

Cambridge  
International  
AS & A Level

**Cambridge Assessment International Education**  
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE  
NAME

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CENTRE  
NUMBER

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**CHEMISTRY**

**9701/34**

Paper 3 Advanced Practical Skills 2

**May/June 2019**

**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.

<b>Session</b>	
<b>Laboratory</b>	

<b>For Examiner's Use</b>	
<b>1</b>	
<b>2</b>	
<b>3</b>	
<b>Total</b>	

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

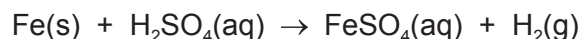
## Quantitative Analysis

Read through the whole method before starting any practical work. Where appropriate, prepare a table for your results in the space provided.

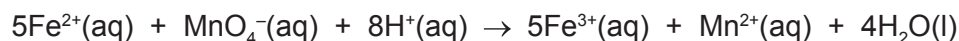
Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

- 1 Iron wire contains impurities. You will investigate the percentage by mass of iron in a sample of iron wire.

A sample of iron wire is reacted with an excess of sulfuric acid to produce a solution of iron(II) sulfate.



You will titrate the solution of iron(II) sulfate with potassium manganate(VII) of known concentration to determine the amount of iron(II) ions present and hence the percentage by mass of iron in the wire. You may assume the impurities do not form any products that react with potassium manganate(VII).



**FB 1** is 0.0200 mol dm<sup>-3</sup> potassium manganate(VII), KMnO<sub>4</sub>.

**FB 2** is a solution of FeSO<sub>4</sub> prepared by reacting 6.02 g of iron wire with sulfuric acid to make 1 dm<sup>3</sup> of solution.

**FB 3** is dilute sulfuric acid, H<sub>2</sub>SO<sub>4</sub>.

### (a) Method

- Fill a burette with **FB 1**.
- Pipette 25.0 cm<sup>3</sup> of **FB 2** into a conical flask.
- Use the measuring cylinder to transfer 25 cm<sup>3</sup> of **FB 3** into the conical flask.
- Perform a rough titration and record your burette readings in the space below.

The rough titre is ..... cm<sup>3</sup>.

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

Keep **FB 3** for use in Question 2.

### Results

I	
II	
III	
IV	
V	
VI	
VII	

[7]

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

25.0 cm<sup>3</sup> of **FB 2** required ..... cm<sup>3</sup> of **FB 1**. [1]

- (c) (i) Give your answers to (ii), (iii), (iv) and (v) to the appropriate number of significant figures. [1]
- (ii) Use your answer to (b) to calculate the number of moles of potassium manganate(VII), **FB 1**, which reacted with 25.0 cm<sup>3</sup> of **FB 2**.

moles of MnO<sub>4</sub><sup>-</sup> = ..... mol [1]

- (iii) Use the information on page 2 to calculate the number of moles of iron(II) ions present in 25.0 cm<sup>3</sup> of **FB 2**.

moles of Fe<sup>2+</sup> = ..... mol [1]

- (iv) Calculate the mass of iron present in 25.0 cm<sup>3</sup> of **FB 2**.

mass of Fe = ..... g [1]

- (v) Calculate the percentage by mass of iron in the sample of iron wire.

percentage by mass of iron in iron wire = ..... % [1]

- (d) A student suggested that when a piece of iron wire was dissolved in a known volume and concentration of sulfuric acid, the number of moles of iron that reacted with the acid could be determined by working out how much acid was left after the reaction. The amount of excess acid could be determined by titrating the mixture with a known concentration of sodium hydroxide.

Explain whether the student was correct.

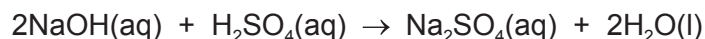
.....

.....

..... [1]

[Total: 14]

- 2 In **Question 1** you used dilute sulfuric acid, **FB 3**. You will now determine the concentration of **FB 4** by measuring the temperature of its reaction with sodium hydroxide.



**FB 4** is  $0.90 \text{ mol dm}^{-3}$  sodium hydroxide, NaOH.

**(a) Method**

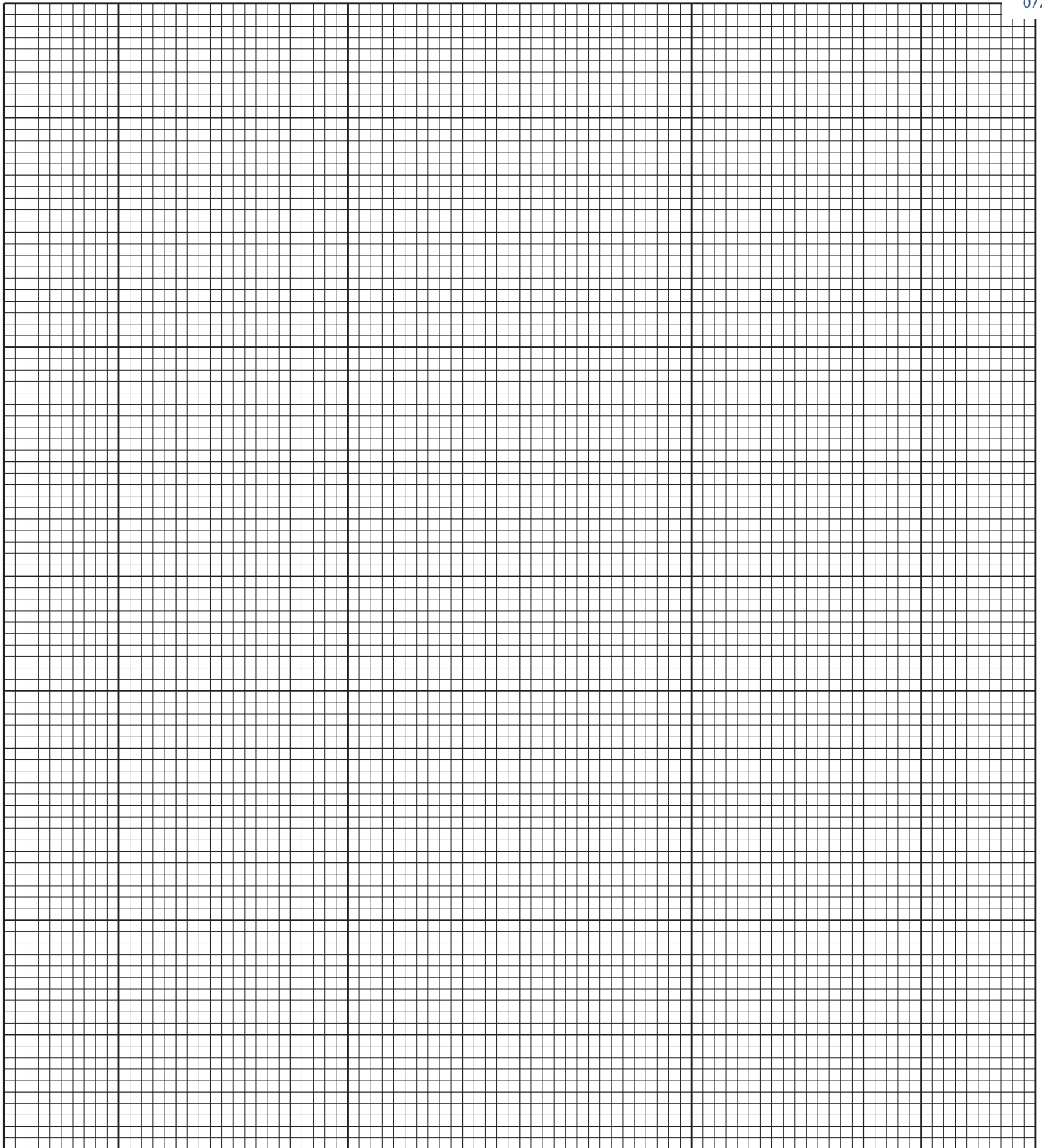
- Fill the second burette with **FB 4**.
- Support the plastic cup in the  $250 \text{ cm}^3$  beaker.
- Pipette  $10.0 \text{ cm}^3$  of **FB 3** into the plastic cup.
- Place the thermometer into the **FB 3**. Tilt the cup so that the bulb of the thermometer is surrounded by solution. Record the temperature in the table below. This is the temperature of the solution before any **FB 4** has been added.
- Add  $5.00 \text{ cm}^3$  of **FB 4** from the burette to the **FB 3** in the plastic cup. Stir the mixture and record the temperature reached. Record the volume of **FB 4** added.
- Add a second  $5.00 \text{ cm}^3$  portion of **FB 4** to the plastic cup, stir the mixture and record the temperature reached. Record the total volume of **FB 4** added.
- Continue adding  $5.00 \text{ cm}^3$  portions of **FB 4** until  $40.00 \text{ cm}^3$  have been added. After each addition, stir and record the temperature reached and total volume of **FB 4** added.

**Results**

total volume of <b>FB 4</b> added / $\text{cm}^3$	temperature of solution / $^{\circ}\text{C}$

[3]

- (b)** Plot a graph of temperature of solution on the  $y$ -axis against total volume of **FB 4** added on the  $x$ -axis. Select a scale on the  $y$ -axis to include a temperature of  $2.0^{\circ}\text{C}$  above your maximum thermometer reading. Label any points you consider to be anomalous. You will use the graph to find the volume of **FB 4** needed to neutralise  $10.0 \text{ cm}^3$  of **FB 3**.



I	
II	
III	
IV	

Draw two lines of best fit through the points on your graph, the first for the increase in temperature and the second for the decrease in temperature of the mixtures. Extrapolate the two lines so they intersect and hence determine the volume of **FB 4** required to neutralise 10.0 cm<sup>3</sup> of **FB 3**.

volume of **FB 4** = ..... cm<sup>3</sup>  
[4]

- (c) (i) Use your answer to (b) to calculate the number of moles of sodium hydroxide required to neutralise 10.0 cm<sup>3</sup> of **FB 3**.

moles of NaOH = ..... mol [1]

- (ii) Calculate the number of moles of sulfuric acid present in 10.0 cm<sup>3</sup> of **FB 3**.

moles of H<sub>2</sub>SO<sub>4</sub> = ..... mol

Hence calculate the concentration, in mol dm<sup>-3</sup>, of sulfuric acid in **FB 3**.

concentration of H<sub>2</sub>SO<sub>4</sub> in **FB 3** = ..... mol dm<sup>-3</sup>  
[1]

- (d) Explain how you would use the data obtained in **Question 2** to calculate the enthalpy change of neutralisation of the sulfuric acid. You do not need to carry out the calculation.

.....  
.....  
.....  
..... [3]

[Total: 12]

## Qualitative Analysis

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

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

- colour changes seen;
- the formation of any precipitate and its solubility in an excess of the reagent added;
- the formation of any gas and its identification by a suitable test.

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

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

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

**No additional tests for ions present should be attempted.**

3 (a) **FB 5** is a solution of a sodium salt of an organic acid.

**FB 6** and **FB 7** each contain one cation and one anion from those listed in the Qualitative Analysis Notes.

Carry out the following tests and record your observations.  
Use a separate 1 cm depth of each solution in a test-tube for each test.

<i>test</i>	<i>observations</i>		
	<b>FB 5</b>	<b>FB 6</b>	<b>FB 7</b>
Add 2 or 3 drops of acidified potassium manganate(VII).			
If there is no visible change, pour into a boiling tube and warm gently.			
Add a 1 cm depth of dilute nitric acid, then			
add 2 or 3 drops of aqueous silver nitrate.			
Add a 1 cm depth of dilute hydrochloric acid, then	X		
add a 1 cm depth of aqueous barium nitrate or aqueous barium chloride.			
Add a 1 cm depth of <b>FB 5</b> and leave to stand for a few minutes.	X		

[7]



- (b) (i) Select reagents for two further tests to help identify the cations present in **FB 6** and **FB 7**

Record in a suitable form below the reagents you use and your observations.

[4]

- (ii) Use your observations to identify as many ions as possible. Give the formula of the ion present. Write 'unknown' if you were unable to identify an ion.

	<b>FB 6</b>	<b>FB 7</b>
cation		
anion		

[2]

- (iii) Write an ionic equation for any precipitation reaction observed involving **FB 7**. Include state symbols.

..... [1]

[Total: 14]

## Qualitative Analysis Notes

### 1 Reactions of aqueous cations

ion	reaction with	
	NaOH(aq)	NH <sub>3</sub> (aq)
aluminium, Al <sup>3+</sup> (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH <sub>4</sub> <sup>+</sup> (aq)	no ppt. ammonia produced on heating	–
barium, Ba <sup>2+</sup> (aq)	faint white ppt. is nearly always observed unless reagents are pure	no ppt.
calcium, Ca <sup>2+</sup> (aq)	white ppt. with high [Ca <sup>2+</sup> (aq)]	no ppt.
chromium(III), Cr <sup>3+</sup> (aq)	grey-green ppt. soluble in excess	grey-green ppt. insoluble in excess
copper(II), Cu <sup>2+</sup> (aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe <sup>2+</sup> (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 <sup>3+</sup> (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg <sup>2+</sup> (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn <sup>2+</sup> (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 <sup>2+</sup> (aq)	white ppt. soluble in excess	white ppt. soluble in excess

## 2 Reactions of anions

<i>ion</i>	<i>reaction</i>
carbonate, $\text{CO}_3^{2-}$	$\text{CO}_2$ 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, $\text{NO}_3^-(\text{aq})$	$\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and $\text{Al}$ foil
nitrite, $\text{NO}_2^-(\text{aq})$	$\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and $\text{Al}$ foil
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, $\text{NH}_3$	turns damp red litmus paper blue
carbon dioxide, $\text{CO}_2$	gives a white ppt. with limewater (ppt. dissolves with excess $\text{CO}_2$ )
chlorine, $\text{Cl}_2$	bleaches damp litmus paper
hydrogen, $\text{H}_2$	'pops' with a lighted splint
oxygen, $\text{O}_2$	relights a glowing splint

## The Periodic Table of Elements

		Group																																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																		
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">1 H hydrogen 1.0</div> <div style="border: 1px solid black; padding: 2px;">                     Key                      atomic number                      atomic symbol                      name                      relative atomic mass                 </div> </div>																																	
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 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.4	61 Pm promethium —	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0	
87 Fr francium —	88 Ra radium —	89 Ac actinium —	89–103 actinoids —	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 —	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium —	94 Pu plutonium —	95 Am americium —	96 Cm curium —	97 Bk berkelium —	98 Cf californium —	99 Es einsteinium —	100 Fm fermium —	101 Md mendelevium —	102 No nobelium —	103 Lr lawrencium —

lanthanoids

actinoids

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