0; Na, 23.0]

I	
II	
III	
IV	
V	
VI	

Borax crystals contain % water.
[6]

- (d) The maximum error for a 25 cm^3 pipette commonly used in schools is $\pm 0.06 \text{ cm}^3$.
The maximum error in any single burette reading is $\pm 0.05 \text{ cm}^3$.

Calculate the maximum percentage error in each of the following.

- (i) The volume of **FA 1** pipetted into the conical flask.

maximum percentage error in the pipetted volume = ... %.

- (ii) The titre volume calculated in (b).

maximum percentage error in titre volume = ... %.
[1]

[Total: 15]

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2 Read through the question carefully before starting any practical work.

For
Examiner's
Use

Sodium carbonate, Na_2CO_3 ,

- reacts exothermically with hydrochloric acid,
 - does not decompose when heated,
 - reacts with acids.
- $$\text{CO}_3^{2-}(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$$

Sodium hydrogencarbonate, NaHCO_3 ,

- reacts endothermically with hydrochloric acid,
 - decomposes when heated,
- $$2\text{HCO}_3^-(\text{s}) \rightarrow \text{H}_2\text{O}(\text{g}) + \text{CO}_2(\text{g}) + \text{CO}_3^{2-}(\text{s})$$
- reacts with acids.
- $$\text{HCO}_3^-(\text{s}) + \text{H}^+(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$$

You are to measure the temperature changes when samples of

- sodium carbonate,
 - sodium hydrogencarbonate,
 - a mixture of sodium carbonate and sodium hydrogencarbonate,
- react with an excess of hydrochloric acid.

FA 4 is sodium carbonate, Na_2CO_3 .

FA 5 is sodium hydrogencarbonate, NaHCO_3 .

FA 6 is a mixture of sodium carbonate and sodium hydrogencarbonate.

FA 7 is 3.0 mol dm^{-3} hydrochloric acid, HCl .

Method

(a) sodium carbonate

- Support the plastic cup in a 250 cm^3 beaker.
- Use a measuring cylinder to transfer 50 cm^3 of **FA 7** into the plastic cup.
- Measure and record the temperature of the acid in the cup.
- Measure and record the mass of the container labelled **FA 4**, containing Na_2CO_3 .
- **Carefully** tip the sodium carbonate from the weighed container **FA 4** into the hydrochloric acid in the plastic cup.
Note: There will be vigorous effervescence. Do not breathe the vapour. Add the solid in small portions with constant stirring using the thermometer.
- Record the highest temperature obtained.
- Reweigh the container **FA 4** with any residual sodium carbonate. Record the mass.
- Empty and rinse the plastic cup and dry it using a paper towel.

In the space at the top of the next page, record, in an appropriate form,

- both balance readings and both temperature measurements,
- the mass of sodium carbonate, m_1 , used in the experiment,
- the temperature rise, ΔT_1 .

I	
II	
III	
IV	

[4]

Calculate the rise in temperature for each gram of sodium carbonate used in the experiment.

$$\frac{\Delta T_1}{m_1} = \boxed{+} \dots\dots\dots ^\circ\text{C g}^{-1}$$

sign *value*

(b) sodium hydrogencarbonate

- Support the plastic cup in a 250 cm³ beaker.
 - Use a measuring cylinder to transfer 50 cm³ of **FA 7** into the plastic cup.
 - Measure and record the temperature of the acid in the cup.
 - Measure and record the mass of the container labelled **FA 5**, containing NaHCO₃.
 - **Carefully** tip the sodium hydrogencarbonate from the weighed container **FA 5** into the hydrochloric acid in the plastic cup.
- Note: There will be vigorous effervescence. Add the solid in small portions with constant stirring using the thermometer.**
- Record the lowest temperature obtained.
 - Reweigh the container **FA 5** with any residual sodium hydrogencarbonate. Record the mass.
 - Empty and rinse the plastic cup and dry it using a paper towel.

In the space below, record, in an appropriate form,

- both balance readings and both temperature measurements,
- the mass of sodium hydrogencarbonate, **m₂**, used in the experiment,
- the temperature fall, **ΔT₂**.

[2]

Calculate the fall in temperature for each gram of sodium hydrogencarbonate used in the experiment.

$$\frac{\Delta T_2}{m_2} = \boxed{-} \dots\dots\dots ^\circ\text{C g}^{-1}$$

sign *value*

I	
II	

(c) mixture of sodium carbonate and sodium hydrogencarbonate

For
Examiner's
Use

- Support the plastic cup in a 250 cm³ beaker.
- Use a measuring cylinder to transfer 50 cm³ of **FA 7** into the plastic cup.
- Measure and record the temperature of the acid in the cup.
- Measure and record the mass of a clean, dry, weighing-bottle or tube.
- Add to the tube between **8.5 g and 9.5 g** of the mixture **FA 6**.
- Record the mass of the weighing-bottle or tube + **FA 6**.
- **Carefully** tip the weighed mixture into the hydrochloric acid in the plastic cup.
- **Note: There will be vigorous effervescence. Add the solid in small portions with constant stirring using the thermometer.**
- Record the highest or lowest temperature obtained.
- Reweigh the weighing-bottle or tube with any residual mixture. Record the mass.

In the space below, record, in an appropriate form,

- all balance readings and temperature measurements,
- the mass of the mixture, **m₃**, used in the experiment,
- the temperature change, **ΔT₃**.

Make certain that your recorded temperature change carries an appropriate sign.

I	
II	

[2]

(d) Transfer the following data from parts (a), (b) and (c).

(a) $\frac{\Delta T_1}{m_1} = + \dots\dots\dots ^\circ\text{C g}^{-1}$

(b) $\frac{\Delta T_2}{m_2} = - \dots\dots\dots ^\circ\text{C g}^{-1}$

(c) $m_3 = \dots\dots\dots \text{ g}$ $\Delta T_3 = \boxed{} \dots\dots\dots ^\circ\text{C}$
sign

The masses of sodium carbonate and sodium hydrogencarbonate in the weighed sample of the mixture used in experiment (c) can be represented as follows.

For
Examiner's
Use

mass of sodium carbonate / g = **W**

mass of sodium hydrogencarbonate / g = (**m₃** – **W**)

Evaluate the following equation to determine a value for **W**.

$$\left[W \times \frac{\Delta T_1}{m_1} \right] + \left[(m_3 - W) \times \frac{\Delta T_2}{m_2} \right] = \Delta T_3$$

The mass of sodium carbonate was g.
[1]

- (e) Use the information at the beginning of question 2 to outline an alternative method that could be used in a school laboratory to find the mass of sodium carbonate and the mass of sodium hydrogencarbonate in the mixture **FA 6**.

.....

.....

.....

.....

[1]

[Total: 10]

3 Qualitative Analysis

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

For
Examiner's
Use

- 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 full name or correct formula of the reagents must be given.

FA 8, FA 9 and FA 10 are aqueous solutions each containing a sodium cation and a single anion which could be a nitrite, a nitrate or a halide.

- (a) By reference to the Qualitative Analysis Notes on page 15, select a single reagent that would enable you to identify any solution containing the nitrite ion, NO_2^- .

reagent

Use **this reagent** to test each of the solutions. Record your observations in the table below. State clearly where no reaction has been observed.

<i>solution</i>	<i>observation</i>
FA 8	
FA 9	
FA 10	

[2]

- (b) By reference to the Qualitative Analysis Notes on page 15, select **one** reagent that would show that a halide ion is present.

reagent

Use **this reagent** to test each of the solutions.
Record your observations in an appropriate form in the space below.

For
Examiner's
Use

Select **another** reagent to **identify or confirm** which halide ions are present in the solutions.

reagent

Tick the appropriate statement about the use of this reagent.

It is added to the tube already containing the first reagent.	
It is added to a fresh sample of solution.	

Use **this reagent** to identify or confirm which halide ions are present in the solutions and record your observations in an appropriate form in the space below.

[3]

I	
II	
III	

(c) From the results in (a) and (b) state which anions have been identified in the solutions.

Complete the following table.

Place a cross in any box if no anion has been identified.

<i>solution</i>	FA 8	FA 9	FA 10
<i>anion present</i>			

[1]

FA 11 and **FA 12** are aqueous solutions each containing one cation from those listed in the Qualitative Analysis Notes printed on page 14.

For
Examiner's
Use

- (d) Use aqueous sodium hydroxide and aqueous ammonia in separate tests to identify the cation present in each of the solutions.
You will also require some of the solution, **FA 11**, for tests in (f).

Record the results of your experiments with sodium hydroxide and ammonia in an appropriate form in the space below.

I	
II	
III	

[3]

- (e) **Identification of the cations in FA 11 and FA 12**

Complete the table below.

<i>solution</i>	FA 11	FA 12
<i>cation present</i>		

What is the evidence **from your observations in (d)** that enables you to identify the cation present in each of the solutions?

The evidence supporting the conclusion for the cation in **FA 11** is

.....

.....

I	
II	

The evidence supporting the conclusion for the cation in **FA 12** is

.....

.....

[2]

(f) Complete the following table.

For
Examiner's
Use

<i>test</i>	<i>observations</i>
(i) Pour 1 cm depth of FA 11 into a test-tube. Add 1 cm depth of aqueous potassium iodide. Divide this mixture into two parts for use in (ii) and (iii)	
(ii) To the first part of the mixture from (i) add a few drops of starch solution.	
(iii) To the second part of the mixture from (i) add aqueous sodium thiosulfate, a drop at a time, until no further change is observed.	

In part (i) and in part (iii) redox reactions have taken place.

Complete the table below to show the ion or molecule which has been oxidised and the ion or molecule which has been reduced in each of these reactions.

<i>reaction</i>	<i>the ion or molecule which has been</i>	
	<i>oxidised</i>	<i>reduced</i>
(i)		
(iii)		

I	
II	
III	
IV	

[4]

[Total: 15]

Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

ion	reaction with	
	NaOH(aq)	NH ₃ (aq)
aluminium, Al ³⁺ (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH ₄ ⁺ (aq)	no ppt. ammonia produced on heating	—
barium, Ba ²⁺ (aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca ²⁺ (aq)	white ppt. with high [Ca ²⁺ (aq)]	no ppt.
chromium(III), Cr ³⁺ (aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu ²⁺ (aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe ²⁺ (aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe ³⁺ (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
lead(II), Pb ²⁺ (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
magnesium, Mg ²⁺ (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn ²⁺ (aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn ²⁺ (aq)	white ppt. soluble in excess	white ppt. soluble in excess

[Lead(II) ions can be distinguished from aluminium ions by the insolubility of lead(II) chloride.]

2 Reactions of anions

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

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