Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	

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CHEMISTRY **9701/31**

Paper 3 Advanced Practical Skills 1 **October/November 2015**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

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

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.
A copy of the Periodic Table is printed on page 12.

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 **12** printed pages and **1** insert.

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1 In this experiment you will determine the ionic equation for the reaction of acidified potassium manganate(VII) with potassium iodide. Excess potassium iodide is used and the reaction produces iodine. The amount of iodine produced is measured by titration with sodium thiosulfate.

FA 1 is 0.0180 mol dm^{-3} potassium manganate(VII), $KMnO_4$.
FA 2 is 1.00 mol dm^{-3} sulfuric acid, H_2SO_4.
FA 3 is 0.500 mol dm^{-3} potassium iodide, KI.
FA 4 is 0.100 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
starch indicator

(a) Method

- Pipette 25.0 cm^3 of **FA 1** into a conical flask.
- Use the measuring cylinder to add 25 cm^3 of **FA 2** to the conical flask.
- Use the measuring cylinder to add 20 cm^3 of **FA 3** to the conical flask.
- Fill the burette with **FA 4**.
- Carry out a rough titration. When the colour of the mixture becomes yellow/orange, add a few drops of starch indicator. Then titrate until the mixture goes colourless.
- Record all 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 4** added in each accurate titration.

Keep FA 1 and FA 2 for use in Question 3 and FA 4 for use in Question 2.

I	
II	
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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 have obtained this value.

Volume of **FA 4** required is ..... cm^3. [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 $Na_2S_2O_3$ = ... mol

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

$$I_2 + 2Na_2S_2O_3 \rightarrow Na_2S_4O_6 + 2NaI$$

moles of I_2 = ... mol

(iii) Use information on page 2 to calculate the number of moles of potassium manganate(VII) in **FA 1** used in the titration.

moles of $KMnO_4$ = ... mol

(iv) From your answers to **(ii)** and **(iii)**, calculate the number of moles of iodine produced by the reaction of **2.00** moles of potassium manganate(VII) with excess potassium iodide.

moles I_2 = ... mol

(v) Using your answer to **(iv)**, put a tick next to the ionic equation that represents the reaction between **FA 1** and **FA 3**.

$2MnO_4^- + 2I^- + 16H^+ \rightarrow I_2 + 2Mn^{6+} + 8H_2O$ .....

$2MnO_4^- + 4I^- + 16H^+ \rightarrow 2I_2 + 2Mn^{5+} + 8H_2O$ .....

$2MnO_4^- + 6I^- + 16H^+ \rightarrow 3I_2 + 2Mn^{4+} + 8H_2O$ .....

$2MnO_4^- + 8I^- + 16H^+ \rightarrow 4I_2 + 2Mn^{3+} + 8H_2O$ .....

$2MnO_4^- + 10I^- + 16H^+ \rightarrow 5I_2 + 2Mn^{2+} + 8H_2O$ .....

$2MnO_4^- + 12I^- + 16H^+ \rightarrow 6I_2 + 2Mn^{+} + 8H_2O$ .....

(vi) Prove that the iodide ion has been oxidised in the equation that you selected in **(v)**.

.....

.....

.....
[5]

(d) (i) The error in calibration of the pipette you used is $\pm 0.06\,cm^3$.
Calculate the percentage error when measuring **FA 1**, using the pipette.

percentage error = ... %

(ii) A student suggested that the experiment would be more accurate if a pipette was used to measure solution **FA 3**.
State and explain whether you agree with the student.

.....

.....

.....
[2]

[Total: 15]

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2 In this experiment you will investigate how the rate of reaction between sodium thiosulfate and hydrochloric acid is affected by the concentration of the acid.

When aqueous thiosulfate ions react with hydrogen ions, H^+, in any acid, a pale yellow precipitate of sulfur is formed. The ionic equation for this reaction is given below.

$$S_2O_3^{2-}(aq) + 2H^+(aq) \rightarrow S(s) + SO_2(aq) + H_2O(l)$$

The rate of the reaction can be determined by measuring the time taken to produce a fixed quantity of sulfur.

FA 4 is 0.10 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
FA 5 is 0.20 mol dm^{-3} hydrochloric acid, HC*l*.

(a) Method

Record **all** your measurements, in an appropriate form, in the space below.

Experiment 1

- Use the larger measuring cylinder to transfer 40 cm^3 of **FA 4** into the 100 cm^3 beaker.
- Rinse the larger measuring cylinder thoroughly with water, then add 30 cm^3 of **FA 5** to the beaker and start timing **immediately**.
- Stir the mixture once and place the beaker on top of the printed insert page 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 invisible.
- Record the reaction time to the **nearest second**.
- Empty and rinse the 100 cm^3 beaker.
- Dry the outside of the beaker ready for Experiment 2.

Experiment 2

- Rinse the larger measuring cylinder, then use it to transfer 40 cm^3 of **FA 4** into the 100 cm^3 beaker.
- Use the smaller measuring cylinder to add 10 cm^3 of distilled water to the beaker.
- Use the same measuring cylinder to add 20 cm^3 of **FA 5** to the mixture in the beaker and start timing **immediately**.
- Stir the mixture once and place the beaker on top of the printed insert page provided.
- Stop timing as soon as the print on the insert becomes invisible.
- Record the reaction time to the **nearest second**.
- Empty and rinse the 100 cm^3 beaker.
- Dry the outside of the beaker ready for Experiment 3.

Experiment 3

- Carry out the reaction using a mixture of 40 cm^3 of **FA 4**, 20 cm^3 of distilled water and 10 cm^3 of **FA 5**.
- Measure and record the reaction time to the **nearest second**.

I	
II	
III	
IV	

[4]

(b) (i) The 'rate of reaction' can be represented by the formula below.

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

Use this formula to calculate the 'rate of reaction' for Experiments 1 and 3.
Give the unit.

'rate of reaction' for Experiment 1 ..... unit .....

'rate of reaction' for Experiment 3 ..... unit .....

(ii) Calculate the initial concentrations of hydrochloric acid in the reaction mixtures in Experiments 1 and 3.

initial concentration of HCl in Experiment 1 = ... $mol\,dm^{-3}$

initial concentration of HCl in Experiment 3 = ... $mol\,dm^{-3}$

(iii) How is the 'rate of reaction' affected by the concentration of hydrochloric acid in the mixture?

.....

.....

(iv) Predict how the reaction time measured in Experiment 1 would have been affected if the experiment had been carried out using 0.20 $mol\,dm^{-3}$ sulfuric acid instead of 0.20 $mol\,dm^{-3}$ hydrochloric acid.
Explain your answer.

.....

.....

.....

(v) Predict how the reaction time measured in Experiment 3 would have been affected if the experiment had been carried out in a 250 cm^3 beaker instead of a 100 cm^3 beaker.
Explain your answer.

.....

.....

[5]

[Total: 9]

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3 Qualitative Analysis

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

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

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

You should indicate clearly at what stage in a test a change occurs.
No additional tests for ions present should be attempted.

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

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

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

(a) **FA 6** is a sodium compound containing one anion listed on page 11.

Dissolve the **FA 6** provided in about 15 cm^3 of distilled water in a boiling tube.
Carry out the following tests and record your observations in the table below.

test	*observations*
(i) To a 1cm depth of the solution of **FA 6** in a test-tube, add a few drops of aqueous barium chloride or aqueous barium nitrate, then	
add dilute hydrochloric acid.	
(ii) To a 1cm depth of the solution of **FA 6** in a test-tube, add an equal volume of aqueous hydrogen peroxide, then	
add a few drops of aqueous barium chloride or aqueous barium nitrate, then	
add dilute hydrochloric acid.	

test	*observations*
(iii) To a 1 cm depth of the solution of **FA 6** in a boiling tube, add an equal volume of **FA 2**, sulfuric acid, then	
heat the mixture **gently and cautiously**.	
(iv) To a 1 cm depth of the solution of **FA 6** in a test-tube, add an equal volume of aqueous sodium hydroxide, then	
add a few drops of **FA 1**, aqueous potassium manganate(VII), then	
add **FA 2**, sulfuric acid.	

(v) Identify the anion in **FA 6**, and state **one** piece of evidence for your identification.

anion .....

evidence .....

.....

.....

(vi) Give the chemical equation for the reaction between **FA 6** and hydrogen peroxide, H_2O_2, in test **(ii)**. State symbols are **not** required.

.....

[7]

(b) **FA 7**, **FA 8**, **FA 9** and **FA 10** each contain one cation from the list on page 10.
You will attempt to identify the cations by testing with aqueous sodium hydroxide and aqueous ammonia.
In each case, use a 1 cm depth of the solution in a test-tube.

(i) Complete the table below.

test	*observations*			
	FA 7	**FA 8**	**FA 9**	**FA 10**
add sodium hydroxide				
add aqueous ammonia				

(ii) Use your observations to identify, as far as possible, the cation present in each solution. If alternative identities are possible, state this clearly.

FA 7 cation .....

FA 8 cation .....

FA 9 cation .....

FA 10 cation .....

(iii) Give the ionic equation for the reaction of **one** of your cations with a few drops of sodium hydroxide. State symbols are **not** required.

.....

(iv) The precipitates obtained when alkalis are added to solutions of certain cations are sometimes difficult to see. Suggest how, using no additional apparatus, the experiment could be repeated in a way that would make these precipitates more visible.

.....

.....
[9]

[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
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

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2 Reactions of anions

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, Cl^-(aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq))
bromide, Br^-(aq)	gives cream ppt. with Ag^+(aq) (partially soluble in NH_3(aq))
iodide, I^-(aq)	gives yellow ppt. with Ag^+(aq) (insoluble in NH_3(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 → (pale) brown NO_2 in air)
sulfate, SO_4^{2-}(aq)	gives white ppt. with Ba^{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

gas	*test and test result*
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	“pops” with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns acidified aqueous potassium manganate(VII) from purple to colourless

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The Periodic Table of the Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
							1.0 **H** Hydrogen 1										4.0 **He** Helium 2
6.9 **Li** Lithium 3	9.0 **Be** Beryllium 4											10.8 **B** Boron 5	12.0 **C** Carbon 6	14.0 **N** Nitrogen 7	16.0 **O** Oxygen 8	19.0 **F** Fluorine 9	20.2 **Ne** Neon 10
23.0 **Na** Sodium 11	24.3 **Mg** Magnesium 12											27.0 **Al** Aluminium 13	28.1 **Si** Silicon 14	31.0 **P** Phosphorus 15	32.1 **S** Sulfur 16	35.5 **Cl** Chlorine 17	39.9 **Ar** Argon 18
39.1 **K** Potassium 19	40.1 **Ca** Calcium 20	45.0 **Sc** Scandium 21	47.9 **Ti** Titanium 22	50.9 **V** Vanadium 23	52.0 **Cr** Chromium 24	54.9 **Mn** Manganese 25	55.8 **Fe** Iron 26	58.9 **Co** Cobalt 27	58.7 **Ni** Nickel 28	63.5 **Cu** Copper 29	65.4 **Zn** Zinc 30	69.7 **Ga** Gallium 31	72.6 **Ge** Germanium 32	74.9 **As** Arsenic 33	79.0 **Se** Selenium 34	79.9 **Br** Bromine 35	83.8 **Kr** Krypton 36
85.5 **Rb** Rubidium 37	87.6 **Sr** Strontium 38	88.9 **Y** Yttrium 39	91.2 **Zr** Zirconium 40	92.9 **Nb** Niobium 41	95.9 **Mo** Molybdenum 42	**Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La** Lanthanum 57 *	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	**Po** Polonium 84	**At** Astatine 85	**Rn** Radon 86
Fr Francium 87	**Ra** Radium 88	**Ac** Actinium 89 †	**Rf** Rutherfordium 104	**Db** Dubnium 105	**Sg** Seaborgium 106	**Bh** Bohrium 107	**Hs** Hassium 108	**Mt** Meitnerium 109	**Uun** Ununnilium 110	**Uuu** Unununium 111	**Uub** Ununbium 112		**Uuq** Ununquadium 114		**Uuh** Ununhexium 116		**Uuo** Ununoctium 118

*	140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	**Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	163 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70	175 **Lu** Lutetium 71
†	**Th** Thorium 90	**Pa** Protactinium 91	**U** Uranium 92	**Np** Neptunium 93	**Pu** Plutonium 94	**Am** Americium 95	**Cm** Curium 96	**Bk** Berkelium 97	**Cf** Californium 98	**Es** Einsteinium 99	**Fm** Fermium 100	**Md** Mendelevium 101	**No** Nobelium 102	**Lr** Lawrencium 103

*58-71 Lanthanides
†90-103 Actinides

Key

a **X** b	a = relative atomic mass **X** = atomic symbol b = proton (atomic) number

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Answer **all** questions.
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1 The formula of hydrated copper(II) sulfate is $CuSO_4.xH_2O$ where ***x*** is the number of moles of water of crystallisation in one mole of salt. You will determine the value of ***x*** by titration.

When aqueous copper(II) ions react with aqueous iodide ions, I^-, iodine is produced.

$$2Cu^{2+}(aq) + 4I^-(aq) \rightarrow I_2(aq) + 2CuI(s)$$

The amount of iodine, I_2, produced can be found by titrating it with aqueous thiosulfate ions, $S_2O_3^{2-}$.

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

FA 1 is aqueous $CuSO_4.xH_2O$ containing 26.2 g dm^{-3}.
FA 2 is 0.100 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
FA 3 is aqueous potassium iodide, KI.
starch indicator

(a) Method

- Pipette 25.0 cm^3 of **FA 1** into a conical flask.
- Use the measuring cylinder to add 15 cm^3 of **FA 3**, an excess of KI, to the conical flask. The solution will turn brown because iodine is formed.
- Fill the burette with **FA 2**.
- Add **FA 2** from the burette until the colour of the mixture changes to pale brown.
- Add 10 drops of starch indicator. The mixture will turn blue-black.
- Continue adding **FA 2** from the burette until the dark colour suddenly disappears to leave an off-white solid. This is the end point of the titration.
- Carry out 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 certain any recorded results show the precision of your practical work.
- Record in a suitable form below, all your burette readings and the volume of **FA 2** added in each accurate titration.

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

(c) Calculations

Show your working and appropriate significant figures in **each** step of your calculations.

(i) Calculate the number of moles of thiosulfate ions present in the volume of **FA 2** you have calculated in **(b)**.

moles of $S_2O_3^{2-}$ = ... mol

(ii) Use your answer to **(i)**, and the equations for the reactions involved, to deduce the number of moles of Cu^{2+} present in 25.0 cm^3 of **FA 1**.

$$2Cu^{2+}(aq) + 4I^-(aq) \rightarrow I_2(aq) + 2CuI(s)$$

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

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

(iii) Use your answer to **(ii)** and the mass of $CuSO_4.\boldsymbol{x}H_2O$ present in the solution, to calculate the relative molecular mass, M_r, of $CuSO_4.\boldsymbol{x}H_2O$.

M_r of $CuSO_4.\boldsymbol{x}H_2O$ = ...

(iv) Determine the value of ***x***.
(Use data from the Periodic Table on page 12.)

x = ...
[6]

[Total: 14]

2 **FA 4** is an impure sample of hydrated calcium chloride, $CaCl_2.2H_2O$. On heating, hydrated calcium chloride loses its water of crystallisation.

$$CaCl_2.2H_2O(s) \rightarrow CaCl_2(s) + 2H_2O(g)$$

You will determine the purity of **FA 4** by measuring the loss in mass that occurs when it is heated. The impurity present in **FA 4** is not decomposed on heating.

(a) Method

You should read the instructions carefully before starting any practical work and draw a table for your results in the space below.

- Weigh a crucible and record its mass.
- Add between 1.80 g and 2.00 g of **FA 4** into the crucible.
- Reweigh the crucible and its contents and record the mass.
- Place the crucible on the pipe-clay triangle and heat gently for 1 minute and then strongly for a further 2 minutes.
- Allow the crucible and its contents to cool. Reweigh the crucible and contents and record the mass.
- Heat the crucible strongly for a further 2 minutes. Allow it to cool. Reweigh the crucible and contents and record the mass.
- Repeat the heating, cooling and weighing until you are satisfied that all the water of crystallisation has been removed.
- Calculate and record the mass of **FA 4** used and the total mass of water lost.

While you are waiting for the crucible to cool, you may wish to start work on Question 3.

I	
II	
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VI	

[6]

(b) Calculations

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

(i) The percentage loss in mass on heating is defined as

$$\frac{\text{the loss in mass on heating}}{\text{the original mass}} \times 100.$$

Calculate the percentage loss in mass of **FA 4**.

percentage loss in mass = ... %

(ii) Calculate the percentage loss in mass when **pure** hydrated calcium chloride, $CaCl_2.2H_2O$, is heated.

percentage loss in mass = ... %

(iii) Use your results to **(i)** and **(ii)** to calculate the percentage purity of **FA 4**, impure $CaCl_2.2H_2O$.

percentage purity = ... %
[3]

(c) A student carried out this experiment using 2.60 g of **FA 4**.

Suggest whether this experiment would give a more accurate result for the percentage purity of **FA 4**. Explain your answer.

.....

..... [1]

(d) In your calculations you assumed that the impurity in **FA 4** does not decompose on heating.

State how the percentage purity that you calculated in **(b)(iii)** would change if the impurity were to decompose on heating.
Explain your answer.

.....

..... [1]

[Total: 11]

3 Qualitative Analysis

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

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

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

You should indicate clearly at what stage in a test a change occurs.
No additional tests for ions present should be attempted.

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

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

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

(a) (i) **FA 5**, **FA 6** and **FA 7** are aqueous solutions each containing one anion and one cation.

Carry out the experiments described below and record your observations for each solution in the table.

	FA 5	**FA 6**	**FA 7**
To a 1 cm depth in a test-tube, add a 1 cm depth of aqueous sodium carbonate.			
To a 1 cm depth in a test-tube, add a 1 cm depth of aqueous copper(II) sulfate.			
To a 1 cm depth in a test-tube, add a 1 cm depth of aqueous barium chloride or aqueous barium nitrate.			

(ii) What ion is present in **both FA 6** and **FA 7**?

.....

(iii) The anion in **FA 5** is one of carbonate, chloride, nitrate or sulfate.

Which anion is present in **FA 5**?

.....

(iv) Write the ionic equation, including state symbols, for the reaction between **FA 5** and aqueous copper(II) sulfate.

.....

[7]

(b) **FA 8** contains two anions and two cations from the lists on pages 10 and 11.

- To a 5 cm depth of distilled water in a boiling tube, add all the **FA 8**.
- Shake the boiling tube thoroughly for one minute to make sure that no more of the solid will dissolve.
- Filter the mixture into a clean boiling tube.
- Place the filter funnel in a conical flask and wash the residue with a little distilled water.
- **Keep both filtrate and residue for tests (i) and (ii) below.**

(i) Tests on the filtrate (the solution in the boiling tube)

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

test	*observations*
To a 1 cm depth of the filtrate in a test-tube, add aqueous sodium hydroxide, then	
add aqueous hydrogen peroxide.	

(ii) Tests on the residue

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

test	*observations*
Place the funnel containing the residue into a clean boiling tube. Pour approximately 5 cm^3 of dilute nitric acid onto the residue. Collect a 1 cm depth of solution in the boiling tube. Remove the funnel and return it to the conical flask.	
To this solution in the boiling tube, add aqueous sodium hydroxide.	

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(iii) Identify **two** cations present in **FA 8**.

cations present ..... and .....

(iv) Identify **one** anion present in **FA 8**.

anion present .....

(v) Suggest what type of reaction is happening when hydrogen peroxide is added in test **(b)(i)**.

.....
[8]

[Total: 15]

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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
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

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2 Reactions of anions

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, Cl^-(aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq))
bromide, Br^-(aq)	gives cream ppt. with Ag^+(aq) (partially soluble in NH_3(aq))
iodide, I^-(aq)	gives yellow ppt. with Ag^+(aq) (insoluble in NH_3(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 → (pale) brown NO_2 in air)
sulfate, SO_4^{2-}(aq)	gives white ppt. with Ba^{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

gas	*test and test result*
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	“pops” with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns acidified aqueous potassium manganate(VII) from purple to colourless

The Periodic Table of the Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
							1.0 **H** Hydrogen 1										4.0 **He** Helium 2
6.9 **Li** Lithium 3	9.0 **Be** Beryllium 4											10.8 **B** Boron 5	12.0 **C** Carbon 6	14.0 **N** Nitrogen 7	16.0 **O** Oxygen 8	19.0 **F** Fluorine 9	20.2 **Ne** Neon 10
23.0 **Na** Sodium 11	24.3 **Mg** Magnesium 12											27.0 **Al** Aluminium 13	28.1 **Si** Silicon 14	31.0 **P** Phosphorus 15	32.1 **S** Sulfur 16	35.5 **Cl** Chlorine 17	39.9 **Ar** Argon 18
39.1 **K** Potassium 19	40.1 **Ca** Calcium 20	45.0 **Sc** Scandium 21	47.9 **Ti** Titanium 22	50.9 **V** Vanadium 23	52.0 **Cr** Chromium 24	54.9 **Mn** Manganese 25	55.8 **Fe** Iron 26	58.9 **Co** Cobalt 27	58.7 **Ni** Nickel 28	63.5 **Cu** Copper 29	65.4 **Zn** Zinc 30	69.7 **Ga** Gallium 31	72.6 **Ge** Germanium 32	74.9 **As** Arsenic 33	79.0 **Se** Selenium 34	79.9 **Br** Bromine 35	83.8 **Kr** Krypton 36
85.5 **Rb** Rubidium 37	87.6 **Sr** Strontium 38	88.9 **Y** Yttrium 39	91.2 **Zr** Zirconium 40	92.9 **Nb** Niobium 41	95.9 **Mo** Molybdenum 42	**Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La** Lanthanum 57 *	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	**Po** Polonium 84	**At** Astatine 85	**Rn** Radon 86
Fr Francium 87	**Ra** Radium 88	**Ac** Actinium 89 †	**Rf** Rutherfordium 104	**Db** Dubnium 105	**Sg** Seaborgium 106	**Bh** Bohrium 107	**Hs** Hassium 108	**Mt** Meitnerium 109	**Uun** Ununnilium 110	**Uuu** Unununium 111	**Uub** Ununbium 112		**Uuq** Ununquadium 114		**Uuh** Ununhexium 116		**Uuo** Ununoctium 118

*	140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	**Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	163 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70	175 **Lu** Lutetium 71
†	**Th** Thorium 90	**Pa** Protactinium 91	**U** Uranium 92	**Np** Neptunium 93	**Pu** Plutonium 94	**Am** Americium 95	**Cm** Curium 96	**Bk** Berkelium 97	**Cf** Californium 98	**Es** Einsteinium 99	**Fm** Fermium 100	**Md** Mendelevium 101	**No** Nobelium 102	**Lr** Lawrencium 103

*58-71 Lanthanides
†90-103 Actinides

Key

a
X
b

a = relative atomic mass
X = atomic symbol
b = proton (atomic) number

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Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER				

9629032111

CHEMISTRY **9701/34**

Paper 3 Advanced Practical Skills 2 **October/November 2015**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

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

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

Qualitative Analysis Notes are printed on pages 10 and 11.
A 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

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1	
2	
3	
Total	

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

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1 In this experiment you will determine the relative atomic mass, A_r, of magnesium by a titration method.

FB 1 is 2.00 mol dm^{-3} hydrochloric acid, HC*l*.
FB 3 is 0.120 mol dm^{-3} sodium hydroxide, NaOH.
magnesium ribbon
bromophenol blue indicator

(a) Method

Reaction of magnesium with FB 1

- Pipette 25.0 cm^3 of **FB 1** into the 250 cm^3 beaker.
- Weigh the strip of magnesium ribbon and record its mass.

mass of magnesium = ... g

- Coil the strip of magnesium ribbon loosely and then add it to the **FB 1** in the beaker.
- Stir the mixture occasionally and wait until the reaction has finished.

Dilution of the excess acid

- Transfer all the solution from the beaker into the volumetric flask.
- Make the solution up to the mark using distilled water.
- Shake the flask to mix the solution before using it for your titrations.
- Label this solution of hydrochloric acid **FB 2**.

Titration

- Fill the burette with **FB 2**.
- Rinse the pipette out thoroughly. Then pipette 25.0 cm^3 of **FB 3** into a conical flask.
- Add several drops of bromophenol blue indicator.
- Perform a rough titration, by running the solution from the burette into the conical flask until the mixture just becomes yellow.
- 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	
VII	

[7]

(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 have obtained this value.

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

(c) Calculations

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

(i) Calculate the number of moles of sodium hydroxide present in 25.0 cm^3 of solution **FB 3**.

moles of NaOH = ... mol

(ii) Give the equation for the reaction of hydrochloric acid, HCl, with sodium hydroxide, NaOH. State symbols are **not** required.

.....

Deduce the number of moles of hydrochloric acid in the volume of **FB 2** you calculated in **(b)**.

moles of HCl = ... mol

(iii) Calculate the number of moles of hydrochloric acid in 250 cm^3 of **FB 2**.

moles of HCl in 250 cm^3 of **FB 2** = ... mol

(iv) Calculate the number of moles of hydrochloric acid in 25.0 cm^3 of **FB 1**.

moles of HCl in 25.0 cm^3 of **FB 1** = ... mol

(v) In **(a)**, you reacted 25.0 cm^3 of **FB 1** with your weighed piece of magnesium. After the reaction, the unreacted hydrochloric acid was used to prepare 250 cm^3 of **FB 2**.

Use your answers to **(iii)** and **(iv)** to calculate the number of moles of hydrochloric acid that reacted with the magnesium ribbon.

moles of HCl reacting with Mg = ... mol

(vi) Complete the equation below, for the reaction of magnesium with hydrochloric acid. State symbols **are** required.

$$Mg + HCl \rightarrow MgCl_2 + \text{.....}$$

Use your answer to **(v)** to calculate the number of moles of magnesium used.

moles of Mg = ... mol

(vii) Use your answer to **(vi)** to calculate the relative atomic mass, A_r, of magnesium.

A_r of Mg = ...
[6]

(d) (i) State **one** observation that proves that the hydrochloric acid in **FB 1** was in excess for the reaction with the magnesium ribbon.

.....

.....

(ii) A student carried out exactly the same experiment but used 1.00 g of magnesium ribbon. State and explain why the student's experiment could not be used to determine the value for the A_r of magnesium.
Include a calculation in your answer.

.....

.....
[3]

[Total: 17]

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2 In this experiment you will determine the relative atomic mass of magnesium by thermal decomposition of hydrated magnesium sulfate.

$$MgSO_4.7H_2O(s) \rightarrow MgSO_4(s) + 7H_2O(g)$$

FB 4 is hydrated magnesium sulfate, $MgSO_4.7H_2O$.

(a) Method

Record all your weighings in the space below.

- Weigh the crucible with its lid.
- Transfer all **FB 4** into the crucible.
- Weigh the crucible, lid and **FB 4**.
- Place the crucible on the pipe-clay triangle.
- Heat the crucible gently with the lid **on**, for about one minute.
- Then heat the crucible strongly, without the lid, for a further four minutes.
- Leave the crucible and its contents to cool with the lid on, for several minutes.
- **While the crucible is cooling, begin work on Question 3.**
- When the crucible has cooled, weigh it, with the lid and contents.
- Calculate and record the mass of anhydrous magnesium sulfate produced and the mass of water lost.

I	
II	
III	

[3]

(b) Calculations

(i) Calculate the number of moles of water lost during heating.
(Use the data in the Periodic Table on page 12.)

moles of H_2O = ... mol

(ii) Use the **equation above** and **your answer to (i)** to calculate the number of moles of anhydrous magnesium sulfate produced.

moles of $MgSO_4$ = ... mol

(iii) Use your weighings and your answer to **(ii)** to calculate the relative formula mass, M_r, of anhydrous magnesium sulfate.

M_r of $MgSO_4$ = ...

(iv) From your answer to **(iii)**, calculate the relative atomic mass, A_r, of magnesium.

A_r of Mg = ...
[4]

(c) **(i)** How could the experiment be improved to ensure that the magnesium sulfate had been completely dehydrated?

.....

.....

(ii) Why is the lid put on the crucible during cooling?

.....

.....
[2]

[Total: 9]

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3 Qualitative Analysis

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

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

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

You should indicate clearly at what stage in a test a change occurs.
Marks are **not** given for chemical equations.
No additional tests for ions present should be attempted.

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

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

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

(a) **FB 5** is a solution containing one cation and one anion.
Carry out test-tube tests to find out whether the cation in **FB 5** is magnesium and whether the anion is sulfate.

- State what reagents you used.
- Record the observations you made in a table.
- State your conclusions about which ions are present.

[4]

(b) **FB 6** is a salt containing one cation and one anion from those listed on pages 10 and 11.

(i) Place a **few** crystals of **FB 6** in a hard-glass test-tube.
Heat gently at first and then strongly.
Leave the test-tube and its contents to cool.

Record **all** your observations below.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(ii) Dissolve the remainder of **FB 6** in about 20 cm^3 of distilled water in a boiling tube for use in the following tests.

test	*observations*
To a 1 cm depth of the solution of **FB 6** in a test-tube, add a few drops of aqueous silver nitrate.	
To a 1 cm depth of the solution of **FB 6** in a test-tube, add a few drops of dilute sulfuric acid.	
To a 1 cm depth of the solution of **FB 6** in a test-tube, add aqueous ammonia.	

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test	*observations*
To a 1 cm depth of the solution of **FB 6** in a boiling tube, add aqueous sodium hydroxide until in excess, then	
heat the mixture gently and carefully, and test any gas produced, then	
add a small piece of aluminium foil while the mixture is still warm. Test any gas produced.	

(iii) Deduce the formula of the salt in **FB 6**.

Formula is .....

[10]

[Total: 14]

Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

ion	*reaction with*	
	NaOH(aq)	NH_3(aq)
aluminium, Al^{3+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH_4^+(aq)	no ppt. ammonia produced on heating	–
barium, Ba^{2+}(aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca^{2+}(aq)	white ppt. with high [Ca^{2+}(aq)]	no ppt.
chromium(III), Cr^{3+}(aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
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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
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

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2 Reactions of anions

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, Cl^-(aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq))
bromide, Br^-(aq)	gives cream ppt. with Ag^+(aq) (partially soluble in NH_3(aq))
iodide, I^-(aq)	gives yellow ppt. with Ag^+(aq) (insoluble in NH_3(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 → (pale) brown NO_2 in air)
sulfate, SO_4^{2-}(aq)	gives white ppt. with Ba^{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

gas	*test and test result*
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
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sulfur dioxide, SO_2	turns acidified aqueous potassium manganate(VII) from purple to colourless

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							1.0 **H** Hydrogen 1										4.0 **He** Helium 2
6.9 **Li** Lithium 3	9.0 **Be** Beryllium 4											10.8 **B** Boron 5	12.0 **C** Carbon 6	14.0 **N** Nitrogen 7	16.0 **O** Oxygen 8	19.0 **F** Fluorine 9	20.2 **Ne** Neon 10
23.0 **Na** Sodium 11	24.3 **Mg** Magnesium 12											27.0 **Al** Aluminium 13	28.1 **Si** Silicon 14	31.0 **P** Phosphorus 15	32.1 **S** Sulfur 16	35.5 **Cl** Chlorine 17	39.9 **Ar** Argon 18
39.1 **K** Potassium 19	40.1 **Ca** Calcium 20	45.0 **Sc** Scandium 21	47.9 **Ti** Titanium 22	50.9 **V** Vanadium 23	52.0 **Cr** Chromium 24	54.9 **Mn** Manganese 25	55.8 **Fe** Iron 26	58.9 **Co** Cobalt 27	58.7 **Ni** Nickel 28	63.5 **Cu** Copper 29	65.4 **Zn** Zinc 30	69.7 **Ga** Gallium 31	72.6 **Ge** Germanium 32	74.9 **As** Arsenic 33	79.0 **Se** Selenium 34	79.9 **Br** Bromine 35	83.8 **Kr** Krypton 36
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Fr Francium 87	**Ra** Radium 88	**Ac** Actinium 89 †	**Rf** Rutherfordium 104	**Db** Dubnium 105	**Sg** Seaborgium 106	**Bh** Bohrium 107	**Hs** Hassium 108	**Mt** Meitnerium 109	**Uun** Ununnilium 110	**Uuu** Unununium 111	**Uub** Ununbium 112		**Uuq** Ununquadium 114		**Uuh** Ununhexium 116		**Uuo** Ununoctium 118

*	140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	**Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	163 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70	175 **Lu** Lutetium 71
†	**Th** Thorium 90	**Pa** Protactinium 91	**U** Uranium 92	**Np** Neptunium 93	**Pu** Plutonium 94	**Am** Americium 95	**Cm** Curium 96	**Bk** Berkelium 97	**Cf** Californium 98	**Es** Einsteinium 99	**Fm** Fermium 100	**Md** Mendelevium 101	**No** Nobelium 102	**Lr** Lawrencium 103

*58-71 Lanthanides
†90-103 Actinides

Key

a
X
b

a = relative atomic mass
X = atomic symbol
b = proton (atomic) number

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CENTRE NUMBER						CANDIDATE NUMBER				

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CHEMISTRY **9701/35**

Paper 3 Advanced Practical Skills 1 **October/November 2015**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
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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.
A copy of the Periodic Table is printed on page 12.

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

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1	
2	
3	
Total	

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1 In this experiment you will determine the ionic equation for the reaction of acidified potassium manganate(VII) with potassium iodide. Excess potassium iodide is used and the reaction produces iodine. The amount of iodine produced is measured by titration with sodium thiosulfate.

FA 1 is 0.0180 mol dm^{-3} potassium manganate(VII), $KMnO_4$.
FA 2 is 1.00 mol dm^{-3} sulfuric acid, H_2SO_4.
FA 3 is 0.500 mol dm^{-3} potassium iodide, KI.
FA 4 is 0.100 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
starch indicator

(a) Method

- Pipette 25.0 cm^3 of **FA 1** into a conical flask.
- Use the measuring cylinder to add 25 cm^3 of **FA 2** to the conical flask.
- Use the measuring cylinder to add 20 cm^3 of **FA 3** to the conical flask.
- Fill the burette with **FA 4**.
- Carry out a rough titration. When the colour of the mixture becomes yellow/orange, add a few drops of starch indicator. Then titrate until the mixture goes colourless.
- Record all 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 4** added in each accurate titration.

Keep FA 1 and FA 2 for use in Question 3 and FA 4 for use in Question 2.

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 have obtained this value.

Volume of **FA 4** required is ..... cm^3. [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 $Na_2S_2O_3$ = ... mol

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

$$I_2 + 2Na_2S_2O_3 \rightarrow Na_2S_4O_6 + 2NaI$$

moles of I_2 = ... mol

(iii) Use information on page 2 to calculate the number of moles of potassium manganate(VII) in **FA 1** used in the titration.

moles of $KMnO_4$ = ... mol

(iv) From your answers to **(ii)** and **(iii)**, calculate the number of moles of iodine produced by the reaction of **2.00** moles of potassium manganate(VII) with excess potassium iodide.

moles I_2 = ... mol

(v) Using your answer to **(iv)**, put a tick next to the ionic equation that represents the reaction between **FA 1** and **FA 3**.

$2MnO_4^- + 2I^- + 16H^+ \rightarrow I_2 + 2Mn^{6+} + 8H_2O$ .....

$2MnO_4^- + 4I^- + 16H^+ \rightarrow 2I_2 + 2Mn^{5+} + 8H_2O$ .....

$2MnO_4^- + 6I^- + 16H^+ \rightarrow 3I_2 + 2Mn^{4+} + 8H_2O$ .....

$2MnO_4^- + 8I^- + 16H^+ \rightarrow 4I_2 + 2Mn^{3+} + 8H_2O$ .....

$2MnO_4^- + 10I^- + 16H^+ \rightarrow 5I_2 + 2Mn^{2+} + 8H_2O$ .....

$2MnO_4^- + 12I^- + 16H^+ \rightarrow 6I_2 + 2Mn^{+} + 8H_2O$ .....

(vi) Prove that the iodide ion has been oxidised in the equation that you selected in **(v)**.

.....

.....

.....
[5]

(d) (i) The error in calibration of the pipette you used is $\pm 0.06\,cm^3$.
Calculate the percentage error when measuring **FA 1**, using the pipette.

percentage error = ... %

(ii) A student suggested that the experiment would be more accurate if a pipette was used to measure solution **FA 3**.
State and explain whether you agree with the student.

.....

.....

.....
[2]

[Total: 15]

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2 In this experiment you will investigate how the rate of reaction between sodium thiosulfate and hydrochloric acid is affected by the concentration of the acid.

When aqueous thiosulfate ions react with hydrogen ions, H^+, in any acid, a pale yellow precipitate of sulfur is formed. The ionic equation for this reaction is given below.

$$S_2O_3^{2-}(aq) + 2H^+(aq) \rightarrow S(s) + SO_2(aq) + H_2O(l)$$

The rate of the reaction can be determined by measuring the time taken to produce a fixed quantity of sulfur.

FA 4 is 0.10 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
FA 5 is 0.20 mol dm^{-3} hydrochloric acid, HC*l*.

(a) Method

Record **all** your measurements, in an appropriate form, in the space below.

Experiment 1

- Use the larger measuring cylinder to transfer 40 cm^3 of **FA 4** into the 100 cm^3 beaker.
- Rinse the larger measuring cylinder thoroughly with water, then add 30 cm^3 of **FA 5** to the beaker and start timing **immediately**.
- Stir the mixture once and place the beaker on top of the printed insert page 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 invisible.
- Record the reaction time to the **nearest second**.
- Empty and rinse the 100 cm^3 beaker.
- Dry the outside of the beaker ready for Experiment 2.

Experiment 2

- Rinse the larger measuring cylinder, then use it to transfer 40 cm^3 of **FA 4** into the 100 cm^3 beaker.
- Use the smaller measuring cylinder to add 10 cm^3 of distilled water to the beaker.
- Use the same measuring cylinder to add 20 cm^3 of **FA 5** to the mixture in the beaker and start timing **immediately**.
- Stir the mixture once and place the beaker on top of the printed insert page provided.
- Stop timing as soon as the print on the insert becomes invisible.
- Record the reaction time to the **nearest second**.
- Empty and rinse the 100 cm^3 beaker.
- Dry the outside of the beaker ready for Experiment 3.

Experiment 3

- Carry out the reaction using a mixture of 40 cm^3 of **FA 4**, 20 cm^3 of distilled water and 10 cm^3 of **FA 5**.
- Measure and record the reaction time to the **nearest second**.

I	
II	
III	
IV	

[4]

(b) (i) The 'rate of reaction' can be represented by the formula below.

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

Use this formula to calculate the 'rate of reaction' for Experiments 1 and 3.
Give the unit.

'rate of reaction' for Experiment 1 ..... unit .....

'rate of reaction' for Experiment 3 ..... unit .....

(ii) Calculate the initial concentrations of hydrochloric acid in the reaction mixtures in Experiments 1 and 3.

initial concentration of HCl in Experiment 1 = ... $mol\,dm^{-3}$

initial concentration of HCl in Experiment 3 = ... $mol\,dm^{-3}$

(iii) How is the 'rate of reaction' affected by the concentration of hydrochloric acid in the mixture?

.....

.....

(iv) Predict how the reaction time measured in Experiment 1 would have been affected if the experiment had been carried out using 0.20 $mol\,dm^{-3}$ sulfuric acid instead of 0.20 $mol\,dm^{-3}$ hydrochloric acid.
Explain your answer.

.....

.....

.....

(v) Predict how the reaction time measured in Experiment 3 would have been affected if the experiment had been carried out in a 250 cm^3 beaker instead of a 100 cm^3 beaker.
Explain your answer.

.....

.....

[5]

[Total: 9]

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3 Qualitative Analysis

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

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

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

You should indicate clearly at what stage in a test a change occurs.
No additional tests for ions present should be attempted.

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

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

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

(a) **FA 6** is a sodium compound containing one anion listed on page 11.

Dissolve the **FA 6** provided in about 15 cm^3 of distilled water in a boiling tube.
Carry out the following tests and record your observations in the table below.

test	*observations*
(i) To a 1cm depth of the solution of **FA 6** in a test-tube, add a few drops of aqueous barium chloride or aqueous barium nitrate, then	
add dilute hydrochloric acid.	
(ii) To a 1cm depth of the solution of **FA 6** in a test-tube, add an equal volume of aqueous hydrogen peroxide, then	
add a few drops of aqueous barium chloride or aqueous barium nitrate, then	
add dilute hydrochloric acid.	

test	*observations*
(iii) To a 1 cm depth of the solution of **FA 6** in a boiling tube, add an equal volume of **FA 2**, sulfuric acid, then	
heat the mixture **gently and cautiously**.	
(iv) To a 1 cm depth of the solution of **FA 6** in a test-tube, add an equal volume of aqueous sodium hydroxide, then	
add a few drops of **FA 1**, aqueous potassium manganate(VII), then	
add **FA 2**, sulfuric acid.	

(v) Identify the anion in **FA 6**, and state **one** piece of evidence for your identification.

anion .....

evidence .....

.....

.....

(vi) Give the chemical equation for the reaction between **FA 6** and hydrogen peroxide, H_2O_2, in test **(ii)**. State symbols are **not** required.

.....

[7]

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(b) **FA 7**, **FA 8**, **FA 9** and **FA 10** each contain one cation from the list on page 10.
You will attempt to identify the cations by testing with aqueous sodium hydroxide and aqueous ammonia.
In each case, use a 1 cm depth of the solution in a test-tube.

(i) Complete the table below.

test	*observations*			
	FA 7	**FA 8**	**FA 9**	**FA 10**
add sodium hydroxide				
add aqueous ammonia				

(ii) Use your observations to identify, as far as possible, the cation present in each solution. If alternative identities are possible, state this clearly.

FA 7 cation .....

FA 8 cation .....

FA 9 cation .....

FA 10 cation .....

(iii) Give the ionic equation for the reaction of **one** of your cations with a few drops of sodium hydroxide. State symbols are **not** required.

.....

(iv) The precipitates obtained when alkalis are added to solutions of certain cations are sometimes difficult to see. Suggest how, using no additional apparatus, the experiment could be repeated in a way that would make these precipitates more visible.

.....

.....
[9]

[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
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

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2 Reactions of anions

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, Cl^-(aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq))
bromide, Br^-(aq)	gives cream ppt. with Ag^+(aq) (partially soluble in NH_3(aq))
iodide, I^-(aq)	gives yellow ppt. with Ag^+(aq) (insoluble in NH_3(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 → (pale) brown NO_2 in air)
sulfate, SO_4^{2-}(aq)	gives white ppt. with Ba^{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

gas	*test and test result*
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	“pops” with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns acidified aqueous potassium manganate(VII) from purple to colourless

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The Periodic Table of the Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
							1.0 **H** Hydrogen 1										4.0 **He** Helium 2
6.9 **Li** Lithium 3	9.0 **Be** Beryllium 4											10.8 **B** Boron 5	12.0 **C** Carbon 6	14.0 **N** Nitrogen 7	16.0 **O** Oxygen 8	19.0 **F** Fluorine 9	20.2 **Ne** Neon 10
23.0 **Na** Sodium 11	24.3 **Mg** Magnesium 12											27.0 **Al** Aluminium 13	28.1 **Si** Silicon 14	31.0 **P** Phosphorus 15	32.1 **S** Sulfur 16	35.5 **Cl** Chlorine 17	39.9 **Ar** Argon 18
39.1 **K** Potassium 19	40.1 **Ca** Calcium 20	45.0 **Sc** Scandium 21	47.9 **Ti** Titanium 22	50.9 **V** Vanadium 23	52.0 **Cr** Chromium 24	54.9 **Mn** Manganese 25	55.8 **Fe** Iron 26	58.9 **Co** Cobalt 27	58.7 **Ni** Nickel 28	63.5 **Cu** Copper 29	65.4 **Zn** Zinc 30	69.7 **Ga** Gallium 31	72.6 **Ge** Germanium 32	74.9 **As** Arsenic 33	79.0 **Se** Selenium 34	79.9 **Br** Bromine 35	83.8 **Kr** Krypton 36
85.5 **Rb** Rubidium 37	87.6 **Sr** Strontium 38	88.9 **Y** Yttrium 39	91.2 **Zr** Zirconium 40	92.9 **Nb** Niobium 41	95.9 **Mo** Molybdenum 42	**Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La** Lanthanum 57 *	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	**Po** Polonium 84	**At** Astatine 85	**Rn** Radon 86
Fr Francium 87	**Ra** Radium 88	**Ac** Actinium 89 †	**Rf** Rutherfordium 104	**Db** Dubnium 105	**Sg** Seaborgium 106	**Bh** Bohrium 107	**Hs** Hassium 108	**Mt** Meitnerium 109	**Uun** Ununnilium 110	**Uuu** Unununium 111	**Uub** Ununbium 112		**Uuq** Ununquadium 114		**Uuh** Ununhexium 116		**Uuo** Ununoctium 118

*	140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	**Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	163 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70	175 **Lu** Lutetium 71
†	**Th** Thorium 90	**Pa** Protactinium 91	**U** Uranium 92	**Np** Neptunium 93	**Pu** Plutonium 94	**Am** Americium 95	**Cm** Curium 96	**Bk** Berkelium 97	**Cf** Californium 98	**Es** Einsteinium 99	**Fm** Fermium 100	**Md** Mendelevium 101	**No** Nobelium 102	**Lr** Lawrencium 103

*58-71 Lanthanides
†90-103 Actinides

Key

a **X** b	a = relative atomic mass **X** = atomic symbol b = proton (atomic) number

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Cambridge International AS & A Level

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Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER				

0597751623

CHEMISTRY **9701/36**

Paper 3 Advanced Practical Skills 2 **October/November 2015**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

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

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

Qualitative Analysis Notes are printed on pages 11 and 12.

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

Session
Laboratory

For Examiner's Use	
1	
2	
Total	

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

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CAMBRIDGE International Examinations

[Turn over

1 You will investigate the rate of reaction between iron(III) ions, Fe^{3+}, and iodide ions, I^-.

$$2Fe^{3+}(aq) + 2I^-(aq) \rightarrow 2Fe^{2+}(aq) + I_2(aq)$$

The iodine, I_2, produced can be reacted immediately with thiosulfate ions, $S_2O_3^{2-}$.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

When all the thiosulfate has been used, the iodine produced will turn starch indicator blue-black. The rate of the reaction can therefore be measured by finding the time for the blue-black colour to appear.

FB 1 is aqueous iron(III) chloride, $FeCl_3$.
FB 2 is aqueous potassium iodide, KI.
FB 3 is 0.0060 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
starch indicator

You are advised to read the instructions before starting any practical work and draw a table for your results in the space on page 3.

(a) Method

Experiment 1

- Fill a burette with **FB 1**.
- Run 20.00 cm^3 of **FB 1** into a 100 cm^3 beaker.
- Use the measuring cylinder to place the following in a second 100 cm^3 beaker.
  - 10 cm^3 of **FB 2**
  - 20 cm^3 of **FB 3**
  - 10 cm^3 of starch indicator
- Add the contents of the second beaker to the first beaker and start timing.
- Stir the mixture once and place the beaker on the white tile.
- The mixture turns brown and then yellow before turning a blue-black colour. Stop timing when this **blue-black colour** appears.
- Record in your table the volume of **FB 1** used, the volume of distilled water used and the time to the **nearest second** for the blue-black colour to appear.
- Wash both beakers.

For each of **Experiments 2-6** you should complete your results table to show the volume of **FB 1** used, the volume of distilled water used and the time taken to the **nearest second** for the blue-black colour to appear.

Experiment 2

- Fill the other burette with distilled water.
- Run 10.00 cm^3 of **FB 1** into a 100 cm^3 beaker.
- Run 10.00 cm^3 of distilled water into the same beaker.
- Use the measuring cylinder to place the following in a second 100 cm^3 beaker.
  - 10 cm^3 of **FB 2**
  - 20 cm^3 of **FB 3**
  - 10 cm^3 of starch indicator
- Add the contents of the second beaker to the first beaker and start timing.
- Stir the mixture once and place the beaker on the white tile.
- Stop timing when a blue-black colour appears.
- Wash both beakers.

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Experiments 3-6

Carry out **four** further experiments to investigate the effect of changing the concentration of $Fe^{3+}(aq)$ by altering the volume of aqueous $FeCl_3$, **FB 1**, used.

You should not use a volume of **FB 1** that is less than 6.00 cm^3 and the total volume of the reaction mixture must always be 60 cm^3.

I	
II	
III	
IV	
V	
VI	
VII	
VIII	

[8]

(b) Calculations

The rate of reaction can be found by calculating the change in concentration of $Fe^{3+}(aq)$ that occurred when enough iodine was produced to change the colour of the indicator to blue-black.

Use your data and the equations on page 2 to carry out the following 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, $S_2O_3^{2-}$ used in each experiment in **(a)**.

moles $S_2O_3^{2-}$ = ... mol

(ii) Calculate the number of moles of iodine, I_2, that react with the number of moles of $S_2O_3^{2-}$ in **(i)**.

moles I_2 = ... mol

(iii) Calculate the number of moles of iron(III) ions, Fe^{3+}, that were used to produce the number of moles of iodine in **(ii)**.

moles Fe^{3+} = ... mol

(iv) When the moles of Fe^{3+} that you calculated in **(iii)** reacted, a change in the concentration of moles of Fe^{3+} occurred. Calculate this change in concentration.

change in concentration of $Fe^{3+}(aq)$ = ... mol dm^{-3}

(v) The following formula can be used as a measure of the 'rate of reaction'.

$$\text{'rate of reaction'} = \frac{\text{change in concentration of } Fe^{3+}(aq)}{\text{reaction time}} \times 10^6$$

Complete the table to show the volume of **FB 1**, the reaction time and the rate in **Experiments 1-6**. You should include units.

If you were unable to calculate a value for the change in concentration of $Fe^{3+}(aq)$ in **(iv)**, you should assume it is 2.50×10^{-3} mol dm^{-3}. (Note: this is not the correct value.)

Experiment			
1			
2			
3			
4			
5			
6			

[5]

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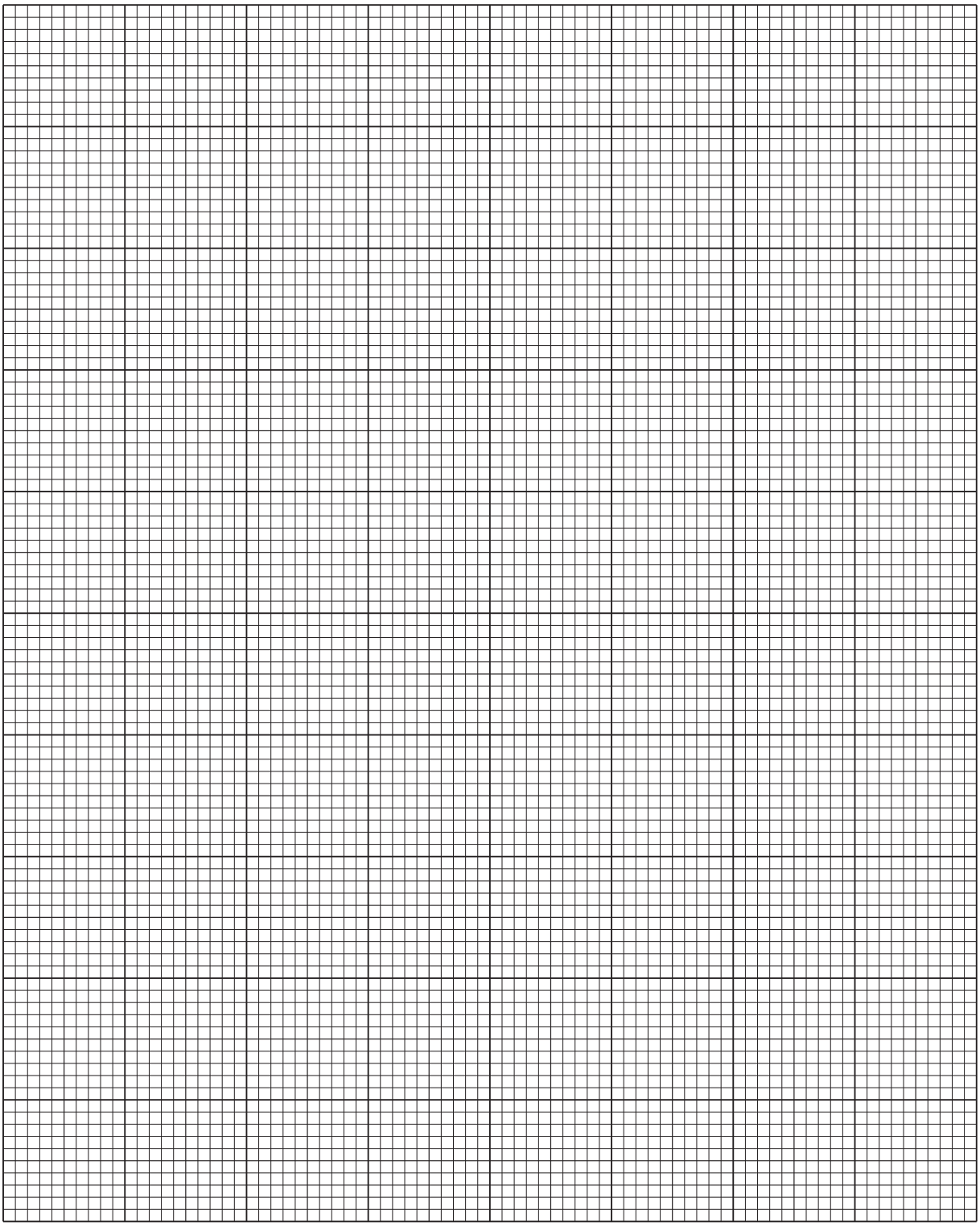
(c) On the grid, plot the rate (*y*-axis) against the volume of **FB 1** (*x*-axis). Draw a line of best fit through the points. You should identify any points you consider anomalous.



[4]

(d) Using your graph, what conclusion can you reach about the effect of changing the concentration of $FeCl_3$ on the rate of the reaction between Fe^{3+}(aq) and I^-(aq)?

.....

.....

..... [2]

(e) A student wanted to investigate how changing the concentration of I^- would affect the rate of reaction. Explain how this investigation could be carried out.

.....

.....

.....

..... [2]

(f) It was found, by carrying out experiments similar to those used in **(a)**, that increasing the concentration of I^- increased the rate of the reaction.

The student suggested modifications to the method as used in **(a)**. In each case, state what the effect would be on the **reaction time** in Experiment 1 and explain how these changes would affect the **possible errors** in the measurements.

Suggested modification 1
The reaction was carried out using the same volumes of all reagents but with the concentrations of **FB 1** and **FB 2** being double their original values.

.....

.....

.....

Suggested modification 2
The reaction was carried out using half the volume of all reagents.

.....

.....

.....
[4]

(g) **(i)** Which of the experiments you carried out in **(a)** had the greatest percentage error in the reaction time?

.....

(ii) Calculate this percentage error. Assume that the error in measuring the reaction time is ±0.5 s.

percentage error = ... %
[2]

[Total: 27]

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

You should indicate clearly at what stage in a test a change occurs.
Marks are **not** given for chemical equations.
No additional tests for ions present should be attempted.

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

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

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

Half fill the 250 cm^3 beaker with water and heat it to about 80 °C and then switch off the burner. This will be used as a water bath in (b).

Keep two clean, dry test-tubes for use in (b).

(a) **FB 4** and **FB 5** each contain two cations and one anion. One of the cations in **FB 4** is the same as one of the cations in **FB 5**. The anion in **FB 4** is the same as the anion in **FB 5**.

(i) Separately dissolve about half of each of your samples of **FB 4** and **FB 5** in about 5 cm depth of distilled water in a boiling tube.

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

test	*observations*	
	FB 4	**FB 5**
To a 1 cm depth of solution in a test-tube, add a 1 cm depth of aqueous edta.		
To a 1 cm depth of solution in a test-tube, add a 1 cm depth of aqueous potassium iodide.		

test	*observations*	
	FB 4	**FB 5**
To a 1 cm depth of solution in a test-tube, add aqueous sodium hydroxide.		
To a 1 cm depth of solution in a test-tube, add aqueous ammonia.		
To a 1 cm depth of solution in a test-tube, add a 1 cm depth of aqueous barium chloride or aqueous barium nitrate, then		
add dilute hydrochloric acid.		

(ii) From the observations identify three of the ions present in **FB 4** and **FB 5**.

The anion present in both **FB 4** and **FB 5** is ..... .

One cation present in **FB 4** is ..... .

One cation present in **FB 5** is ..... .

(iii) **FB 4** and **FB 5** each contain another cation from the list on page 11. This cation is the same in both **FB 4** and **FB 5**.

Carry out a test to identify this cation. Record details of the test and your observations.

.....

.....

.....

Identify the cation present in both **FB 4** and **FB 5**.

Cation is ..... .

[8]

(b) **FB 6** is an aqueous solution of an organic compound.

(i) Complete the table below. The observation with 2,4-dinitrophenylhydrazine has already been made.

test	*observations*
To a 1 cm depth of **FB 6** in a test-tube, a few drops of 2,4-dinitrophenylhydrazine were added.	orange precipitate formed
To a 1 cm depth of **FB 6** in a test-tube, add a 2 cm depth of dilute sulfuric acid. Place the test-tube in the water bath. Then add two or three drops of acidified aqueous potassium manganate(VII).	
To a 1 cm depth of aqueous silver nitrate in a test-tube, add a few drops of aqueous sodium hydroxide. Then add aqueous ammonia until the brown precipitate **just** dissolves. To this, add a 1 cm depth of **FB 6**. Place the test-tube in the water bath and leave to stand. **Care: rinse the tube as soon as you have completed this test.**	

(ii) What conclusion can you make about the identity of **FB 6** from the observation of its reaction with 2,4-dinitrophenylhydrazine?

.....

(iii) What conclusion can you make about the identity of **FB 6** from the observation of its reactions with acidified potassium manganate(VII) and silver nitrate in ammonia solution?

.....

(iv) What change in the oxidation state of silver occurs in the reaction between **FB 6** and silver nitrate in ammonia solution?

change from ..... to .....

[5]

[Total: 13]

Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

ion	*reaction with*	
	NaOH(aq)	NH_3(aq)
aluminium, Al^{3+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH_4^+(aq)	no ppt. ammonia produced on heating	–
barium, Ba^{2+}(aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca^{2+}(aq)	white ppt. with high [Ca^{2+}(aq)]	no ppt.
chromium(III), Cr^{3+}(aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu^{2+}(aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe^{2+}(aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe^{3+}(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg^{2+}(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn^{2+}(aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn^{2+}(aq)	white ppt. soluble in excess	white ppt. soluble in excess

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2 Reactions of anions

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, Cl^-(aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq))
bromide, Br^-(aq)	gives cream ppt. with Ag^+(aq) (partially soluble in NH_3(aq))
iodide, I^-(aq)	gives yellow ppt. with Ag^+(aq) (insoluble in NH_3(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 → (pale) brown NO_2 in air)
sulfate, SO_4^{2-}(aq)	gives white ppt. with Ba^{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

gas	*test and test result*
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	“pops” with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns acidified aqueous potassium manganate(VII) from purple to colourless

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