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9701/31

October/November 2017

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

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

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

Qualitative Analysis Notes are printed on pages 10 and 11.
A copy of the Periodic Table is printed on page 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 In this experiment you will determine the oxidation number of iodine in one of its compounds by titration.

FA 1 is a $0.0197 \text{ mol dm}^{-3}$ solution of the iodine-containing compound.

FA 2 is dilute sulfuric acid, H_2SO_4 .

FA 3 is aqueous potassium iodide, KI .

FA 4 is $0.105 \text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.
starch indicator

FA 1 reacts with excess acidified potassium iodide to produce iodine, I_2 . This iodine is then titrated with aqueous sodium thiosulfate using starch indicator.

(a) Method

- Fill the burette with **FA 4**.
- Pipette 25.0 cm^3 of **FA 1** into a conical flask.
- Using the measuring cylinder, add 10 cm^3 of **FA 2** to the same conical flask.
- Using the same measuring cylinder, add 20 cm^3 of **FA 3** to the mixture in the conical flask. The mixture will now be a red-brown colour, due to iodine produced.
- Carry out a rough titration by adding **FA 4** from the burette until the mixture becomes light brown.
- Then add 10 drops of starch indicator. The mixture will change to a dark blue colour.
- Continue titrating until the mixture becomes colourless. This is the end-point.

The rough titre is cm^3 .

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make sure any recorded results show the precision of your practical work.
- Record in a suitable form below all of your burette readings and the volume of **FA 4** added in each accurate titration.

I	
II	
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VII	

[7]

- (b)** From your accurate titration results, obtain a suitable value for the volume of **FA 4** to be used in your calculations. Show clearly how you obtained this value.

The iodine produced required cm^3 of **FA 4**. [1]

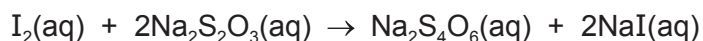
(c) Calculations

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

- (i) Calculate the number of moles of sodium thiosulfate in the volume of **FA 4** calculated in (b).

moles of $\text{Na}_2\text{S}_2\text{O}_3 = \dots\dots\dots \text{mol}$

- (ii) The equation for the reaction of iodine with sodium thiosulfate is shown.



Calculate the number of moles of iodine that reacted with the sodium thiosulfate calculated in (i).

moles of $\text{I}_2 = \dots\dots\dots \text{mol}$

- (iii) Use the information on page 2 to calculate the number of moles of iodine-containing compound in the 25 cm^3 of **FA 1** used in each titration.

moles of iodine-containing compound in 25 cm^3 **FA 1** = $\dots\dots\dots \text{mol}$

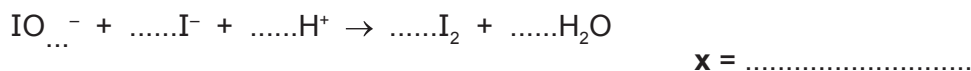
- (iv) Use your answers to (ii) and (iii) to calculate the number of moles of iodine produced when 1 mole of the iodine-containing compound in **FA 1** reacts with excess **FA 3**. Give your answer as an integer.

moles of $\text{I}_2 = \dots\dots\dots \text{mol}$

- (v) The anion in **FA 1** is IO_x^- where **x** is the number of oxygen atoms present in the formula.

Use your answer to (iv) to balance the ionic equation for the reaction between **FA 1** and **FA 3** under acidic conditions.

Hence deduce the value of **x** in the formula IO_x^- .



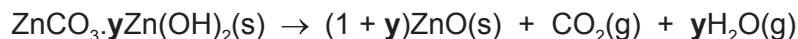
- (vi) Calculate the oxidation state of iodine in **FA 1**.
(If you were unable to calculate **x** in part (v), assume that **x** = 4.)

oxidation state of iodine = $\dots\dots\dots$
[6]

[Total: 14]

- 2 Zinc carbonate occurs in a basic form, which means that zinc hydroxide is also present. The chemical formula of basic zinc carbonate can be written as $\text{ZnCO}_3 \cdot y\text{Zn(OH)}_2$, where y may not be an integer. In this experiment you will heat basic zinc carbonate to decompose it and use your results to determine the value of y .

When basic zinc carbonate is heated, it decomposes as shown.



FA 5 is basic zinc carbonate, $\text{ZnCO}_3 \cdot y\text{Zn(OH)}_2$.

(a) Method

Read through the method before starting any practical work.

Prepare a table for all your results from Experiments 1 and 2 in the space on page 5.

Experiment 1

- Weigh a crucible with its lid and record the mass.
- Add 2.1–2.5 g of **FA 5** to the crucible. Weigh the crucible and lid with **FA 5** and record the mass.
- Place the crucible in the pipe-clay triangle on top of the tripod.
- Heat the crucible and contents gently for 1 minute with the lid on.
- Remove the lid. Heat the crucible and contents strongly, with the lid off, for approximately 4 minutes.
- Replace the lid and leave the crucible and residue to cool for at least 5 minutes, before re-weighing it with the lid on. Record the mass.
- **While the crucible is cooling, you may wish to begin work on Question 3.**
- Calculate, and record in your table, the mass of **FA 5** used and the mass of residue obtained.

- (i) State the observation(s) you made while you were heating **FA 5**.

.....

- (ii) State the observation(s) you made once the residue had cooled down.

.....

Experiment 2

- Repeat the procedure used in **Experiment 1**, using 1.5–1.9 g of **FA 5** and using the other crucible and lid.
- Record the three balance readings made during the experiment.
- Calculate and record the mass of **FA 5** used and the mass of residue obtained.

Results

I	
II	
III	
IV	
V	
VI	

[6]

(b) Calculations

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

- (i) Calculate the relative formula mass, M_r , of zinc hydroxide, $\text{Zn}(\text{OH})_2$.

M_r of $\text{Zn}(\text{OH})_2$ = ...

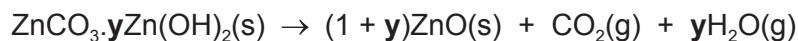
- (ii) Using your answer to (i), write down an expression, in terms of **y**, for the relative formula mass, M_r , of basic zinc carbonate, $\text{ZnCO}_3 \cdot y\text{Zn}(\text{OH})_2$.

M_r of $\text{ZnCO}_3 \cdot y\text{Zn}(\text{OH})_2$ = ...

- (iii) Using the mass of $\text{ZnCO}_3 \cdot y\text{Zn}(\text{OH})_2$ from **Experiment 1** and your answer to (ii), write down an expression, in terms of **y**, for the number of moles of $\text{ZnCO}_3 \cdot y\text{Zn}(\text{OH})_2$ that you heated in **Experiment 1**.

moles of $\text{ZnCO}_3 \cdot y\text{Zn}(\text{OH})_2$ = ... mol

- (iv) Using your answer to (iii) and the equation below, write an expression, in terms of **y**, for the number of moles of zinc oxide produced in **Experiment 1**.



moles of ZnO produced = ... mol

- (v) Use your results from **Experiment 1** to calculate the number of moles of zinc oxide, ZnO, obtained in the residue. You may assume complete decomposition has occurred.

moles of ZnO = ... mol

- (vi) Using your answers to (iv) and (v), calculate the value of **y** to one decimal place.

y = ...
[6]

- (c) (i) Apart from altering the balance or the masses of **FA 5** used, state **one** improvement you could make to the experimental procedure to improve its accuracy.

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

- (ii) Which experiment should be more accurate, **Experiment 1** or **Experiment 2**? Explain your answer.

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

[2]

[Total: 14]

3 Qualitative Analysis

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

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

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

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

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

No additional tests for ions present should be attempted.

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

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

FA 6, **FA 7** and **FA 8** are solutions of salts.

Information about FA 6 , FA 7 and FA 8
• Each salt contains one cation and one anion. • One of the ions is sodium; the other five ions are listed in the Qualitative Analysis Notes. • Each salt contains a different nitrogen-containing ion. • FA 7 or FA 8 contains a halide ion.

(a) You will identify the **cations** present in **FA 6**, **FA 7** and **FA 8**.

To do this you will carry out **six** separate tests. You will use dilute sulfuric acid and aqueous sodium hydroxide separately with **FA 6**, **FA 7** and **FA 8**.

Use a 1 cm depth of each salt solution in a suitable tube for each test you carry out.

Record **all** of your observations in a table in the space below.

- (b) Name the reagents you would use to identify the halide ion present in either **FA 7** or **FA 8**. Test **FA 7** and **FA 8** with these reagents and record your observations.

reagents used

unknown	observations	halide ion present ✓ / ✗
FA 7		
FA 8		

[2]

- (c) (i) Name the reagents you would use to confirm the presence of the nitrogen-containing **anions** in the two solutions that do **not** contain a halide ion. Test both solutions with these reagents and record your observations.

reagents used

unknown	observations
FA	
FA	

- (ii) Name the reagent you would use to positively identify one of the nitrogen-containing anions in the two solutions tested in (i). Test both solutions with this reagent. Record all your observations.

reagent used

unknown	observations
FA	
FA	

[4]

- (d) Use the information given in (a) and your observations in all tests to deduce the chemical formulae of the three salts.

FA 6 is **FA 7** is **FA 8** is

[2]

[Total: 12]

Qualitative Analysis Notes

1 Reactions of aqueous cations

<i>ion</i>	<i>reaction with</i>	
	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)	faint white ppt. is nearly always observed unless 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	grey-green ppt. insoluble in excess
copper(II), Cu ²⁺ (aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe ²⁺ (aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe ³⁺ (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg ²⁺ (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn ²⁺ (aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn ²⁺ (aq)	white ppt. soluble in excess	white ppt. soluble in excess

2 Reactions of anions

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

The Periodic Table of Elements

Group																						
1	2	Key												13	14	15	16	17	18			
		atomic number atomic symbol name relative atomic mass												1 H hydrogen 1.0								
3	4																					
Li lithium 6.9	Be beryllium 9.0																					
11	12																					
Na sodium 23.0	Mg magnesium 24.3																					
19	20																					
K potassium 39.1	Ca calcium 40.1																					
37	38																					
Rb rubidium 85.5	Sr strontium 87.6																					
55	56																					
Cs caesium 132.9	Ba barium 137.3																					
87	88																					
Fr francium —	Ra radium —																					

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* 1 2 2 5 1 7 0 3 9 5 *

CHEMISTRY

9701/33

Paper 3 Advanced Practical Skills 1

October/November 2017

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

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Answer **all** questions.
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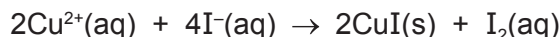
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The number of marks is given in brackets [] at the end of each question or part question.

Session
Laboratory

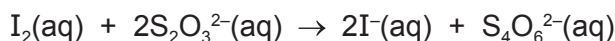
For Examiner's Use	
1	
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3	
Total	

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

- 1 In this experiment you will determine the value of **x** in the formula for hydrated copper(II) sulfate, $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$. You will first react a solution of Cu^{2+} ions with excess iodide ions, I^- . This reaction produces iodine.



The amount of iodine produced can be determined by titrating with thiosulfate ions, $\text{S}_2\text{O}_3^{2-}$.



FA 1 is $0.150 \text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.

FA 2 is dilute sulfuric acid.

FA 3 is 1.00 mol dm^{-3} potassium iodide, KI .

FA 4 is a solution made by dissolving 32.5 g of $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$ in 1.00 dm^3 of solution.
starch indicator

(a) Method

- Fill the burette with **FA 1**.
- Pipette 25.0 cm^3 of **FA 4** into a conical flask.
- Use the measuring cylinder to add 10 cm^3 of **FA 2** to the same conical flask.
- Use the measuring cylinder to add 10 cm^3 of **FA 3** to the same conical flask. The mixture will become brown because of the formation of I_2 , and will become cloudy because of the formation of the white precipitate of CuI .
- Add **FA 1** from the burette until the mixture becomes a light brown colour.
- Add 10 to 20 drops of starch indicator until the mixture becomes blue-black.
- Continue to titrate with **FA 1** until the blue-black colour disappears leaving a mixture with an off-white solid. This is the end-point.
- You should test that the end-point has been reached by adding 2 more drops of starch indicator. If the titration has reached the end-point the added starch indicator will cause no change in colour.
- Perform a rough titration and record your burette readings in the space below.

The rough titre is cm^3 .

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

I	
II	
III	
IV	
V	
VI	
VII	

[7]

- (b) From your accurate titration results, obtain a suitable value for the volume of **FA 1** to be used in your calculations.
Show clearly how you obtained this value.

25.0 cm³ of **FA 4** required cm³ of **FA 1**. [1]

(c) Calculations

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

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

moles of S₂O₃²⁻ = ... mol

- (ii) Using the equations on page 2, calculate the number of moles of copper(II) ions in 25.0 cm³ of **FA 4**.

moles of Cu²⁺ = ... mol

- (iii) Calculate the concentration, in mol dm⁻³, of copper(II) ions in **FA 4**.

concentration of Cu²⁺ in **FA 4** = ... mol dm⁻³

- (iv) Calculate the value of **x** in CuSO₄·**x**H₂O.

x = ...
[5]

- (d) (i) Calculate the maximum percentage error in one of your accurate titres.

maximum percentage error = ... %

- (ii) A student suggests that the experiment could be made more accurate if the volume of **FA 3** was measured using a burette.

Give a reason why the student might make this suggestion.

.....

.....

.....

Explain why this change would **not** improve the accuracy of the experiment.

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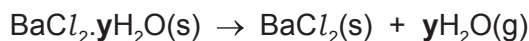
.....

[3]

[Total: 16]

Question 2 starts on the next page.

- 2 In this experiment you will determine the value of **y** in the formula for hydrated barium chloride, $\text{BaCl}_2 \cdot y\text{H}_2\text{O}$. You will do this by measuring the mass loss when a sample of hydrated barium chloride is heated.



FA 5 is hydrated barium chloride, $\text{BaCl}_2 \cdot y\text{H}_2\text{O}$.

(a) Method

Before starting any practical work, read through all the instructions and prepare a table for your results in the space provided.

- Weigh the crucible with a lid and record the mass.
- Add all the **FA 5** to the crucible.
- Reweigh the crucible with the lid and **FA 5**. Record the mass.
- Place the crucible in the pipe-clay triangle on top of a tripod.
- Heat the crucible **gently** with the lid on for about 1 minute.
- Remove the lid and then heat more strongly for a further 4 minutes.
- Replace the lid and allow the crucible to cool.
- **While the crucible is cooling you may wish to begin work on Question 3.**
- Once the crucible has cooled, reweigh the crucible with the lid and contents. Record the mass.
- Calculate and record the mass of **FA 5** used, the mass of the residue and the mass of water lost.

I	
II	
III	
IV	
V	

[5]

(b) Calculations

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

- (i) Calculate the number of moles of barium chloride in the residue. You may assume all the water has been removed.

moles of $\text{BaCl}_2 = \dots\dots\dots$ mol

- (ii) Calculate the number of moles of water lost.

moles of H_2O lost = $\dots\dots\dots$ mol

- (iii) Calculate the value of **y** in $\text{BaCl}_2 \cdot y\text{H}_2\text{O}$.

y = $\dots\dots\dots$
[3]

- (c) (i) For this experiment to give an accurate value for **y**, anhydrous barium chloride must be thermally stable.

Explain fully what would happen to the value of **y** if BaCl_2 were to decompose slightly during heating.

$\dots\dots\dots$
 $\dots\dots\dots$
 $\dots\dots\dots$

- (ii) Starting with the same mass of hydrated barium chloride, suggest how you could modify the experiment to determine more accurately the mass of water lost.

$\dots\dots\dots$
 $\dots\dots\dots$
[3]

[Total: 11]

3 Qualitative Analysis

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

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

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

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

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

No additional tests for ions present should be attempted.

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

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

FA 6 and **FA 7** are both salts which contain cations and anions from those listed in the Qualitative Analysis Notes. Each salt contains a single cation and a single anion.

(a) Carry out the following test and record your observations.

test	observations	
	FA 6	FA 7
(i) Place a small spatula measure of the solid in a hard-glass test-tube and heat gently at first, then		
more strongly.		

(ii) From your observations, what is present in both salts?

.....

[4]

(b) Prepare solutions of **FA 6** and **FA 7** by placing the rest of each solid into separate 100 cm³ beakers. Add approximately 30 cm³ of distilled water to each beaker and stir until fully dissolved. Use these solutions for tests in (b).

- (i) Carry out tests to determine the cation present in each solution.
Record your tests and results in the space below.

(ii) Carry out all the following tests and record your observations.

test	observations	
	solution of FA 6	solution of FA 7
To a 1 cm depth of solution in a test-tube add a 1 cm depth of barium chloride or barium nitrate, then		
add an excess of hydrochloric acid or nitric acid.		
To a 1 cm depth of solution in a test-tube add a 1 cm depth of silver nitrate.		

(iii) Identify the ions present in each salt.

FA 6 contains and

FA 7 contains and

[9]

[Total: 13]

Qualitative Analysis Notes

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)	faint white ppt. is nearly always observed unless 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	grey-green ppt. insoluble in excess
copper(II), Cu ²⁺ (aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe ²⁺ (aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe ³⁺ (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg ²⁺ (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn ²⁺ (aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn ²⁺ (aq)	white ppt. soluble in excess	white ppt. soluble in excess

2 Reactions of anions

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

The Periodic Table of Elements

Group																									
1	2	Key												13	14	15	16	17	18						
		atomic number atomic symbol name relative atomic mass												1 H hydrogen 1.0											
3	4																								
Li lithium 6.9	Be beryllium 9.0																								
11	12																								
Na sodium 23.0	Mg magnesium 24.3																								
19	20																								
K potassium 39.1	Ca calcium 40.1																								
37	38																								
Rb rubidium 85.5	Sr strontium 87.6																								
55	56																								
Cs caesium 132.9	Ba barium 137.3																								
87	88																								
Fr francium —	Ra radium —																								

CANDIDATE
NAME

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CHEMISTRY

9701/34

Paper 3 Advanced Practical Skills 2

October/November 2017

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

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

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

Qualitative Analysis Notes are printed on pages 10 and 11.
A copy of the Periodic Table is printed on page 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.

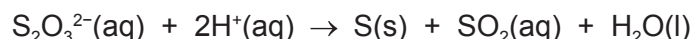
Session
Laboratory

For Examiner's Use	
1	
2	
Total	

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



- 1 Sodium thiosulfate reacts with acid to produce a pale yellow precipitate of sulfur.



You will investigate how the rate of this reaction varies with the concentration of thiosulfate ions. To do this you will measure the time taken for a fixed amount of sulfur to be formed.

FB 1 is 0.10 mol dm⁻³ sodium thiosulfate, Na₂S₂O₃.

FB 2 is 1.00 mol dm⁻³ hydrochloric acid, HCl.

(a) Method

Read through the instructions and prepare a table on page 3 for your results before starting any practical work. You will need to include volume of **FB 1**, volume of water, reaction time and rate of reaction for each of the five experiments.

Experiment 1

- Use the larger measuring cylinder to transfer 40 cm³ of **FB 1** into the 100 cm³ beaker.
- Use the smaller measuring cylinder to measure 25 cm³ of **FB 2**.
- Pour the **FB 2** into the **FB 1** in the beaker and start timing **immediately**.
- Stir the mixture in the beaker once and place the beaker on top of the printed insert provided.
- Look down through the solution in the beaker at the print on the insert.
- Stop timing as soon as the precipitate of sulfur makes the print on the insert **just** invisible.
- Record the reaction time to the nearest second.
- Empty, rinse and dry the beaker so it is ready for use in **Experiment 2**.
- Rinse the sink with tap water to wash away the products of the reaction.

Experiment 2

- Use the larger measuring cylinder to transfer 30 cm³ of **FB 1** into the 100 cm³ beaker.
- Use the same measuring cylinder to add 10 cm³ of distilled water to the beaker.
- Use the smaller measuring cylinder to add 25 cm³ of **FB 2** to the mixture in the beaker and start timing **immediately**.
- Stir the mixture in the beaker once and place the beaker on top of the printed insert provided.
- Look down through the solution in the beaker at the print on the insert.
- Stop timing as soon as the precipitate of sulfur makes the print on the insert **just** invisible.
- Record the reaction time to the nearest second.
- Empty, rinse and dry the beaker so it is ready for use in **Experiment 3**.
- Rinse the sink with tap water to wash away the products of the reaction.

Experiment 3

Repeat **Experiment 2** using 20 cm³ of **FB 1**, 20 cm³ of distilled water and 25 cm³ of **FB 2**.

Experiments 4 and 5

Choose suitable volumes that will enable you to investigate further the effect of changing the concentration of thiosulfate ions on the rate of the reaction. You should not use a volume of less than 10 cm³ of **FB 1**.

Results

The rate of the reaction can be calculated as shown.

$$\text{rate} = \frac{1000}{\text{reaction time}}$$

Calculate the rate of reaction for each experiment and complete the table.

I	
II	
III	
IV	
V	
VI	
VII	
VIII	
IX	
X	

[10]

- (b) On the grid plot a graph of rate of reaction (y -axis) against volume of **FB 1** (x -axis). Circle any points that you consider anomalous and draw a line of best fit to show how the rate of the reaction depends on the volume of **FB 1**.

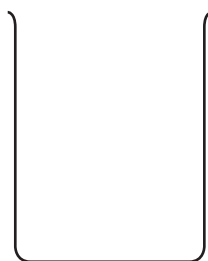


[3]

- (c) Use your graph to calculate the time that the reaction would have taken if 8 cm^3 of **FB 1** had been used. Show on the grid how you obtained your answer.

time = ... s [2]

- (d) (i) A student broke the 100 cm^3 beaker when carrying out the experiment and decided to use a petri dish instead. This has a different shape.



beaker



petri dish

State and explain what effect this would have on the student's results.

.....

.....

.....

- (ii) Another student suggested that the experiment could be improved by using a less concentrated solution of sodium thiosulfate.

Explain whether this suggestion would improve the accuracy of the results.

.....

.....

.....

[4]

- (e) Calculate the maximum percentage error in the reaction time for **Experiment 1**. Show how you obtained your answer.

maximum percentage error = ... % [1]

- (f) Using a similar method to (a), explain how you would investigate how the rate of the reaction varies with changes in the concentration of hydrochloric acid.

.....

.....

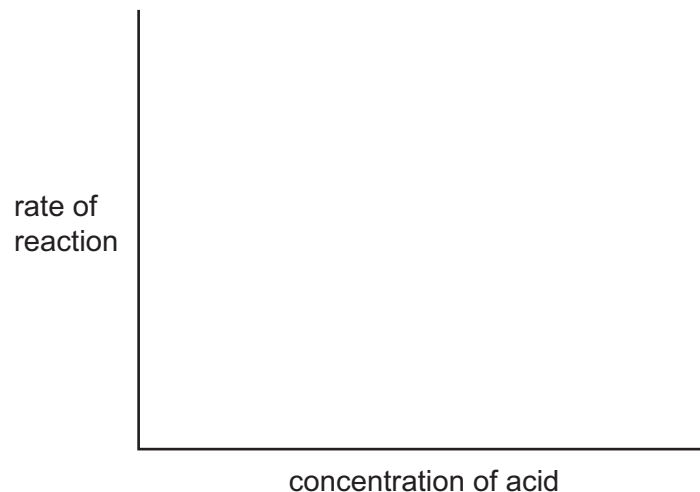
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..... [3]

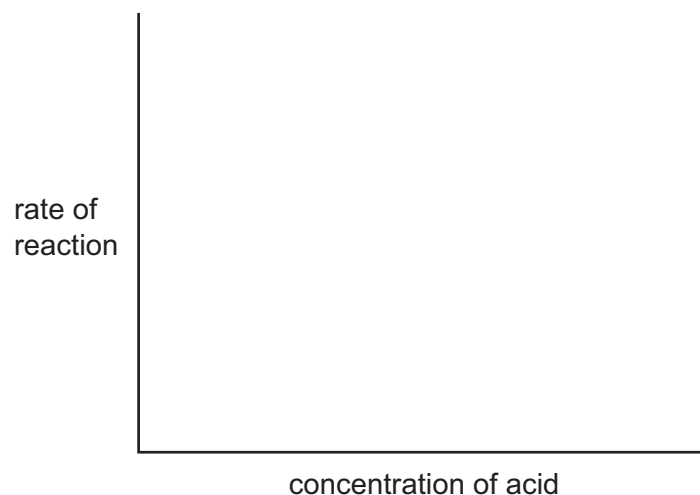
- (g) An experiment to investigate the effect of changing the concentration of hydrochloric acid gave results that could be plotted to produce a graph.

On the axes, sketch the graph that would show that:

- (i) the rate of reaction was directly proportional to the concentration of acid,



- (ii) the rate of reaction did **not** depend on the concentration of acid.



[2]

[Total: 25]

2 Qualitative Analysis

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

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

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

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

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

No additional tests for ions present should be attempted.

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

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

(a) FB 3, FB 4, FB 5 and FB 6 are aqueous solutions each containing one cation and one anion.

- (i)** Carry out the following tests by adding, to a 1 cm depth of each solution in a test-tube, a 1 cm depth of the other solution. Record your observations in the table.

test	observations		
	FB 4	FB 5	FB 6
FB 3			
FB 4			
FB 5			

- (ii) **FB 3** and **FB 4** both contain the same anion.

Use your observations from (i) to suggest the identity of this anion.

anion:

- (iii) Suggest and carry out a test to confirm the identity of the anion you identified in (ii). You should include the test and your result.

test

result

- (iv) **FB 5** contains one cation from those listed in the Qualitative Analysis Notes.

Use your observations in (i) to suggest **two** cations that could be present in **FB 5**.

cations present or

- (v) Suggest and carry out a test to identify which of the cations you suggested in (iv) is present in **FB 5**.

test

result

cation present in **FB 5**

[9]

(b) **FB 7**, **FB 8** and **FB 9** are aqueous solutions.

(i) Carry out the following tests and record your observations.

<i>test</i>	<i>observations</i>		
	FB 7	FB 8	FB 9
To a 1 cm depth of solution in a test-tube add a 1 cm depth of aqueous potassium iodide, then			
add aqueous starch.			
To a 1 cm depth of solution in a test-tube add a 1 cm depth of aqueous iodine.			
To a 1 cm depth of solution in a test-tube add a few drops of aqueous barium nitrate or aqueous barium chloride.			

(ii) From your observations in (i) suggest **two** anions from those listed in the Qualitative Analysis Notes that could be present in **FB 9**.

anions present or

(iii) Suggest and carry out a test to identify which of the anions you suggested in (ii) is present in **FB 9**.

test

result

anion present in **FB 9**

[6]

[Total: 15]

Qualitative Analysis Notes

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)	faint white ppt. is nearly always observed unless 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	grey-green ppt. insoluble in excess
copper(II), Cu ²⁺ (aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe ²⁺ (aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe ³⁺ (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg ²⁺ (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn ²⁺ (aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn ²⁺ (aq)	white ppt. soluble in excess	white ppt. soluble in excess

2 Reactions of anions

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

Group																						
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														1 H hydrogen 1.0								2 He helium 4.0
																				Key		
																				atomic number atomic symbol name relative atomic mass		
3 Li lithium 6.9	4 Be beryllium 9.0													5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2			
11 Na sodium 23.0	12 Mg magnesium 24.3													13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9			
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8					
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium —	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3					
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids		72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium —	85 At astatine —	86 Rn radon —				
87 Fr francium —	88 Ra radium —	89–103 actinoids		104 Rf rutherfordium —	105 Db dubnium —	106 Sg seaborgium —	107 Bh bohrium —	108 Hs hassium —	109 Mt meitnerium —	110 Ds darmstadtium —	111 Rg roentgenium —	112 Cn copernicium —	113 Nh nihonium —	114 Fl flerovium —	115 Lv livermorium —	116 Ts tennessine —	117 Og oganeson —	118 — — —				

lanthanoids

actinoids

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
lanthanum	cerium	praseodymium	neodymium	promethium	samarium	euroium	gadolinium	terbium	dysprosium	holmium	erbium	thulium	ytterbium	lutetium
138.9	140.1	140.9	144.4	—	150.4	152.0	157.3	158.9	162.5	164.9	167.3	168.9	173.1	175.0
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
actinium	thorium	protactinium	uranium	neptunium	plutonium	americium	curium	berkelium	californium	einsteinium	fermium	mendeleevium	nobelium	lawrencium
—	232.0	231.0	238.0	—	—	—	—	—	—	—	—	—	—	—

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NUMBER

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CHEMISTRY

9701/35

Paper 3 Advanced Practical Skills 1

October/November 2017

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.
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DO NOT WRITE IN ANY BARCODES.

Answer **all** questions.
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You may lose marks if you do not show your working or if you do not use appropriate units.
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A copy of the Periodic Table is printed on page 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 In this experiment you will determine the oxidation number of iodine in one of its compounds by titration.

FA 1 is a $0.0197 \text{ mol dm}^{-3}$ solution of the iodine-containing compound.

FA 2 is dilute sulfuric acid, H_2SO_4 .

FA 3 is aqueous potassium iodide, KI .

FA 4 is $0.105 \text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.
starch indicator

FA 1 reacts with excess acidified potassium iodide to produce iodine, I_2 . This iodine is then titrated with aqueous sodium thiosulfate using starch indicator.

(a) Method

- Fill the burette with **FA 4**.
- Pipette 25.0 cm^3 of **FA 1** into a conical flask.
- Using the measuring cylinder, add 10 cm^3 of **FA 2** to the same conical flask.
- Using the same measuring cylinder, add 20 cm^3 of **FA 3** to the mixture in the conical flask. The mixture will now be a red-brown colour, due to iodine produced.
- Carry out a rough titration by adding **FA 4** from the burette until the mixture becomes light brown.
- Then add 10 drops of starch indicator. The mixture will change to a dark blue colour.
- Continue titrating until the mixture becomes colourless. This is the end-point.

The rough titre is cm^3 .

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make sure any recorded results show the precision of your practical work.
- Record in a suitable form below all of your burette readings and the volume of **FA 4** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

- (b)** From your accurate titration results, obtain a suitable value for the volume of **FA 4** to be used in your calculations. Show clearly how you obtained this value.

The iodine produced required cm^3 of **FA 4**. [1]

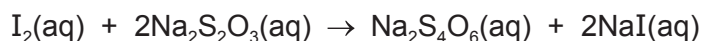
(c) Calculations

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

- (i) Calculate the number of moles of sodium thiosulfate in the volume of **FA 4** calculated in (b).

moles of $\text{Na}_2\text{S}_2\text{O}_3 = \dots\dots\dots \text{mol}$

- (ii) The equation for the reaction of iodine with sodium thiosulfate is shown.



Calculate the number of moles of iodine that reacted with the sodium thiosulfate calculated in (i).

moles of $\text{I}_2 = \dots\dots\dots \text{mol}$

- (iii) Use the information on page 2 to calculate the number of moles of iodine-containing compound in the 25 cm^3 of **FA 1** used in each titration.

moles of iodine-containing compound in 25 cm^3 **FA 1** = $\dots\dots\dots \text{mol}$

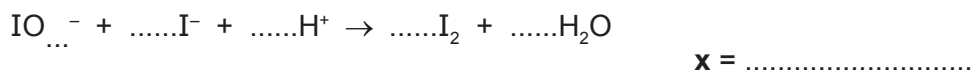
- (iv) Use your answers to (ii) and (iii) to calculate the number of moles of iodine produced when 1 mole of the iodine-containing compound in **FA 1** reacts with excess **FA 3**. Give your answer as an integer.

moles of $\text{I}_2 = \dots\dots\dots \text{mol}$

- (v) The anion in **FA 1** is IO_x^- where **x** is the number of oxygen atoms present in the formula.

Use your answer to (iv) to balance the ionic equation for the reaction between **FA 1** and **FA 3** under acidic conditions.

Hence deduce the value of **x** in the formula IO_x^- .



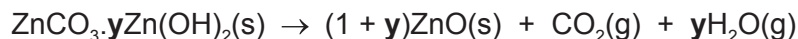
- (vi) Calculate the oxidation state of iodine in **FA 1**.
(If you were unable to calculate **x** in part (v), assume that **x** = 4.)

oxidation state of iodine = $\dots\dots\dots$
[6]

[Total: 14]

- 2 Zinc carbonate occurs in a basic form, which means that zinc hydroxide is also present. The chemical formula of basic zinc carbonate can be written as $\text{ZnCO}_3 \cdot y\text{Zn(OH)}_2$, where y may not be an integer. In this experiment you will heat basic zinc carbonate to decompose it and use your results to determine the value of y .

When basic zinc carbonate is heated, it decomposes as shown.



FA 5 is basic zinc carbonate, $\text{ZnCO}_3 \cdot y\text{Zn(OH)}_2$.

(a) Method

Read through the method before starting any practical work.

Prepare a table for all your results from Experiments 1 and 2 in the space on page 5.

Experiment 1

- Weigh a crucible with its lid and record the mass.
- Add 2.1–2.5 g of **FA 5** to the crucible. Weigh the crucible and lid with **FA 5** and record the mass.
- Place the crucible in the pipe-clay triangle on top of the tripod.
- Heat the crucible and contents gently for 1 minute with the lid on.
- Remove the lid. Heat the crucible and contents strongly, with the lid off, for approximately 4 minutes.
- Replace the lid and leave the crucible and residue to cool for at least 5 minutes, before re-weighing it with the lid on. Record the mass.
- **While the crucible is cooling, you may wish to begin work on Question 3.**
- Calculate, and record in your table, the mass of **FA 5** used and the mass of residue obtained.

- (i) State the observation(s) you made while you were heating **FA 5**.

.....

- (ii) State the observation(s) you made once the residue had cooled down.

.....

Experiment 2

- Repeat the procedure used in **Experiment 1**, using 1.5–1.9 g of **FA 5** and using the other crucible and lid.
- Record the three balance readings made during the experiment.
- Calculate and record the mass of **FA 5** used and the mass of residue obtained.

Results

I	
II	
III	
IV	
V	
VI	

[6]

(b) Calculations

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

- (i) Calculate the relative formula mass, M_r , of zinc hydroxide, $\text{Zn}(\text{OH})_2$.

M_r of $\text{Zn}(\text{OH})_2$ = ...

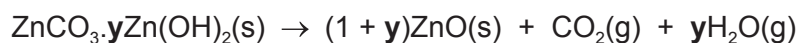
- (ii) Using your answer to (i), write down an expression, in terms of **y**, for the relative formula mass, M_r , of basic zinc carbonate, $\text{ZnCO}_3 \cdot y\text{Zn}(\text{OH})_2$.

M_r of $\text{ZnCO}_3 \cdot y\text{Zn}(\text{OH})_2$ = ...

- (iii) Using the mass of $\text{ZnCO}_3 \cdot y\text{Zn}(\text{OH})_2$ from **Experiment 1** and your answer to (ii), write down an expression, in terms of **y**, for the number of moles of $\text{ZnCO}_3 \cdot y\text{Zn}(\text{OH})_2$ that you heated in **Experiment 1**.

moles of $\text{ZnCO}_3 \cdot y\text{Zn}(\text{OH})_2$ = ... mol

- (iv) Using your answer to (iii) and the equation below, write an expression, in terms of **y**, for the number of moles of zinc oxide produced in **Experiment 1**.



moles of ZnO produced = ... mol

- (v) Use your results from **Experiment 1** to calculate the number of moles of zinc oxide, ZnO, obtained in the residue. You may assume complete decomposition has occurred.

moles of ZnO = ... mol

- (vi) Using your answers to (iv) and (v), calculate the value of **y** to one decimal place.

y = ...
[6]

- (c) (i) Apart from altering the balance or the masses of **FA 5** used, state **one** improvement you could make to the experimental procedure to improve its accuracy.

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

- (ii) Which experiment should be more accurate, **Experiment 1** or **Experiment 2**?
Explain your answer.

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

[2]

[Total: 14]

3 Qualitative Analysis

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

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

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

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

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

No additional tests for ions present should be attempted.

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

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

FA 6, **FA 7** and **FA 8** are solutions of salts.

Information about FA 6 , FA 7 and FA 8
• Each salt contains one cation and one anion. • One of the ions is sodium; the other five ions are listed in the Qualitative Analysis Notes. • Each salt contains a different nitrogen-containing ion. • FA 7 or FA 8 contains a halide ion.

(a) You will identify the **cations** present in **FA 6**, **FA 7** and **FA 8**.

To do this you will carry out **six** separate tests. You will use dilute sulfuric acid and aqueous sodium hydroxide separately with **FA 6**, **FA 7** and **FA 8**.

Use a 1 cm depth of each salt solution in a suitable tube for each test you carry out.

Record **all** of your observations in a table in the space below.

- (b) Name the reagents you would use to identify the halide ion present in either **FA 7** or **FA 8**.
Test **FA 7** and **FA 8** with these reagents and record your observations.

reagents used

unknown	observations	halide ion present ✓ / ✗
FA 7		
FA 8		

[2]

- (c) (i) Name the reagents you would use to confirm the presence of the nitrogen-containing **anions** in the two solutions that do **not** contain a halide ion. Test both solutions with these reagents and record your observations.

reagents used

unknown	observations
FA	
FA	

- (ii) Name the reagent you would use to positively identify one of the nitrogen-containing anions in the two solutions tested in (i). Test both solutions with this reagent. Record all your observations.

reagent used

unknown	observations
FA	
FA	

[4]

- (d) Use the information given in (a) and your observations in all tests to deduce the chemical formulae of the three salts.

FA 6 is **FA 7** is **FA 8** is

[2]

[Total: 12]

Qualitative Analysis Notes

1 Reactions of aqueous cations

<i>ion</i>	<i>reaction with</i>	
	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)	faint white ppt. is nearly always observed unless 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	grey-green ppt. insoluble in excess
copper(II), Cu ²⁺ (aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe ²⁺ (aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe ³⁺ (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg ²⁺ (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn ²⁺ (aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn ²⁺ (aq)	white ppt. soluble in excess	white ppt. soluble in excess

2 Reactions of anions

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

The Periodic Table of Elements

Group																									
1	2	Key												13	14	15	16	17	18						
		atomic number atomic symbol name relative atomic mass												1 H hydrogen 1.0											
3	4																								
Li lithium 6.9	Be beryllium 9.0																								
11	12																								
Na sodium 23.0	Mg magnesium 24.3																								
19	20																								
K potassium 39.1	Ca calcium 40.1																								
37	38																								
Rb rubidium 85.5	Sr strontium 87.6																								
55	56																								
Cs caesium 132.9	Ba barium 137.3																								
87	88																								
Fr francium —	Ra radium —																								

CANDIDATE
NAMECENTRE
NUMBER

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CANDIDATE
NUMBER

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CHEMISTRY

9701/36

Paper 3 Advanced Practical Skills 2

October/November 2017

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

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

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

Qualitative Analysis Notes are printed on pages 10 and 11.
A copy of the Periodic Table is printed on page 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

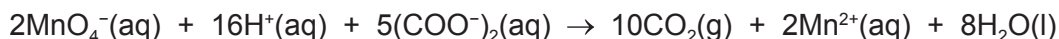
For Examiner's Use	
1	
2	
Total	

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

- 1 **FB 1** is a solution made by dissolving an unknown mass of a mixture of ethanedioic acid, $(\text{COOH})_2$, and sodium ethanedioate, $(\text{COONa})_2$. You will carry out two titrations to find the percentage by mass of ethanedioic acid in the mixture.

Titration 1

In aqueous solution both ethanedioic acid and sodium ethanedioate release all their ethanedioate ions, $(\text{COO}^-)_2$. These ions react with manganate(VII) ions as shown.



FB 1 is an aqueous solution of the mixture containing ethanedioic acid and sodium ethanedioate.

FB 2 is $0.0200 \text{ mol dm}^{-3}$ potassium manganate(VII), KMnO_4 .

FB 3 is 1.00 mol dm^{-3} sulfuric acid, H_2SO_4 .

(a) Method

- Fill a burette with **FB 2**.
- Pipette 25.0 cm^3 of **FB 1** into a conical flask.
- Use the measuring cylinder to add 30 cm^3 of **FB 3** to the same conical flask.
- Place the conical flask on the tripod and gauze and heat until the solution is at a temperature of approximately 70°C .
- **Carefully** remove the flask from the tripod and place it under the burette, ready for the titration.
- Add **FB 2** from the burette, slowly at first, until a permanent pale pink colour is formed. If the reaction mixture turns brown, reheat it to about 70°C . If the brown colour disappears, continue with the titration. If the brown colour remains, discard the contents of the flask and begin a new titration.
- Perform a rough titration and record your burette readings in the space below.

The rough titre is cm^3 .

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

I	
II	
III	
IV	
V	
VI	

[6]

- (b) From your accurate titration results, obtain a suitable value for the volume of **FB 2** to be used in your calculations.

Show clearly how you obtained this value.

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

(c) Calculations

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

- (i) Calculate the number of moles of manganate(VII) ions in the volume of **FB 2** calculated in (b).

moles of MnO_4^- = ... mol

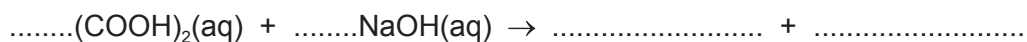
- (ii) Calculate the total number of moles of ethanedioate ions present in 25.0 cm³ of **FB 1**.

total moles of $(\text{COO}^-)_2$ = ... mol
[2]

Titration 2

Ethanedioic acid reacts with aqueous sodium hydroxide. In this reaction both the H^+ ions formed by the acid molecule react.

- (d) Complete the equation showing the reaction between ethanedioic acid and sodium hydroxide including state symbols.



[1]

FB 4 is $0.0400 \text{ mol dm}^{-3}$ sodium hydroxide, NaOH .
thymol blue indicator

(e) Method

- Fill the second burette with **FB 4**.
- Pipette 25.0 cm^3 of **FB 1** into a conical flask.
- Add about 10 drops of thymol blue indicator.
- Add **FB 4** from the burette until the end-point has been reached.
- Perform a rough titration and record your burette readings in the space below.

The rough titre is cm^3 .

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make sure any recorded results show the precision of your practical work.
- Record in a suitable form below all of your burette readings and the volume of **FB 4** added in each accurate titration.

[4]

(f) Calculations

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

- (i) From your accurate titration results, obtain a suitable value for the volume of **FB 4** to be used in your calculations.

25.0 cm³ of **FB 1** required cm³ of **FB 4**.

- (ii) Calculate the number of moles of sodium hydroxide in the volume of **FB 4** calculated in (i).

moles of NaOH = ... mol

- (iii) Use your equation from (d) to calculate the number of moles of ethanedioic acid present in 25.0 cm³ of **FB 1**.

moles of (COOH)₂ = ... mol
[1]

- (g) (i) Use your answers to (c)(ii) and (f)(iii) to calculate the number of moles of sodium ethanedioate, (COONa)₂, present in 25.0 cm³ of **FB 1**.

moles of (COONa)₂ = ... mol

- (ii) Calculate the mass of sodium ethanedioate present in 25.0 cm³ of **FB 1**.

mass of (COONa)₂ = ... g

- (iii) Use your answer to (f)(iii) to calculate the mass of ethanedioic acid present in 25.0 cm^3 of **FB 1**.

mass of $(\text{COOH})_2 = \dots\dots\dots \text{ g}$

- (iv) Calculate the percentage by mass of ethanedioic acid in the solid mixture used to prepare **FB 1**.

percentage by mass of $(\text{COOH})_2 = \dots\dots\dots \%$
[5]

- (h) A student checked the formula of ethanedioic acid on the internet and found it to be $(\text{COOH})_2 \cdot 2\text{H}_2\text{O}$. This differs from the formula $(\text{COOH})_2$ that you used in your calculations.

The **FB 1** you used was made from $(\text{COOH})_2 \cdot 2\text{H}_2\text{O}$ and sodium ethanedioate.

State and explain the effect this knowledge has on;

- (i) the volume of **FB 4** needed for reaction in (e),

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

- (ii) the calculated percentage by mass of $(\text{COOH})_2$ in the solid mixture used to prepare **FB 1**.

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

[2]

- (i) Another student suggested that the investigation could be improved by making the titrations more accurate. He said that the concentrations of **FB 2** and **FB 4** should be reduced.

State and explain whether or not this suggestion would make the titrations more accurate.

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

[Total: 23]

2 Qualitative Analysis

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

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

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

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

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

No additional tests for ions present should be attempted.

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

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

FB 5, **FB 6** and **FB 7** are aqueous solutions that each have an ion containing one of the metals from those listed in the Qualitative Analysis Notes.

(a) Carry out the following tests and record your observations.

<i>test</i>	<i>observations</i>
(i) To a 1 cm depth of FB 5 in a test-tube add a 1 cm depth of aqueous sodium hydroxide, then	
add several drops of hydrogen peroxide.	
(ii) To a 1 cm depth of FB 6 in a test-tube add aqueous sodium hydroxide.	
(iii) To a 1 cm depth of FB 6 in a test-tube add several drops of hydrogen peroxide and then add aqueous sodium hydroxide.	
(iv) To a 1 cm depth of FB 6 in a test-tube add a 1 cm depth of dilute sulfuric acid and then add a few drops of FB 7 .	
(v) To a 1 cm depth of FB 6 in a test-tube add a 1 cm depth of FB 7 .	
(vi) To a 1 cm depth of aqueous potassium iodide in a test-tube add a few drops of FB 7 , then	
add a few drops of aqueous starch.	

[8]

(b) Identify the metal present in **FB 5**, **FB 6** and **FB 7**.

FB 5 contains

FB 6 contains

FB 7 contains

[3]

- (c) What do your observations in (a)(vi) tell you about what has happened to the iodide ions on addition of **FB 7** to KI(aq)?

You may give your answer in the form of an equation.

..... [1]

- (d) (i) **FB 8** is a solid sample of the compound present in aqueous solution **FB 7**.
Heat all of **FB 8** in a hard-glass test-tube gently for about 10s and then strongly for about 20s.

observations

.....

- (ii) Leave the test-tube and contents to cool completely.

To the cooled test-tube add a 1 cm depth of aqueous sodium hydroxide. Observe the appearance of the contents of the test-tube.

appearance

[2]

- (e) **FB 6** contains one of the anions Cl^- , Br^- , I^- , SO_4^{2-} or SO_3^{2-} .

- (i) Construct a table to show reagents you would use to identify which anion is present in **FB 6**. Include in your table space to record your observations and deductions.

- (ii) Carry out your tests on **FB 6** until you have identified the anion. Record your observations and deductions in your table.

anion in **FB 6** = ... [3]

[Total: 17]

Qualitative Analysis Notes

1 Reactions of aqueous cations

<i>ion</i>	<i>reaction with</i>	
	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)	faint white ppt. is nearly always observed unless reagents are pure	no ppt.
calcium, Ca ²⁺ (aq)	white ppt. with high [Ca ²⁺ (aq)]	no ppt.
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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
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2 Reactions of anions

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iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$)
nitrate, $\text{NO}_3^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
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3 Tests for gases

<i>gas</i>	<i>test and test result</i>
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oxygen, O_2	relights a glowing splint

The Periodic Table of Elements

Group																											
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		atomic number atomic symbol name relative atomic mass												1 H hydrogen 1.0							2 He helium 4.0						
3 Li lithium 6.9	4 Be beryllium 9.0																										
11 Na sodium 23.0	12 Mg magnesium 24.3																										
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8										
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium —	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3										
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids		72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium —	85 At astatine —	86 Rn radon —									
87 Fr francium —	88 Ra radium —	89–103 actinoids		104 Rf rutherfordium —	105 Db dubnium —	106 Sg seaborgium —	107 Bh bohrium —	108 Hs hassium —	109 Mt meitnerium —	110 Ds darmstadtium —	111 Rg roentgenium —	112 Cn copernicium —	114 Fl flerovium —	116 Lv livermorium —													