

Anglo-Chinese Junior College
JC2 Preliminary Examination
Higher 2



A Methodist Institution
(Founded 1886)

CANDIDATE
NAME

FORM
CLASS

TUTORIAL
CLASS

INDEX
NUMBER

CHEMISTRY
Paper 4 Practical

9476/04

3 August 2026

2 hour 30 minutes

You must answer on the question paper.

You will need: The materials and apparatus listed in the confidential instructions

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and index number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen. Do **not** use correction fluid or tape.
- Do **not** write on any bar codes.
- You may use an approved calculator.
- Qualitative analysis notes are printed in the question paper.
- Write the details of the shift and laboratory in the boxes provided.

INFORMATION

- The total mark for this paper is 50.
- The number of marks for each question or part question is shown in brackets [].

Shift

Laboratory

For Examiner's Use	
Question No.	Marks
1 (13 m)	
2 (17 m)	
3 (12 m)	
4 (8 m)	
Presentation of answers	
Total (50 m)	

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

1 Identification of two cations and one anion

(a) **FA 1** and **FA 2** contain a different cation and the same anion.

The volumes given in Table 1.1 are approximate and should be estimated rather than measured.

Test any gas evolved during the tests.

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

(i) Carry out the tests described in Table 1.1.

Carefully record your observations in Table 1.1.

Table 1.1

	test	observations with FA 1	observations with FA 2
1	Add 1 cm depth of the FA solution into a clean test-tube. Test the FA solution using Universal Indicator paper.		
2	Add 1 cm depth of the FA solution into a clean boiling tube. Add 1 cm depth of aqueous sodium hydroxide slowly, with shaking, until the aqueous sodium hydroxide is in excess.		
	Gently warm the boiling tube.		
3	Add 1 cm depth of the FA solution into a clean test-tube. Add 1 cm depth of aqueous ammonia slowly, with shaking, until the		

	aqueous ammonia is in excess.		
4	Add 1 cm depth of the FA solution into a clean test-tube. Add a few drops of aqueous silver nitrate, then		
	add aqueous ammonia to the mixture, with shaking, until the aqueous ammonia is in excess.		

[7]

- (b) (i) Complete Table 1.2 to identify the cations and anion in **FA 1** and **FA 2**.

Table 1.2

	FA 1	FA 2
cation present		
anion present		

[3]

- (ii) Explain which test was used to identify the anion.

Test of **FA** was used to identify the anion.

Evidence:

..... [1]

- (iii) Write an equation and explain the observation of **FA 2** in test 1.

.....

.....

..... [2]

[Total: 13]

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2 Determination of the kinetics of a clock reaction

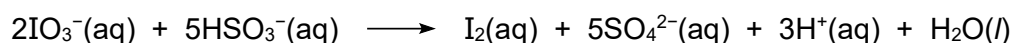
FA 3 is $0.100 \text{ mol dm}^{-3}$ potassium iodate(V), KIO_3 .

FA 4 is $0.0500 \text{ mol dm}^{-3}$ sodium hydrogensulfite, NaHSO_3 .

You are also provided with:

- **starch solution**
- deionised water.

Iodate(V) ions react with hydrogensulfite ions in aqueous solution according to the equation shown.



In this experiment, the rate of reaction is studied by measuring the time taken to form a fixed amount of iodine using a 'clock' method. In the presence of starch, a blue-black colour indicates the formation of iodine.

The reaction proceeds through several steps, so the blue-black colour does not appear immediately. You will vary the concentration of iodate(V) ions and measure the time, t , taken for the blue-black complex to appear.

You will perform a series of five experiments, in which the volume of **FA 3** is varied while the volume of **FA 4** is kept constant. In each experiment, you will adjust the volume of deionised water so that the total volume of the reaction mixture is 20.0 cm^3 .

Experiment 1

1. Use a teat pipette to add 10 drops of **starch solution** to a clean 100 cm³ conical flask.
2. Use a 10 cm³ measuring cylinder to measure 2.0 cm³ of **FA 3** into the conical flask.
3. Use a 25 cm³ measuring cylinder to add 16.0 cm³ of deionised water into the same conical flask. Swirl gently to mix.
4. Use a second 10 cm³ measuring cylinder to measure 2.0 cm³ of **FA 4**.
5. Pour **FA 4** into the conical flask, starting the stopwatch during this addition.
6. Swirl the mixture thoroughly. Place the flask on a 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. Wash the conical flask thoroughly with tap water, then with deionised water. Stand it upside down on a paper towel to drain.

Record all volumes, the time taken and the calculated values of $1/t$, $\log(1/t)$ and $\log(V_{\text{FA3}})$ in the space provided on page 6.

Experiments 2 to 5

Repeat experiment 1 four times, using 4.0 cm³, 6.0 cm³, 8.0 cm³ and 10.0 cm³ of **FA 3** respectively in step 2.

In each experiment, you should adjust the volume of deionised water in step 3 to ensure that the total volume of reaction mixture is 20.0 cm³.

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

(a) Results

- (b) Plot a graph of $\log(1/t)$ on the y -axis against $\log(V_{FA3})$ on the x -axis for experiments 1 to 5 on the grid in Fig. 2.1.

Draw the best-fit straight line.

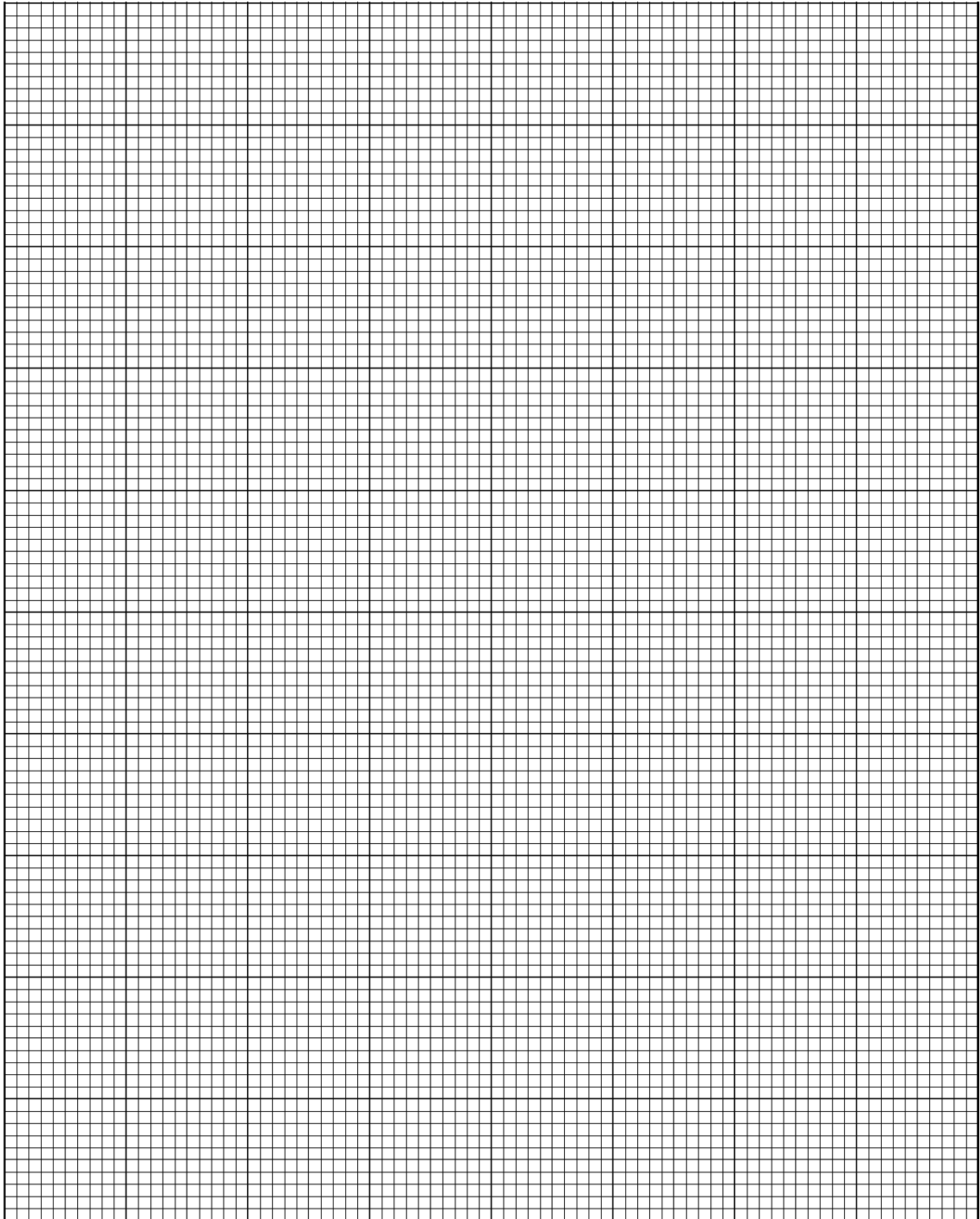


Fig. 2.1

[3]

- (c) Calculate the gradient of your best-fit line to three significant figures, showing clearly how you did this.

gradient =[1]

- (d) The gradient of the line in (b) gives the order of reaction, n , with respect to $[\text{IO}_3^-]$. State the value of n .

n = [1]

- (e) Explain why $\log(V_{\text{FA3}})$ may be plotted directly on the x-axis instead of $\log[\text{IO}_3^-]$ to determine the order of reaction with respect to $[\text{IO}_3^-]$.

.....

 [2]

(f) **Planning**

It is suggested that an ion of transition element **X** serves as a catalyst in the reaction between iodate(V) and hydrogensulfite ions.

- (i) Suggest why the reaction between iodate(V) and hydrogensulfite ions is slow and the rate of reaction increases in the presence of a catalyst.

.....

 [2]

- (ii) Plan an extension to the investigation in question 2 to determine if aqueous X^{n+} act as a catalyst. You should **not** carry out your plan.

You may assume you are provided with the following solutions:

- $0.10 \text{ mol dm}^{-3} \text{ X}^{n+}(\text{aq})$
- the solutions provided in question 2.

Your plan should include:

- one further experiment
- a table of volumes of solutions used
- how you would know if aqueous X^{n+} act as a catalyst in the clock reaction

You do **not** need to rewrite the method given.

[3]

[Total: 17]

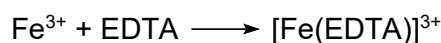
3 Analysis of the mass of iron in an iron tablet

Iron is an essential element in the human diet. Some people need to take iron supplement tablets to ensure an adequate intake of iron.

FA 5 is a solution prepared by dissolving 5 tablets in 1.00 dm³ of acidified hydrogen peroxide solution. The iron in each iron supplement tablet has the formula FeSO₄•7H₂O. As hydrogen peroxide is present in excess, Fe²⁺ is oxidised completely to Fe³⁺.

You will investigate the mass of iron in an iron supplement tablet by titrating **FA 5** with ethylenediaminetetraacetic acid (EDTA).

When titrated with EDTA, Fe³⁺ binds strongly to form a yellow – coloured complex.



There is no reaction between EDTA and hydrogen peroxide.

FA 6 is 0.010 mol dm⁻³ EDTA solution.

Solution S is salicylic acid indicator.

(a) (i) Procedure

1. Fill the burette with **FA 6**.
2. Pipette 10.0 cm³ of **FA 5** into a 100 cm³ conical flask.
3. Add 5 drops of **Solution S**.
4. Titrate the solution in the conical flask with **FA 6**. The end-point is reached when the solution turns from dark purple to pale yellow.
5. Record your titration results to an appropriate level of precision in the space on page 10.
6. Repeat steps 2 to 5 until consistent results are obtained.

Results

[4]

- (ii) From your titrations, obtain a suitable volume of **FA 6** to be used in your calculations. Show clearly how you obtained this volume.

Volume of **FA 6** = [1]

- (b) (i) Calculate the amount of Fe^{3+} in 10.0 cm^3 of **FA 5**.

amount of Fe^{3+} in 10.0 cm^3 of **FA 5** = [1]

- (ii) Calculate the concentration of Fe^{3+} in **FA 5**.

concentration of **FA 5** = [1]

The manufacturer of the iron supplement tablets used to make **FA 5** claims that one tablet contains 100 mg of iron. Health authorities allow manufacturers to have a 20.0 % error in the percentage mass of iron in each tablet. [1 g = 1000 mg]

- (iii) Use your answer to (b)(ii) and the information given about **FA 5** to determine whether the mass of iron in one tablet falls within the acceptable margin of error. Show your working.

[A_r : Fe, 55.8]

..... [4]

- (c) Table 3.1 gives the colours of some manganese-containing ions and some of the substances you have used in (a)(i).

Table 3.1

species	colour
MnO_4^-	deep purple
Mn^{2+}	pale pink
H_2O_2	colourless

A student suggested that acidified potassium manganate KMnO_4 can be used to replace hydrogen peroxide H_2O_2 in the preparation of **FA5**.

Use information from Table 3.1 to explain if KMnO_4 is a suitable replacement.

.....
 [1]

[Total: 12]

4 Planning

The basicity of an acid can be determined by the following procedure.

Solutions of two acids of unknown basicity are provided, one acid being monobasic and the other being dibasic. 40.0 cm^3 of the acid solution, with a concentration of $0.035 \text{ mol dm}^{-3}$ is reacted with excess solid magnesium carbonate and the gaseous carbon dioxide produced is collected. Comparing the relative volumes of carbon dioxide collected in the reaction with each acid allows the basicity of the acid to be determined.

- (a) (i)** Determine the volume of carbon dioxide produced, when 40.0 cm^3 solution of the dibasic acid of $0.035 \text{ mol dm}^{-3}$ reacted with an excess of magnesium carbonate.

Assume all measurements are made at room temperature and pressure.

[1]

- (ii)** State how the volume of carbon dioxide collected would compare with that in **(a)(i)**, if a monobasic acid of the same concentration and volume, were used.

Explain your answer.

.....

..... [1]

- (iii)** By considering your answer to **(a)(i)** and **(a)(ii)**, determine the minimum mass of magnesium carbonate to be used, which would be present in excess in the reaction with both acids.

[A_r : C, 12.0; O, 16.0; Mg, 24.3]

[1]

- (b) Plan an investigation to determine the basicity of the two acids, using 40.0 cm³ solution of each acid and excess solid magnesium carbonate.

You may assume you are provided with:

- 0.035 mol dm⁻³ acid solutions **A** and **B**, each containing either the monobasic or dibasic acid
- solid magnesium carbonate
- the equipment normally found in a school or college laboratory.

Your plan should include brief details of:

- the apparatus you would use
- the procedure you would follow
- the measurements you would take
- how you would ensure your results are accurate

You may include a suitable, labelled diagram in your plan.

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[5]

Qualitative Analysis Notes

[ppt. = precipitate]

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