



# Catholic Junior College

## JC2 Preliminary Examinations

### Higher 2

CANDIDATE  
NAME

CLASS

## CHEMISTRY

9729/04

Paper 4 Practical

26 August 2025  
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 and class in the boxes above.

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 17 and 18.

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	/ 11
3	/ 19
4	/ 12
Total	/ 55

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

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

# 1 Investigation of an organic compound and an inorganic compound

**FA 1** is an aqueous solution that contains a mixture of salts with two cations and one anion listed in the Qualitative Analysis Notes.

**FA 2** is an aqueous solution of an organic compound, **X**, with only one functional group present.

You will perform tests to identify:

- the ions present in **FA 1**.
- the functional group of **X** in **FA 2**.

(a) (i) Carry out the following tests. Carefully record your observations in Tables 1.1 and 1.2.

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 <b>FA 1</b> in a boiling tube, add aqueous sodium hydroxide until there is no further change.  Heat the boiling tube gently.	
2	To 1 cm depth of <b>FA 1</b> in a test-tube, add a few drops of $\text{Ba}(\text{NO}_3)_2$ (aq). Then, add excess nitric acid.	
3	To 1 cm depth of <b>FA 1</b> in a test-tube, add excess aqueous hydrogen peroxide until no further change.	

From your observations, identify the ions present in **FA 1**.

The cations are ..... and .....

The anion is .....

[7]

- (ii) Explain the observation for the reaction between **FA 1** and aqueous hydrogen peroxide in Test 3.

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

**Table 1.2**

tests		observations
1	To 1 cm depth of <b>FA 2</b> in a test tube, add 2 cm depth of water.  Test this solution with Universal Indicator paper.  Hence conclude the pH of the resultant solution of <b>FA 2</b> .  <b>Keep this solution for test 2 below.</b>	
2	To the resultant solution in test 1, add 1 full spatula of solid $\text{Na}_2\text{CO}_3$ .	
3	To a 1 cm depth of <b>FA 2</b> in a test-tube, add 1 cm depth of aqueous silver nitrate.	

[3]

- (b) (i) Use your results of Test 3 in Table 1.2 to identify the anion present in **FA 2**.

Anion present: .....

- (ii) Suggest a possible functional group that could be present in **X** in **FA 2** and state the evidence by completing Table 1.3.

**Table 1.3**

Functional group	evidence

[2]

**[Total: 13]**

**[Turn over]**

## 2 Determination of the amount of water of crystallisation in $\text{CuSO}_4 \cdot n\text{H}_2\text{O}$ .

In this experiment, you are to determine the amount of water of crystallisation (value of  $n$ ) in a sample of hydrated copper(II) sulfate,  $\text{CuSO}_4 \cdot n\text{H}_2\text{O}$  by titration.

When excess aqueous potassium iodide is added to the aqueous  $\text{Cu}^{2+}$  ions, iodine and a white precipitate of copper(I) iodide are produced.



The amount of iodine produced is found by titration with aqueous thiosulfate ions,  $\text{S}_2\text{O}_3^{2-}$ .



You are provided with

**FA 3** is a solution of aqueous hydrated copper(II) sulfate of concentration  $20.0 \text{ g dm}^{-3}$ .

**FA 4** is a solution of aqueous potassium iodide, KI.

**FA 5** is  $0.100 \text{ mol dm}^{-3}$  aqueous sodium thiosulfate,  $\text{Na}_2\text{S}_2\text{O}_3$ .

Starch indicator

### (a)(i) Titration of **FA 3** against **FA 5**

1. Fill a burette with **FA 5**.
2. Use a pipette to transfer  $25.0 \text{ cm}^3$  of **FA 3** into a  $250 \text{ cm}^3$  conical flask.
3. Use a measuring cylinder to add about  $15 \text{ cm}^3$  of **FA 4** to this flask. A white precipitate forms in a brown solution.
4. Run **FA 5** from the burette into this flask. Near the end-point, when the brown solution becomes pale, add about  $1 \text{ cm}^3$  of starch indicator.
5. Continue adding **FA 5** slowly. The end-point is reached when the **solution** first becomes colourless. The white precipitate remains.
6. Record your titration results, to an appropriate level of precision, in the space provided below.
7. Repeat points 2 to 6 until consistent results are obtained.

### Titration Results

- (ii) From your titrations, obtain a suitable volume of **FA 5**,  $V_{\text{FA5}}$ , to be used in your calculations. Show clearly how you obtained this volume and place a tick (✓) under the readings used.

$V_{\text{FA5}} = \dots\dots\dots$   
[3]

- (b) (i) Calculate the concentration of  $\text{CuSO}_4 \cdot n\text{H}_2\text{O}$  in **FA 3**.

concentration of  $\text{CuSO}_4 \cdot n\text{H}_2\text{O} = \dots\dots\dots$  [1]

- (ii) Determine the relative molecular mass of  $\text{CuSO}_4 \cdot n\text{H}_2\text{O}$  in **FA 3** and hence calculate the value of  $n$ . You **must** show your working. [Ar: H, 1.0; O, 16.0; S, 32.1; Cu, 63.5]

relative molecular mass,  $M_r$ , of  $\text{CuSO}_4 \cdot n\text{H}_2\text{O}$  = .....

value of  $n$  = .....  
[2]

- (c) Calculate the maximum total percentage uncertainty for your titration in **2(a)(i)** if the uncertainty associated with each reading using a  $25.0 \text{ cm}^3$  pipette and a burette are  $\pm 0.06 \text{ cm}^3$  and  $\pm 0.05 \text{ cm}^3$  respectively.

Percentage uncertainty = .....  
[2]

**[Total: 11]**

### 3 Determination of an enthalpy change of neutralisation by thermometric titration

**FA 6** is  $1.00 \text{ mol dm}^{-3}$  aqueous sodium hydroxide, NaOH.

**FA 7** is aqueous sulfuric acid,  $\text{H}_2\text{SO}_4$ .

You are to carry out a thermometric titration to determine the enthalpy change of neutralisation per mole of water formed when these two solutions, **FA 6** and **FA 7** react. This involves adding volumes of aqueous sulfuric acid to a fixed volume of aqueous sodium hydroxide and measuring the temperature of the resulting solution.

(a) **Before starting any practical work, read through the instructions carefully and complete the table in the space provided on page 8.** Record, to the appropriate level of precision:

- all volumes of acid, **FA 7** added,  $V$
- the maximum temperature,  $T$ , reached after each addition of **FA 7**

It is important that the volume of **FA 7** recorded is the total volume you have added up to the point when the temperature reading was made.

Note: If you overshoot on an addition, record the actual volume of **FA 7** added up to that point.

#### Procedure

1. Place a polystyrene cup inside a second polystyrene cup and place both cups in a  $250 \text{ cm}^3$  beaker. The retort clamp provided may be used to clamp the beaker to prevent it from tipping.
2. Use the pipette labelled **FA 6** to transfer  $25.0 \text{ cm}^3$  of **FA 6** into the first polystyrene cup.
3. Fill the burette labelled **FA 7** with **FA 7**.
4. Stir the **FA 6** in the cup gently with the thermometer. Read and record its temperature.
5. Use the burette to add  $2.00 \text{ cm}^3$  of **FA 7** to the cup and stir the mixture gently with the thermometer. Read and record both the maximum temperature and the actual total volume of **FA 7** added.
6. Repeat step 5 until a total of  $24.00 \text{ cm}^3$  of **FA 7** has been added. For each addition of **FA 7**, read and record both the maximum temperature and the actual total volume of **FA 7** added up to that point.

[Turn over

**Results**

<b>Total volume of FA 7 added, V/cm<sup>3</sup></b>	
<b>0.00</b>	
<b>2.00</b>	
<b>4.00</b>	

[3]



- (b) Plot a graph of temperature,  $T$ , on the  $y$ -axis, against total volume of **FA 7**,  $V$ , on the  $x$ -axis on the grid in Fig 3.1. Your scale on the  $y$ -axis should allow for extrapolation above the highest temperature recorded.

Draw two lines of best-fit, taking into account the points when the temperature of the mixture was rising and the points when the temperature was falling. Each line should have a shape best suited to its plotted points.

Extrapolate (extend) both lines until they intersect.

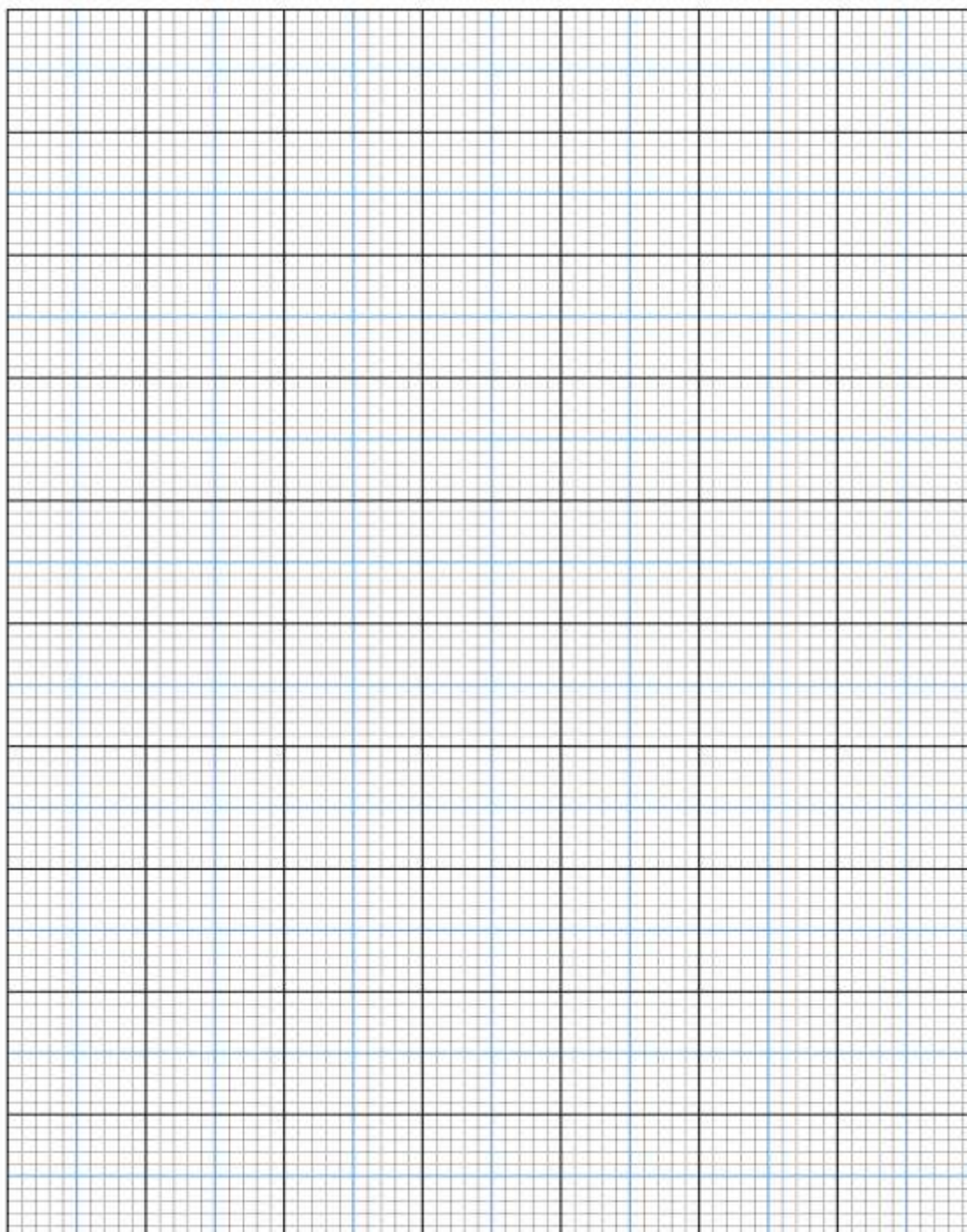


Fig. 3.1

[3]

[Turn over

- (c) From your graph, read the initial temperature of **FA 6**,  $T_{\text{initial}}$ , and the maximum temperature of the mixture,  $T_{\text{max}}$ .

Use these values to calculate the temperature change in the reaction,  $\Delta T$ .

Read the volume of **FA 7** added,  $V_{\text{neut}}$ , at the maximum temperature of the mixture.

Record all these values below.

$T_{\text{initial}} = \dots\dots\dots$

$T_{\text{max}} = \dots\dots\dots$

$\Delta T = \dots\dots\dots$

$V_{\text{neut}} = \dots\dots\dots$

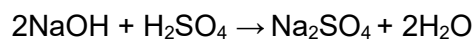
[4]

- (d) Calculate the heat change,  $q$ , at the point of neutralisation in your experiment, using the values you calculated in (c).

You should assume that the specific heat capacity of the solution is  $4.18 \text{ J g}^{-1} \text{ K}^{-1}$ , and that the density of the solution is  $1.0 \text{ g cm}^{-3}$ .

$q = \dots\dots\dots$  [2]

- (e) Calculate the enthalpy change of neutralisation,  $\Delta H_{\text{neut}}$ , per mole of water formed. The equation for the reaction is shown.



Include the sign of  $\Delta H_{\text{neut}}$  in your answer.

$\Delta H_{\text{neut}} = \dots\dots\dots$  [4]

- (f) (i) Suggest why the magnitude of  $\Delta H_{\text{neut}}$  obtained by this method is lower than the magnitude of the true  $\Delta H_{\text{neut}}$ .

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

- (ii) Suggest **two** improvements to the method that would give a more accurate value for  $\Delta H_{\text{neut}}$ .

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

- (g) Your value of  $V_{\text{neut}}$  could be used to calculate the concentration of the sulfuric acid. Explain why a conventional titration using an indicator gives a more accurate volume of neutralisation for this calculation.

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

[Total: 19]

#### 4 Planning – Preparation of paracetamol

Paracetamol,  $\text{HOC}_6\text{H}_4\text{NHCOCH}_3$ , is a white solid at room temperature. It is made by the reaction of 4-aminophenol,  $\text{HOC}_6\text{H}_4\text{NH}_2$ , with ethanoic anhydride,  $(\text{CH}_3\text{CO})_2\text{O}$ . The equation for this reaction is shown.



1.1 g of 4-aminophenol was added into 3 cm<sup>3</sup> of water. 1.5 cm<sup>3</sup> (excess) of ethanoic anhydride was added and the mixture was swirled thoroughly. The mixture was then warmed under reflux for 10 minutes, with the temperature not being allowed to raise above 70 °C.

The mixture was allowed to cool for a few minutes and then poured into 25 cm<sup>3</sup> of cold water, stirring well to precipitate the impure solid paracetamol. The impure paracetamol was separated by filtration and then purified.

Table 4.1 gives information about some of the chemicals involved.

**Table 4.1**

chemical	$M_r$	melting point/ °C
4-aminophenol	109.0	185
ethanoic anhydride	102.0	–73
paracetamol	151.0	169

You are required to plan a procedure to prepare a sample of **10.0 g** of paracetamol using the above method.

- (a) Calculate the mass of 4-aminophenol needed to give an expected yield of 10.0 g of paracetamol, assuming the percentage yield in the whole process is 75 %.

Mass of 4-aminophenol = ..... g

[2]

- (b) Plan a procedure for the preparation of 10.0 g of pure and dry paracetamol using 4-aminophenol and ethanoic anhydride.

In your plan, using 30 cm<sup>3</sup> of water, you should include details of:

- a calculation to obtain an approximate volume of ethanoic anhydride to be used
- the apparatus you would use
- a diagram of the apparatus you would use to warm the mixture under reflux

You may assume that you have access to the following apparatus:

- reflux condenser
- water bath
- 250 cm<sup>3</sup> round-bottomed flask
- electronic mass balance reading to 2 decimal places
- Buchner funnel with a vacuum filtration set-up
- Infra-red lamp,
- any other apparatus commonly found in a school laboratory

**Procedure:**

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**[Turn over**





- (c) Describe the process how you would carry out recrystallisation of paracetamol in (b) to ensure you obtain a pure and dry sample of paracetamol.

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..... [2]

- (d) Describe briefly how you would show that your sample of paracetamol is pure.

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..... [1]

**[Total: 12]**



**Qualitative Analysis Notes**

[ppt. = precipitate]

**(a) Reactions of aqueous cations**

<b>cation</b>	<b>reaction with</b>	
	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)	ammonia produced on heating	–
barium, Ba <sup>2+</sup> (aq)	no ppt. (if 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 giving dark green solution	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

**[Turn over**

**(b) Reactions of aqueous anions**

<b>ion</b>	<b>reaction</b>
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 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, $\text{NO}_3^-(\text{aq})$	$\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
nitrite, $\text{NO}_2^-(\text{aq})$	$\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil; $\text{NO}$ liberated by dilute acids (colourless $\text{NO} \rightarrow$ (pale) brown $\text{NO}_2$ 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, $\text{SO}_3^{2-}(\text{aq})$	$\text{SO}_2$ liberated with dilute acids; gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in dilute strong acids)

**(c) Tests for gases**

<b>gas</b>	<b>test and test result</b>
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
sulfur dioxide, $\text{SO}_2$	turns aqueous acidified potassium manganate(VII) from purple to colourless

**(d) Colour of halogens**

<b>halogen</b>	<b>colour of element</b>	<b>colour in aqueous solution</b>	<b>colour in hexane</b>
chlorine, $\text{Cl}_2$	greenish yellow gas	pale yellow	pale yellow
bromine, $\text{Br}_2$	reddish brown gas / liquid	orange	orange-red
iodine, $\text{I}_2$	black solid / purple gas	brown	purple