



Catholic Junior College

JC2 Preliminary Examinations

Higher 2

CANDIDATE
NAME

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CLASS

2T

CHEMISTRY

Paper 4 Practical

9476/04

25 August 2026
2 hours 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 and class 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.
- 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.

Shift
Laboratory

INFORMATION

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

For Examiner's Use	
1	/ 14
2	/ 11
3	/ 8
4	/ 17
Total	/ 50

This document consists of **18** printed pages.

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

1 Identification of two cations and one anion

FA 1 is an aqueous solution containing two cations and one anion listed in the Qualitative Analysis notes on pages 16 and 17.

You will perform tests to identify the two cations and one anion in **FA 1**.

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

Colours of filtrates and residues should be reported. You **do not** need to test any gases evolved.

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

- (a) (i) Carry out the following tests. Carefully record your observations **at each stage** of the tests in Table 1.1.

Table 1.1

tests		observations
1	Test the FA 1 solution using Universal Indicator paper. Hence, conclude the pH of FA 1 solution.	
2	Add 1 cm depth of FA 1 into a clean test-tube. Add 3 cm depth of aqueous sodium hydroxide, slowly with shaking, to FA 1 . Filter the mixture into a clean boiling tube. Keep the filtrate for test 4. While waiting, proceed to test 3.	
3	Add 1 cm depth of FA 1 into a clean test-tube. Add aqueous ammonia, slowly with shaking, until no further change is seen.	
4	To the filtrate from test 2, carefully add dilute sulfuric acid dropwise until no further change is seen.	

5	Add 1 cm depth of FA 1 into a clean test-tube. Add an equal volume of potassium iodide, KI(aq), and shake. To this mixture, add 15 drops of sodium thiosulfate, Na₂S₂O₃(aq), and shake.	
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[8]

(ii) Identify the two cations present in **FA 1**.

Cations present: and

[2]

(b) (i) **FA 1** does not contain CO₃²⁻, NO₂⁻, NO₃⁻ and SO₃²⁻.

Devise and perform two tests to identify the anion present in **FA 1**. Your tests should be based on the Qualitative Analysis Notes provided on page 17 and should use only the bench reagents provided. Record your tests and observations in the space below.

	tests	observations
1		
2		

[2]

(ii) Use your observations in (b)(i) to deduce the identity of the anion in **FA 1**.

Identity of anion:

[1]

[Turn over

- (c) A student discovered a bottle of solution with the label “ammonium nitrate, $\text{NH}_4\text{NO}_3(\text{aq})$ ” and decided to conduct some tests to verify whether the solution was indeed as labelled.

Subsequently, the student correctly identified the presence of NH_4^+ in the solution through the addition of aqueous sodium hydroxide followed by heating.

Suggest why the student might find it difficult to identify the presence of NO_3^- in the solution.

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.....[1]

[Total: 14]

2 Organic analysis

In this question, you will deduce the identities of the organic compounds **FA 2**, **FA 3**, **FA 4** and **FA 5**.

- Each compound contains only carbon, hydrogen and oxygen.
- Each molecule contains only three carbon atoms and only one oxygen atom.

You will perform a series of test-tube reactions and use the observations to help you identify the compounds. The observations for some of the reactions, including **all** observations for **FA 5**, have already been recorded in Table 2.1.

You are provided with:

- liquid samples **FA 2**, **FA 3** and **FA 4**
- iodine solution
- other necessary bench reagents.

(a) Follow the instructions below to prepare Tollens' reagent.

To a 2 cm depth of aqueous silver nitrate in a test-tube, add 4 drops of aqueous sodium hydroxide. Then add aqueous ammonia dropwise, with shaking, until the brown solid **just** dissolved. **Do not add an excess of aqueous ammonia.**

Perform the tests described in Table 2.1 on page 6, and record your observations in the table. If there is no observable change, write **no observable change**.

Use a fresh sample of each liquid in each test.

(i) Carry out the following tests. Carefully record your observations in Table 2.1.

The volumes given below are approximate and should be estimated rather than measured.

You do **not** need to test for any gases evolved.

[Turn over

Table 2.1

tests		observations with FA 2	observations with FA 3	observations with FA 4	observations with FA 5
1	Add 1 cm depth of Tollens' reagent to a clean test-tube. Add 5 drops of FA 3 and shake the test-tube. Place the test-tube in the test-tube rack and leave it for 3 minutes. Repeat using FA 4 in place of FA 3.	No observable change			No observable change
2	Add 1 cm depth of FA 2 to a clean test-tube. To this test-tube, add 5 drops of dilute sulfuric acid followed by 5 drops of potassium manganate(VII) solution. Warm the mixture in a hot water bath for two minutes. Repeat using FA 4 in place of FA 2.		KMnO ₄ solution decolourises		KMnO ₄ solution decolourises
3	Add 1 cm depth of deionised water to a clean test-tube. To this test-tube, add 6 drops of aqueous sodium hydroxide, then add iodine solution, dropwise, until a permanent pale yellow colour is present. To this solution, add 5 drops of FA 2. Warm the mixture in a hot water bath for two minutes. Repeat using FA 4 in place of FA 2.		No observable change		Pale yellow ppt formed
4	You should not do this test. Observations have been recorded for you. Add 1 cm depth of the organic compound to a test tube. To this test-tube, add a small spatula of solid phosphorus(V) chloride. Repeat using the other organic compounds.	No observable change	White fumes	No observable change	White fumes

[4]

[Turn over]

- (b) Use the observations recorded in Table 2.1 to complete Table 2.2 to identify the organic compounds **FA 2**, **FA 3**, **FA 4** and **FA 5**.

For each compound, give evidence to support your conclusion.

Table 2.2

	identity of compound	evidence
FA 2		
FA 3		
FA 4		
FA 5		

[4]

- (c) (i) There are two other unknown compounds containing C, H and O atoms only, with $M_r = 74.0$ that would give:
- no observable change in tests 1 to 3 in Table 2.1
 - white fumes with phosphorus(V) chloride (test 4 in Table 2.1)
- [A_r : H, 1.0; C, 12.0; O, 16.0]
- One of the compounds is 2-methylpropan-2-ol, $(\text{CH}_3)_3\text{COH}$.
Give the structure of the other compound, which has a pH less than 7 in aqueous solution.

[1]

- (ii) Suggest a chemical test that would enable you to distinguish between the two compounds in (c)(i). In your answer, provide information on the reagents, conditions, and expected observations for each compound.

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.....[2]

[Total: 11]

[Turn over

3 Determination of the kinetics of the reaction between iron(III) and iodide ions

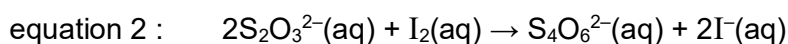
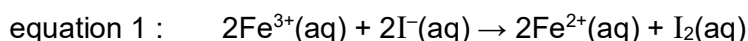
FA 6 is aqueous potassium iodide, KI.

FA 7 is aqueous iron(III) chloride, FeCl_3 .

FA 8 is $0.0065 \text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.

You are also provided with a starch indicator and deionised water.

A solution containing potassium iodide, sodium thiosulfate and starch is mixed with iron(III) chloride solution. After a few seconds a dark blue colour suddenly appears. This is one of a number of reactions referred to as iodine clock reaction.



When the above solutions are mixed, iodine is generated according to equation 1. The iodine is being consumed as it is generated, according to equation 2. Therefore, only a small amount of iodine is present in the mixture.

The reaction in equation 2 stops once all the thiosulfate ions have reacted. The concentration of iodine now increases and the dark blue colour of the iodine-starch complex appears.

The reaction in equation 1 is first order with respect to the iodide ion concentration, $[\text{I}^{-}]$.

You are to perform a series of experiments to determine the rate order for the reaction in equation 1 with respect to the iron(III) chloride concentration, $[\text{FeCl}_3]$.

Experiments to be performed

You will attempt four experiments.

- In Experiment 1, **Solution A** will be prepared as described below.
- In the remaining experiments you will repeat the procedure from Experiment 1, but using different volumes of **FA 7**.

For each experiment, you should note the time taken, t , for the solution to first turn dark blue.

(i) Experiment 1

1. Fill the burette with **FA 7**. Transfer 35.00 cm³ of **FA 7** to a conical flask.
2. Using appropriate measuring cylinders, transfer to beaker labelled **Solution A**
 - 10.0 cm³ of **FA 6**
 - 20.0 cm³ of **FA 8**
 - 5.0 cm³ of starch indicator
3. Stir the contents of the beaker using a glass rod.
4. Pour **Solution A** rapidly into the conical flask containing **FA 7**. Start the stopwatch during the addition of **Solution A**.
5. Mix the contents thoroughly by swirling the flask several times. Then place it on a white tile.
6. Stop the stopwatch at the first appearance of a blue-black / purple colour.
7. Record the time elapsed, t , to the nearest second in your table.
8. Wash out the conical flask and beaker thoroughly with tap water, and then deionised water.

(ii) Remaining experiments

In order to determine the order of reaction with respect to $[\text{FeCl}_3]$ for reaction 1, you should repeat Experiment 1 three more times and number these Experiments 2 to 4 respectively.

In each experiment, the volumes of **FA 6**, **FA 8** and starch indicator are the same as those used in Experiment 1.

Instead of adding 35.00 cm³ of **FA 7**, you should be adding 20.00 cm³, 25.00 cm³ and 30.00 cm³ of **FA 7**. The volume of deionised water added to the conical flask before **Solution A** should be adjusted to ensure that the **same total volume** of reaction mixture is used.

[Turn over

The volumes of **FA 6**, **FA 8** and starch indicator are not changed in these experiments, and do not need to be recorded.

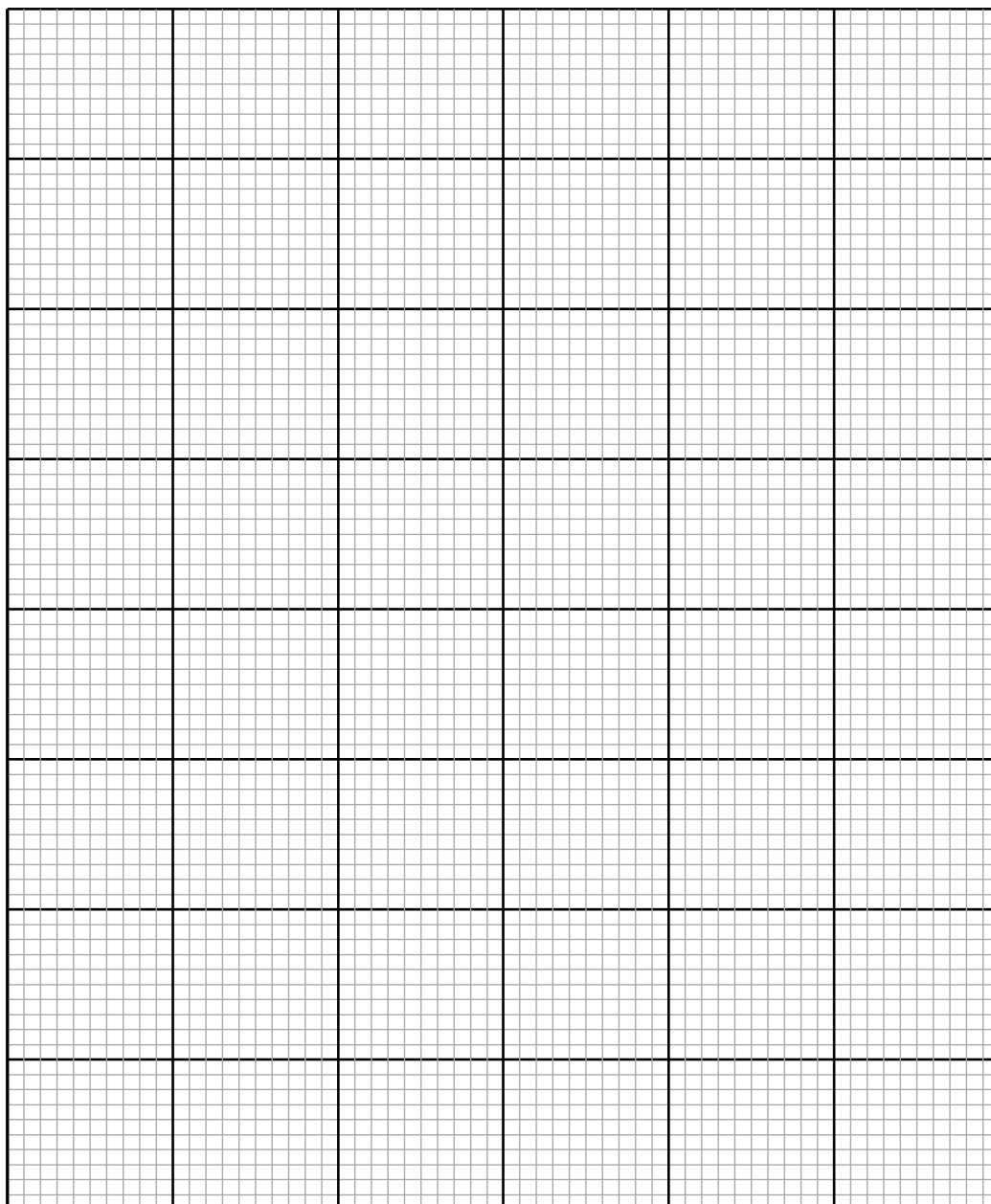
Prepare a table in the space provided below in which to record to an appropriate degree of precision, for each experiment:

- volumes of **FA 7** ($V_{\text{FA 7}}$) and deionised water used
- time taken, t , to the nearest second
- calculated values for $\lg(V_{\text{FA 7}})$ and $\lg(1/t)$.

(a) Results

[3]

- (b) Plot a graph of $\lg(1/t)$ on the y -axis against $\lg(V_{FA7})$ on the x -axis.
Draw the best-fit straight line.



[3]

- (c) Calculate the gradient, to 3 significant figures, and state the order of reaction with respect to $[\text{FeCl}_3]$.

[2]

[Total : 8]

[Turn over

4 Determination of the percentage composition by mass in a sample

Dolomite ore, primarily made of $\text{MgCa}(\text{CO}_3)_2$, serves as a primary ore for the extraction of pure magnesium metal. Due to the insolubility of magnesium calcium carbonate in water, back titration is typically performed first to determine the batch of ore's percentage purity.

A back titration is an analytical chemistry technique used to determine the concentration or amount of an analyte by reacting it with a known, excess amount of a reagent. The unreacted excess reagent is then titrated against a second standard solution.

- (a) Calculate the amount of carbonate ions in 4.0 g of dolomite ore. The percentage composition by mass of $\text{MgCa}(\text{CO}_3)_2$ is assumed to be 100%.

[A_r : C = 12.0; O = 16.0; Mg = 24.3; Ca = 40.1]

amount of carbonate ions in 4.0 g of dolomite ore = mol [1]

- (b) The reaction between $\text{MgCa}(\text{CO}_3)_2$ and HCl shown below :



You may assume that you are provided with :

- approximately 4.0 g of dolomite ore (percentage composition assumed to be 100%),
- 2.50 mol dm^{-3} HCl solution,
- 250 cm^3 volumetric flask,
- the equipment normally found in a school or college laboratory.

Write a plan to prepare a 250 cm^3 solution of dissolved dolomite sample with excess H^+ .

You should include details of:

- an estimate of the volume of HCl to be used to ensure that the solution used for back-titration has a concentration of at least $0.020 \text{ mol dm}^{-3} \text{ H}^+$,
- the apparatus that you would use,
- the procedure you would follow,
- the measurements you would make.

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- (c) In this part of the experiment, you will be performing titrations to determine the excess amount of acid present to determine the percentage composition by mass of magnesium in the solid sample.

The equation for the reaction is shown below.



A sample of 3.39 g of dolomite ore from a mining site was crushed and mixed with 100 cm³ of 2.50 mol dm⁻³ HCl solution. The mixture was then filtered and made up to 1 dm³ of **FA 9**.

FA 9 is an aqueous solution containing the treated dolomite sample (as mentioned above)

FA 10 is 0.200 mol dm⁻³ NaOH solution

thymolphthalein indicator

- (i) Titration of **FA 9** against **FA 10**

1. Fill the burette with **FA 10**.
2. Use the pipette to transfer 25.0 cm³ of **FA 9** into a 250 cm³ conical flask.
3. Add 6 drops of indicator to the same conical flask.
4. Titrate the mixture in the conical flask until the end-point is reached.
5. Record your titration results, to an appropriate level of precision, in the space provided below.
6. Repeat points 2 to 5 until consistent results are obtained.

Titration results

[5]

- (ii) From your titrations, obtain a suitable volume of **FA 10** to be used in your calculations. Show clearly how you obtained this volume.

volume of **FA 10** used = cm³ [1]

- (d) (i) Calculate the amount of H^+ ions in 1 dm^3 of **FA 9**.

amt of H^+ ions = mol [1]

- (ii) Calculate the amount of H^+ ions that reacted with $\text{MgCa}(\text{CO}_3)_2$ to form 1 dm^3 of **FA 9**.



Determine the mass of magnesium in 3.39 g of ore provided and hence the percentage composition by mass of magnesium of this sample.

[A_r : Mg = 24.3]

mass of magnesium in 3.39 g of ore = g [2]

percentage composition by mass of magnesium in ore = % [2]

[Total : 17]

[Turn over

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>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

[Turn over

(e) Tests for organic compounds

organic compounds	reactions
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 pt. with Fehling's solution on warming (for aliphatic aldehydes) • gives silver mirror with Tollens' reagent on warming (for aldehydes)
carboxylic acid	• CO₂ liberated with Na₂CO₃(aq) • gives white fumes with solid PCl₅
phenylamine	decolourises orange Br ₂ (aq) and form a white ppt
primary amide	NH ₃ liberated on heating with NaOH(aq)