

NAME _____

CLASS _____

**JURONG PIONEER JUNIOR COLLEGE**
JC2 PRELIMINARY EXAMINATION 2026**CHEMISTRY****Higher 2**

Paper 4 Practical

9476/04**25 August 2026****2 hours 30 minutes****Candidates answer on the Question paper.**

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your name, class and exam index number on all the work you hand in.
Give details of the practical shift and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use a HB pencil for any diagrams, graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.
Qualitative Analysis Notes are printed on pages 18, 19 and 20.

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.

Shift**Laboratory****For Examiner's Use**

1	13
2	12
3	25
Total	50

This document consists of **20** printed pages and **2** blank pages.

Answer **all** the questions in the spaces provided.

1 Inorganic and Organic Qualitative Analysis

For
Examiner's
Use

- (a) **FA 1** and **FA 2** are salts containing the **same** transition metal but in different oxidation states.

You are provided with solutions of **FA 1** and **FA 2**.

You are also provided with **Solution S**, 1% starch solution (*Keep for use in Question 2*).

You will perform tests to identify the transition metal contained in **FA 1** and **FA 2**.

- (i) Perform the tests described in Table 1.1, and record your observations in the table.

Unless otherwise stated, the volumes given below are approximate and should be estimated rather than measured.

Test and identify any gases evolved. If there is no observable change, write **no observable change**.

Table 1.1

	tests	observations
1	To 1 cm depth of FA 1 in a test-tube add 1 cm depth of dilute sulfuric acid, followed by 1 cm depth of aqueous potassium iodide. To the resulting mixture, add a few drops of Solution S .	
2	To 1 cm depth of FA 2 in a test-tube add aqueous sodium hydroxide dropwise, with shaking, until in excess. Leave the mixture on standing for 2 minutes.	
	To the resulting mixture, add 1 cm depth of hydrogen peroxide.	

[4]

Commented [JPAA(1): Added "in" for the phrase for use in Question 2

Commented [KYSJ(2): To be fair and consistent with our teaching and QA notes, let's add "Leave the mixture on standing for 2 minutes." which is what we taught in TP4

- (ii) Explain the observations in Test 2 as fully as you can, with reference to the reactions occurring.

Identify the transition metal ion present in **FA2**.

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

[3]

- (iii) State, with supporting evidence, the nature of **FA 1**.

Nature of **FA 1**:

Evidence:

.....

[2]

For
Examiner's
Use

(b) Before starting this analysis, ensure your Bunsen burner is turned off.

You are provided with an organic liquid sample **FA 3**.

The molecular formula of **FA 3** is $C_3H_6O_2$.

You will perform tests to deduce the structure of **FA 3**.

- (i) Perform the tests described in Table 1.2, and record your observations in Table 1.2.

Observations in Test 4 have been recorded. **Do not perform this test.**

Unless otherwise stated, the volumes given below are approximate and should be estimated rather than measured.

If there is no observable change, write **no observable change**.

Table 1.2

	tests	observations
1	To a 1 cm depth of FA 3 in a test-tube, add 2 cm depth of dilute sulfuric acid. Then add 2–3 drops of aqueous potassium manganate(VII). Warm the mixture in the hot water bath for two minutes.	
2	Add 1 cm depth of aqueous silver nitrate to a test-tube. Then slowly add 1 cm depth of aqueous sodium hydroxide.	
	Add aqueous ammonia slowly, with shaking, until the precipitate just dissolves. You may use a clean glass rod to stir the mixture and help dissolve the precipitate.	
	Add 1 cm depth of FA 3 to this mixture and shake the tube. Warm the mixture in the hot water bath for two minutes.	
	Important: After about 3 minutes, pour the mixture down the sink and wash out the test-tube several times with tap water.	
3	To a 1 cm depth of FA 3 in a test-tube, add 10 drops of aqueous sodium hydroxide. Now add iodine solution dropwise, until a permanent yellow/orange colour is obtained. Warm the mixture in the hot water bath for two minutes.	
4	To a 1 cm depth of FA 3 in a test-tube, cautiously add a small piece of sodium metal.	<i>Effervescence observed. H_2 gas produced extinguishes a lighted splint with a “pop” sound.</i>

For
Examiner's
Use

[3]

5

- (ii) The molecular formula of **FA 3** is $C_3H_6O_2$. Use the observations recorded in Table 1.2 to deduce a possible structure of **FA 3**.

For
Examiner's
Use

[1]

[Total: 13]

2 Investigating the kinetics of the reaction between iodate(V) ions and hydrogensulfite ions

For
Examiner's
Use

FA 4 is $0.100 \text{ mol dm}^{-3}$ potassium iodate(V), KIO_3 .

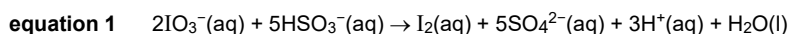
FA 5 is $0.0500 \text{ mol dm}^{-3}$ sodium hydrogensulfite, NaHSO_3 .

You are also provided with:

- **Solution S**, 1% starch solution
- deionised water
- a waste beaker containing sodium carbonate solution

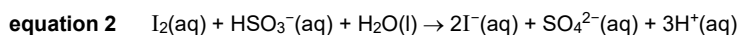
Iodate(V) ions, $\text{IO}_3^- (\text{aq})$ react with hydrogensulfite ions, $\text{HSO}_3^- (\text{aq})$ as shown in **equation 1** shown.

Commented [JPAA(3): Corrected the spelling error



In this experiment, the rate of the reaction is studied by measuring the rate of formation of iodine using a 'clock' method. You will vary the concentration of iodate(V) ions and measure the time taken for a fixed amount of iodine to be produced, which will be indicated by the formation of a blue-black colour in the presence of starch.

The blue-black colour does not appear immediately because the iodine, $\text{I}_2 (\text{aq})$, produced can be reacted immediately with unreacted hydrogensulfite ions, $\text{HSO}_3^- (\text{aq})$, in a competing reaction (fast) as shown in **equation 2**.



When all the hydrogensulfite has been consumed, any additional iodine that forms will turn the starch indicator blue-black.

You will perform a series of five experiments. For each experiment, you will need to ensure that the same total volume of reaction mixture is used by adding deionised water as required. For each experiment, you will measure the time, t , for the blue-black colour to appear. You should avoid inhaling any gases produced.

(a) In the space provided on page 8, prepare a table to record the following, to an appropriate level of precision:

- all volumes of **FA 4** ($V_{\text{FA 4}}$), **FA 5** ($V_{\text{FA 5}}$) and deionised water (V_{water}) used
- all values of t , to the nearest second
- calculated values of $\frac{1000}{t}$ to 3 significant figures

Procedure**Experiment 1**

1. Use a teat pipette to add 10 drops of **Solution S** to a 100 cm³ conical flask.
2. Use a 10 cm³ measuring cylinder to measure 2.0 cm³ of **FA 4** into the conical flask.
3. Use a 25 cm³ measuring cylinder to measure 16.0 cm³ of deionised water into the same conical flask.
4. Use a second 10 cm³ measuring cylinder to measure 2.0 cm³ of **FA 5**.
5. Pour the **FA 5** into the same conical flask, starting the stopwatch during this addition.
6. Mix the contents thoroughly by swirling the flask several times. Then place the flask on the white tile.
7. Stop the stopwatch at the first appearance of a blue-black colour.
8. Record the time taken, t , to the nearest second, in your table.
9. Discard the reaction mixture immediately into the waste beaker containing sodium carbonate solution.
10. Wash out the flask thoroughly with tap water and then with deionised water. Stand the flask upside down on a paper towel to drain.

Experiments 2 to 5

Carry out four further experiments to investigate how the reaction time, t , changes with different volumes of potassium iodate(V), **FA 4** in step 2.

Volumes of **FA 4** used should not be higher than 10 cm³ and should not be lower than 2 cm³.

In each experiment, you should adjust the volume of deionised water in step 3 to ensure the **same total volume** of reaction mixture is used.

You should alternate the use of the two 100 cm³ conical flasks.

Record all volumes, the time taken and the calculated values of $\frac{1000}{t}$ in your table.

Results

For
Examiner's
Use

[5]

- (b) (i) Plot a graph of $\left(\frac{1000}{t}\right)$ on the y-axis against V_{FA4} on the x-axis on the grid in Figure 2.1. Include the origin, (0,0), in your scale. Draw a line of best-fit.

For
Examiner's
Use

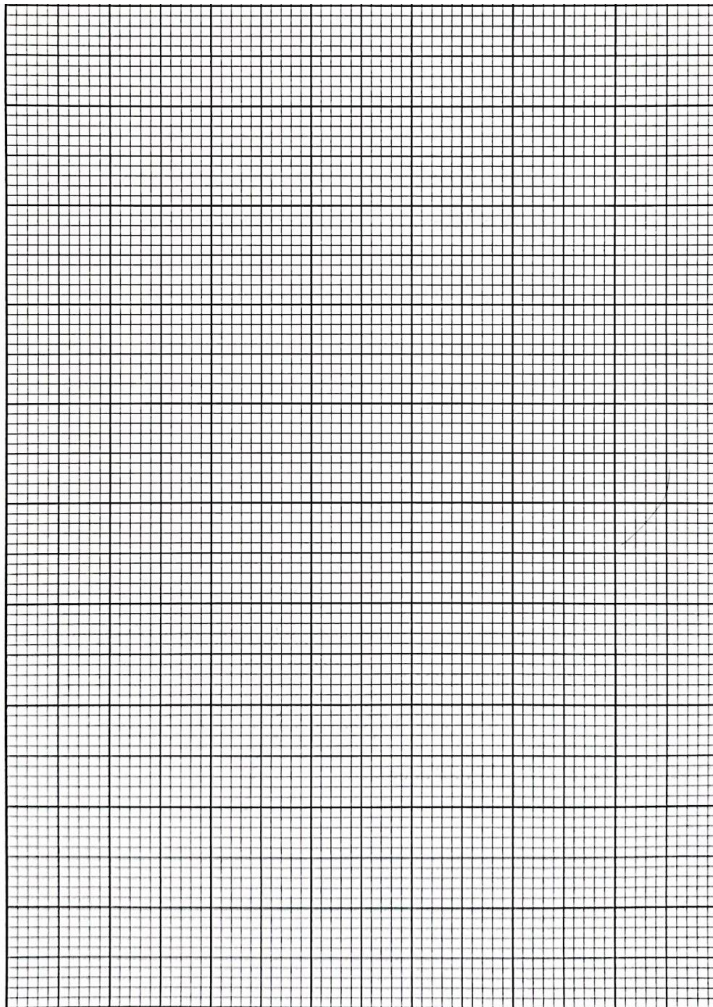


Figure 2.1

[3]

- (ii) $\left(\frac{1000}{t}\right)$ is a measure of the rate of reaction. By referring to your graph in Figure 2.1, explain how the rate of reaction is affected by the concentration of the iodate(V) ions, $[\text{IO}_3^-]$.

.....

.....

.....

.....

.....

.....

[2]

- (c) A student suggests modifying the experiment by varying the volume of **FA 5** while keeping the total volume and volume of **FA 4** constant, to investigate the effect of $[\text{HSO}_3^-]$ on the reaction rate. Explain why this approach would not work.

.....

.....

.....

.....

.....

.....

[2]

[Total: 12]

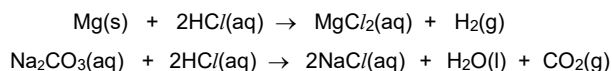
For
Examiner's
Use

3 Determining the relative atomic mass (A_r) of magnesium

FA 6 is an aqueous solution prepared by reacting 0.210 g of magnesium ribbon, Mg, with 30.0 cm³ of 1.00 mol dm⁻³ hydrochloric acid, HCl, and made up to 250 cm³ with deionised water. You are provided with **FA 6**.

FA 7 is aqueous sodium carbonate containing 2.68 g dm⁻³ Na₂CO₃.

In this question, you will titrate **FA 7** with **FA 6** to determine how much HCl was left over after the reaction with Mg.



Using the experimental results, you will determine the A_r of magnesium.

(a) Titration of FA 7 against FA 6

1. Fill the burette with **FA 6**.
2. Use a pipette to transfer 25.0 cm³ of **FA 7** into a 250 cm³ conical flask.
3. Add a few drops of methyl orange indicator.
4. Run **FA 6** from the burette into the conical flask until the yellow colour of the solution changes to orange.
5. Record your titration results, to an appropriate level of precision, in the space provided.
6. Repeat points 2 to 5 until consistent results are obtained.

Results

[5]

- (b)** From your titrations, obtain a suitable volume of **FA 6**, $V_{\text{FA 6}}$, to be used in your calculations. Show clearly how you obtained this volume.

$V_{\text{FA 6}} = \dots\dots\dots$ [1]

- (c) (i) Calculate the amount of Na_2CO_3 in the 25.0 cm^3 of **FA 7** used in each titration. [A_r : Na, 23.0; C, 12.0; O, 16.0]

For
Examiner's
Use

Amount of Na_2CO_3 in 25.0 cm^3 of **FA 7** = [1]

- (ii) Use your answer in (c)(i) to calculate the amount of hydrochloric acid present in 250 cm^3 of **FA 6**.

Amount of HCl present in 250 cm^3 of **FA 6** = [1]

- (iii) Calculate the amount of hydrochloric acid that reacted with the magnesium.

Amount of HCl that reacted with the magnesium = [1]

- (iv) Hence calculate the relative atomic mass, A_r , of magnesium.

A_r of magnesium = [1]

- (d) The A_r of magnesium given in the Periodic Table is 24.3. Use this value given in the Periodic Table to calculate the percentage error of your A_r value of Mg obtained in (c)(iv).

For
Examiner's
Use

percentage error = [4]

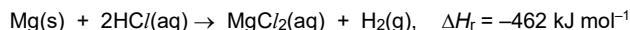
- (e) A solution of NaOH was prepared at the same concentration, in mol dm^{-3} , as **FA 7**. A student repeated the titration but replaced **FA 7** with this NaOH solution. Explain the effect that replacing **FA 7** with this solution of NaOH would have on the volume of **FA 6** needed for the titration.

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

(f) Planning

The relative atomic mass, A_r , of magnesium can be determined using an alternative method based on calorimetry.

When magnesium ribbon reacts with hydrochloric acid, an exothermic reaction occurs as follows:



The maximum temperature change, ΔT_{max} , occurring during this reaction can be determined graphically and can be used to calculate the heat change, q , for this experiment.

Using the value of q and the literature value for the enthalpy change of reaction, the relative atomic mass of magnesium can be determined.

In this question, you are to plan a procedure that would provide sufficient data to allow you to determine the relative atomic mass of magnesium.

- (i) Plan an investigation to determine the maximum temperature change, ΔT_{max} , **graphically** for the reaction between magnesium and hydrochloric acid.

Measurements should be taken:

- before the reaction starts,
- during the reaction,
- some time after the reaction is complete.

You may assume that you are provided with:

- about 1 g of magnesium ribbons,
- 200 cm³ of 1.00 mol dm⁻³ hydrochloric acid,
- the apparatus normally found in a school laboratory,

In your plan you should include brief details of:

- the apparatus you would use
- the quantities you would use, so that there is an excess of hydrochloric acid
- the procedure you would follow
- the measurements you would make to allow a suitable temperature-time graph to be drawn
- how you would ensure that an accurate and reliable value of ΔT_{max} is obtained.

[A_r : H, 1.0; Cl, 35.5, Mg, 24.3]

[6]

For
Examiner's
Use

Commented [KYSJ(4)]: Inserted 'of'

Commented [KYSJ(5)]: Enthalpy change

Commented [JPAA(6)]: Removed "for"

[illegible]

- (ii) Sketch, on Figure 3.1, the graph you would expect to obtain using the measurements you planned to make in (f)(i).

Show clearly how $\Delta T_{\max}$ can be determined from your graph, including any lines you would draw.

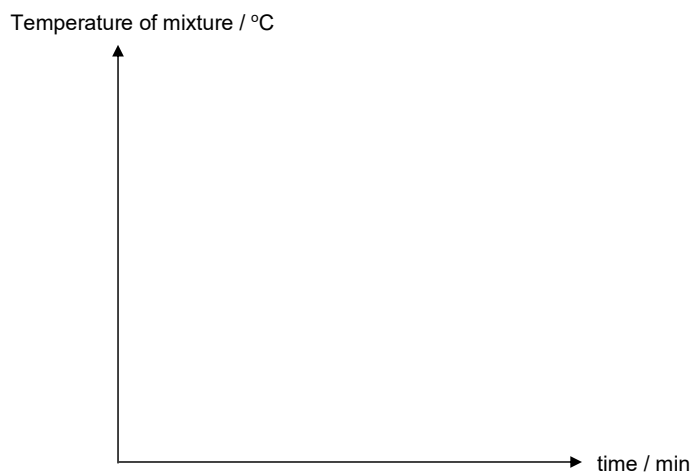


Figure 3.1

[2]

- (iii) Outline how you would use your $\Delta T_{\max}$ value and the literature enthalpy change value to calculate the relative atomic mass of magnesium.

In your calculations, let m g be the actual mass of magnesium used and V cm³ be the volume of hydrochloric acid used.

It is not necessary to simplify the expression in your final answer.

You should assume that the specific heat capacity of the final solution is 4.2 J g⁻¹ K⁻¹ and its density is 1.00 g cm⁻³.

Given: $\text{Mg(s)} + 2\text{HCl(aq)} \rightarrow \text{MgCl}_2\text{(aq)} + \text{H}_2\text{(g)}$, $\Delta H_r = -462 \text{ kJ mol}^{-1}$

[2]

[Total: 25]

For
Examiner's
Use

BLANK PAGE

Qualitative Analysis Notes

[ppt. = precipitate]

(a) Reactions of aqueous cations

cation	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)	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

(b) Reactions of anions

Anion	Reaction
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$);
bromide, $\text{Br}^-(\text{aq})$	gives pale cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$);
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$);
nitrate, $\text{NO}_3^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
nitrite, $\text{NO}_2^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil; NO liberated by dilute acids (colourless $\text{NO} \rightarrow$ (pale) brown NO_2 in air)
sulfate, $\text{SO}_4^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)
sulfite, $\text{SO}_3^{2-}(\text{aq})$	SO_2 liberated on warming with dilute acids; gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in excess dilute strong acids)

(c) Tests for gases

gas	test and test results
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

(d) Colour of halogens

halogen	colour of element	colour in aqueous solution	colour in hexane
chlorine, Cl_2	greenish yellow gas	pale yellow	pale yellow
bromine, Br_2	reddish brown gas/liquid	orange	orange-red
iodine, I_2	black solid/purple gas	brown	purple

(e) Tests for organic compounds

organic compounds	reactions
alkene	decolourises orange $\text{Br}_2(\text{aq})$
chloroalkane	heat with $\text{NaOH}(\text{aq})$, white ppt. formed on adding dilute HNO_3 , followed by $\text{Ag}^+(\text{aq})$
bromoalkane	heat with $\text{NaOH}(\text{aq})$, pale cream ppt. formed on adding dilute HNO_3 , followed by $\text{Ag}^+(\text{aq})$
iodoalkane	heat with $\text{NaOH}(\text{aq})$, yellow ppt. formed on adding dilute HNO_3 , followed by $\text{Ag}^+(\text{aq})$
alcohol	- forms white fumes with solid PCl_5 - decolourises purple acidified $\text{KMnO}_4(\text{aq})$ on heating (for primary and secondary alcohols) - gives pale yellow ppt. with alkaline $\text{I}_2(\text{aq})$ on warming (for alcohols with $\text{CH}_3\text{CH}(\text{OH})-$ group)
phenol	decolourises orange $\text{Br}_2(\text{aq})$ and forms a white ppt.
carbonyl compounds (aldehydes and ketones)	- gives orange ppt. with 2,4-dinitrophenylhydrazine - gives pale yellow ppt. with alkaline $\text{I}_2(\text{aq})$ on warming (for carbonyl compounds with $\text{CH}_3\text{CO}-$ group) - gives red-brown ppt. with Fehling's solution on warming (for aliphatic aldehydes) - gives silver mirror with Tollens' reagent on warming (for aldehydes)
carboxylic acid	CO_2 liberated by $\text{Na}_2\text{CO}_3(\text{aq})$ - gives white fumes with solid PCl_5
phenylamine	decolourises orange $\text{Br}_2(\text{aq})$ and forms a white ppt.
primary amide	NH_3 liberated on heating with $\text{NaOH}(\text{aq})$