

NANYANG JUNIOR COLLEGE
JC2 PRACTICAL PRELIMINARY EXAMINATION
Higher 2

CANDIDATE
NAME

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CLASS

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CENTRE
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INDEX
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CHEMISTRY

Paper 4 Practical

9476/04

19 August 2026

2 hour 30 minutes

Candidates answer on the Question Paper

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number, name and class 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 an HB pencil for any diagrams or 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 15 to 17.

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	/ 12
2	/ 15
3	/13
4	/ 10
Total	/50

1 Identification of two cations and two anions

FA 1 and **FA 2** each contain one cation and one anion. The ions in the two compounds are different.

You will carry out tests to identify the ions in **FA 1** and **FA 2**.

The volumes given in Table 1.1 and Table 1.2 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**.

(a) Tests on FA1

Carry out the tests described in Table 1.1.

Carefully record your observations **at each stage** of the tests in Table 1.1.

Table 1.1

Test		Observations
1	Add 1 cm depth of FA 1 into a clean test tube. Add aqueous sodium hydroxide slowly with shaking until the aqueous sodium hydroxide is in excess. Keep the reaction mixture for test 2.	
2	Pour the reaction mixture from test 1 into a boiling tube. Add 1 cm depth of aqueous sodium hydroxide to the reaction mixture. Warm the mixture. Add a piece of aluminium foil to the reaction mixture.	
3	Add 1 cm depth of FA 1 into a clean test-tube. Add aqueous ammonia slowly with shaking until the aqueous ammonia is in excess.	

[3]

(b) Tests on FA2

Carry out the tests described in Table 1.2.

Carefully record your observations **at each stage** of the tests in Table 1.2.

Table 1.2

Test		Observations
1	Add 1 cm depth of FA 2 into a clean test tube. Add aqueous sodium hydroxide slowly with shaking until the aqueous sodium hydroxide is in excess.	
2	Add 1 cm depth of FA 2 into a clean test-tube. Add aqueous ammonia slowly with shaking until the aqueous ammonia is in excess.	
3	Add 1 cm depth of FA 2 into a clean test-tube. Add 1 cm depth of dilute nitric acid followed by a few drops of aqueous silver nitrate.	

[2]

(c) (i) Complete Table 1.3 to identify the ions present in FA1 and FA2.**Table 1.3**

	FA1	FA2
cation present		
anion present		

[2]

(ii) Write **two ionic equations to explain the chemistry of Test 3 on FA1.**

.....

..... [2]

- (d) (i) Carry out the following test on **FA2**.

Add 2 cm depth of FA 2 into a clean test-tube.	
Add FA3 slowly with shaking until FA3 is in excess.	

[2]

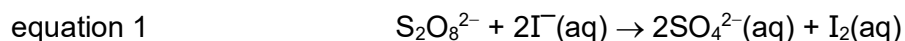
- (ii) Identify the anion in **FA3**.

..... [1]

[Total: 12]

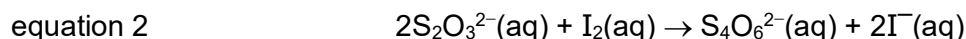
2 Investigating the kinetics of the reaction between peroxydisulfate ions and iodide ions

Equation 1 represents the reaction between iodide ions and peroxydisulfate ions.



When starch is added to the reaction mixture, a blue-black colour is immediately seen due to the formation of an iodine-starch complex.

If a small amount of sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$, is also present in the reaction mixture, the formation of the blue-black colour is delayed. The $\text{Na}_2\text{S}_2\text{O}_3$ reacts with I_2 as shown in equation 2.



FA 4 is $0.100 \text{ mol dm}^{-3}$ potassium peroxydisulfate, $\text{K}_2\text{S}_2\text{O}_8$.

FA 5 is 0.20 mol dm^{-3} potassium iodide, KI .

FA 6 is $0.0050 \text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.

Solution S is starch indicator

You will perform a series of four experiments. You will add a fixed amount of **FA 5** and **FA 6** to each of your experiments. You will add an amount of deionised water so that the total volume is 50 cm^3 . The time taken for the blue-black colour to form allows the reaction rate to be determined. You should avoid inhaling any gases produced.

(a) Prepare a table on page 6 in which to record, to an appropriate degree of precision:

- volumes of **FA 4** (V_{FA4}) and deionised water (V_{water}) used
- all values of t
- calculated values of $100/t$

Experiment 1

The end-point of the reaction is the **first** appearance of a blue-black colour.

Note: Insufficient swirling of the reaction mixture may lead to a blue-black colour appearing before the true end-point is reached.

1. Fill a burette with **FA 6**.
2. Use a 50 cm^3 measuring cylinder, measure 25 cm^3 of **FA 4** and top it up to the 30 cm^3 mark with deionised water. Transfer the contents in this measuring cylinder into a 250 cm^3 conical flask.
3. Add to the conical flask 5.00 cm^3 of **FA 6** from the burette and 5 cm^3 of starch indicator from a 10 cm^3 measuring cylinder.
4. Use a second 10 cm^3 measuring cylinder to measure 10 cm^3 of **FA 5**.
5. Pour the **FA 5** into the same conical flask, start the stopwatch during this addition.
6. Swirl the flask to ensure even mixing and place the flask on a white tile.
7. Stop the stopwatch when the solution **first** turns blue-black.
8. Record the time taken, t , to the nearest second in your table.
9. Wash out the flask thoroughly with tap water and then with deionised water. Stand the flask upside down on a paper towel to drain.

Repeat Experiments 2 – 4

Carry out **three** further experiments to investigate the effect of changing the concentration of $\text{S}_2\text{O}_8^{2-}(\text{aq})$ by altering the volume of $\text{K}_2\text{S}_2\text{O}_8$, **FA 4**, used.

You should not use a volume of **FA 4** that is less than 10 cm^3 and more than 25 cm^3 .

In each experiment, you should adjust the volume of deionised water in step 2 to ensure the **same total volume** of reaction mixture is used.

You should alternate the use of the two 250 cm^3 conical flasks. You should keep **FA 5** and **FA 6** for use in **Question 3**.

Record volumes, the time taken and the calculated values of $100/t$ in your table.

Results

[4]

- (b) The relative rate of reaction for the above experiments is related to the time taken for the blue-black colour to appear according to the following formula.

$$\text{relative rate} = \frac{100}{t}$$

- (i) Explain why the relative rate is proportional to $\frac{1}{t}$.

.....
 [1]

- (ii) Plot a graph of $100/t$ on the y-axis against V_{FA4} on the x-axis, on the grid in Fig. 2.1. **Start each of the axes at zero.**
Draw a best-fit line to prove that the reaction is first order with respect to $S_2O_8^{2-}$ ions.

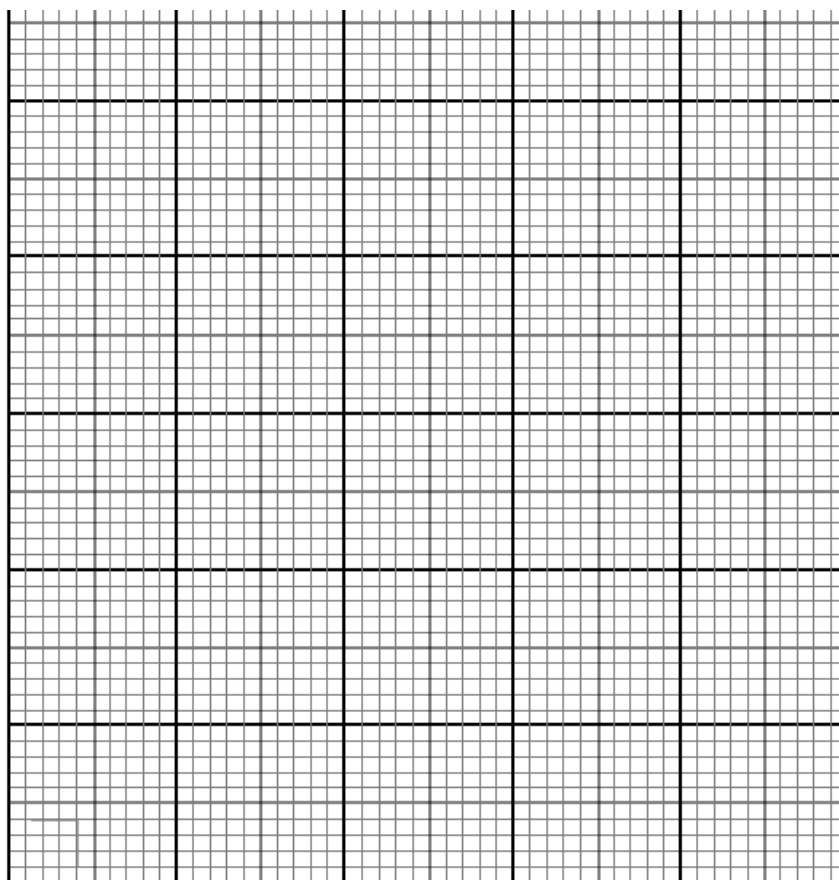


Fig. 2.1

[3]

- (iii) Use your graph in (b)(ii) to explain why the reaction is first order with respect to $S_2O_8^{2-}$ ions.

.....

 [2]

- (c) The rate of reaction can be found by calculating the change in concentration of $\text{S}_2\text{O}_8^{2-}(\text{aq})$ that occurred when enough iodine was produced to change the colour of the starch indicator to blue-black.

Use your data and the equations on page 5 to carry out the following calculations.

- (i) Calculate the amount in moles of iodine, I_2 , that react with the amount of thiosulfate ions, $\text{S}_2\text{O}_3^{2-}$ used in each experiment in (a).

amount of iodine, I_2 = [1]

- (ii) When the amount of peroxydisulfate ions, $\text{S}_2\text{O}_8^{2-}$, that was used to produce the amount of I_2 in part (i) reacted, a change in $[\text{S}_2\text{O}_8^{2-}]$ occurred. Calculate this change in $[\text{S}_2\text{O}_8^{2-}]$. Hence deduce the rate of change of $[\text{S}_2\text{O}_8^{2-}]$ for experiment 1, in $\text{mol dm}^{-3} \text{h}^{-1}$.

change in $[\text{S}_2\text{O}_8^{2-}]$ =

rate of change of $[\text{S}_2\text{O}_8^{2-}]$ for experiment 1 = $\text{mol dm}^{-3} \text{h}^{-1}$
[2]

- (d) 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.

A student suggested conducting Experiment 1 in (a) by halving all the volumes used. State and explain the effect this would have on the reaction time in Experiment 1 and the possible errors in the measurements.

.....

 [2]

[Total: 15]

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3 To determine the concentration of hydrochloric acid, HCl in FA 8

In the presence of acid, iodate(V) ions react with iodide ions to form iodine and water as shown in equation 3.



If sodium thiosulfate is present in the reaction mixture the iodine formed is immediately reduced back to iodide and the solution remains colourless.

Iodate(V) ions can therefore be titrated against acid in the presence of an excess of iodide and thiosulfate ions.

You are to use this method to determine the concentration of the hydrochloric acid, HCl in **FA 8**.

FA 5 is 0.20 mol dm^{-3} potassium iodide, KI.

FA 6 is $0.0050 \text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.

FA 7 is aqueous potassium iodate(V) containing 0.214 g dm^{-3} of KIO_3 .

FA 8 is an aqueous solution of hydrochloric acid, HCl.

Solution B is bromophenol blue indicator.

(a) (i) Dilution of FA 8

Use a pipette to transfer 10.0 cm^3 of **FA 8** into a 250 cm^3 volumetric flask.

Make the solution up to the mark with deionised water. Label this solution **FA 9**. This is a solution of hydrochloric acid of a concentration suitable for the titration.

Titration of FA 7 against FA 9

1. Fill the burette with **FA 9**.
2. Use a pipette to transfer 25.0 cm^3 of **FA 7** into a 250 cm^3 conical flask.
3. Add to the conical flask:
 - approximately 10 cm^3 of **FA 5** using a 10 cm^3 measuring cylinder
 - approximately 30 cm^3 of **FA 6** using a 50 cm^3 measuring cylinder
 - 8 drops of **Solution B**
4. Run **FA 9** from the burette into the conical flask. Swirl the flask continuously to observe the colour change accurately. The end-point is reached when the colour of **Solution B** first turns to greenish-yellow.
5. Record your titration results, to an appropriate level of precision, in the space provided on page 11.
6. Discard the reaction mixture in the sink.
7. Repeat steps 2 to 6 until consistent results are obtained.

Titration results

[3]

- (ii) From your titrations, obtain a suitable volume of **FA 9** to be used in your calculations. Show clearly how you obtained this volume.

volume of **FA 9** = [3]

- (b) (i) Calculate the amount in moles of potassium iodate(V), KIO_3 , that were pipetted into the conical flask.
[Ar: K, 39.1; I, 126.9; O, 16.0]

amount of potassium iodate(V), KIO_3 = [1]

- (ii) Calculate the amount of hydrochloric acid, HCl , that reacted with KIO_3 in the flask during the titration.

amount of hydrochloric acid, HCl = [1]

- (iii) Calculate the concentration of HCl in **FA 8**.

concentration of HCl in **FA 8** = [4]

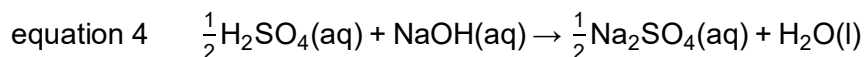
- (c) Suggest how the titration would be affected if sodium thiosulfate is **not** added in excess.

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

[Total: 13]

4 Planning

When sulfuric acid neutralises sodium hydroxide, water is produced.



The neutralisation process is exothermic, and the heat change, q , depends on the amount of water formed.

It is possible to determine the concentration of sulfuric acid and the enthalpy change of neutralisation by measuring the temperature rise obtained when different volumes of sulfuric acid are added to a fixed volume of a known concentration of sodium hydroxide in a series of experiments. The total volume of the reaction mixture for each experiment is not kept constant.

The data obtained is plotted and two best-fit lines are drawn. One line is drawn using data before the equivalence point and the second line using the remaining data. These lines are then extrapolated until they intersect each other.

In this question, you are to plan an investigation that would provide sufficient data to allow you to determine:

- the concentration of sulfuric acid,
- the maximum temperature change, ΔT_{max} ,
- the enthalpy change of neutralisation, ΔH_{n} .

You may assume that you are provided with:

- 1.50 mol dm⁻³ aqueous sodium hydroxide,
- sulfuric acid of approximately 1 mol dm⁻³ concentration,
- the equipment normally found in a school or college laboratory.

You may also assume that:

- the density of all solutions is 1.00 g cm⁻³,
- the specific heat capacity of all solutions is 4.18 J g⁻¹ K⁻¹.

- (a) Plan an investigation in which different volumes of sulfuric acid are added to a fixed volume of sodium hydroxide.

In your plan you should include brief details of:

- how you would select suitable volumes of sulfuric acid,
- the quantities of solutions you would use,
- the apparatus you would use and their precision,
- the procedure you would follow,
- the table of results you would prepare to allow a suitable graph to be drawn to determine the equivalence point accurately.

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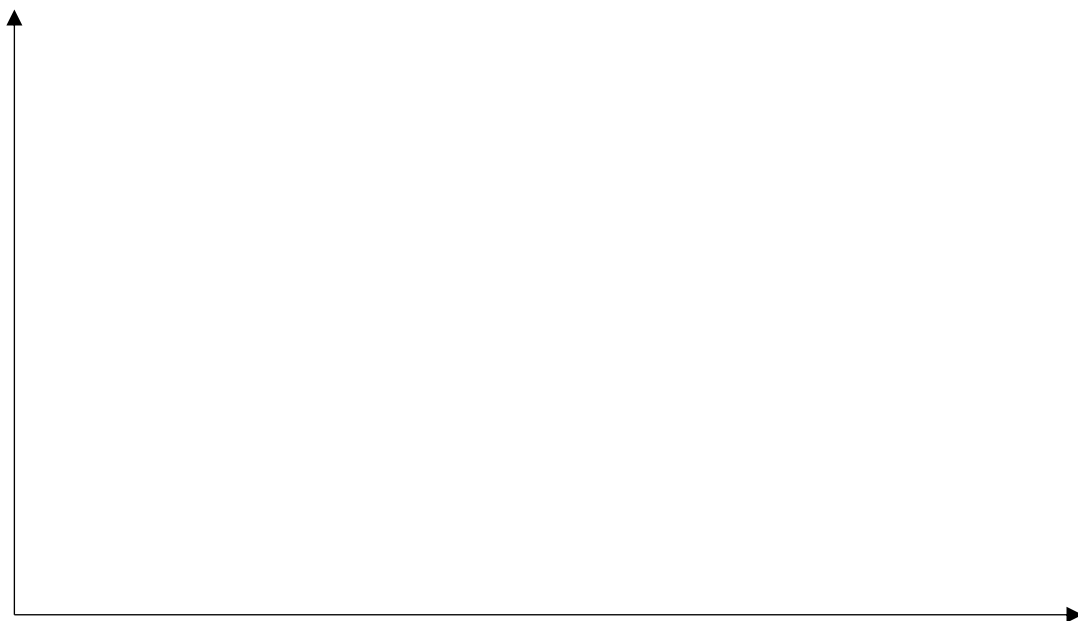
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..... [6]

- (b) (i) Sketch a suitable graph you would expect to obtain using the measurements you planned to make in **4(a)**. Indicate on the graph the volume of H_2SO_4 at equivalence point, V , and ΔT_{max} .



[2]

- (ii) Describe how you would use your ΔT_{max} value to calculate a value for q and hence determine a value for ΔH_{r} for this reaction.

You do not need to perform any calculations.

[2]

[Total: 10]

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

<i>anion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$)
bromide, $\text{Br}^-(\text{aq})$	gives 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 with dilute acids; gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in dilute strong acids)

(c) Tests for gases

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

(d) Colour of halogens

<i>halogen</i>	<i>colour of element</i>	<i>colour in aqueous solution</i>	<i>colour in hexane</i>
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

<i>organic compounds</i>	<i>reactions</i>
alkene	decolourises orange Br ₂ (aq)
chloroalkane	heat with NaOH(aq), white ppt. formed on adding dilute HNO ₃ followed by Ag ⁺ (aq)
bromoalkane	heat with NaOH(aq), pale cream ppt. formed on adding dilute HNO ₃ , followed by Ag ⁺ (aq)
iodoalkane	heat with NaOH(aq), yellow ppt. formed on adding dilute HNO ₃ , followed by Ag ⁺ (aq)
alcohol	• forms white fumes with solid PCl₅ • decolourises purple acidified KMnO₄(aq) on heating (for primary and secondary alcohols) • gives pale yellow ppt. with alkaline I₂(aq) on warming (for alcohols with CH₃CH(OH)– group)
phenol	decolourises orange Br ₂ (aq) and forms a white ppt.
carbonyl compounds (aldehydes and ketones)	• gives orange ppt. with 2,4-dinitrophenylhydrazine • gives pale yellow ppt. with alkaline I₂(aq) on warming (for carbonyl compounds with CH₃CO– 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	• CO₂ liberated by Na₂CO₃(aq) • Gives white fumes with solid PCl₅
phenylamine	decolourises orange Br ₂ (aq) and forms a white ppt.
primary amide	NH ₃ liberated on heating with NaOH(aq)