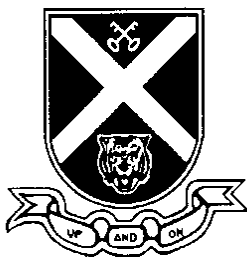


Name:		Class:	
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## ST ANDREW'S JUNIOR COLLEGE



## JC 2 PRELIMINARY EXAMINATION

**CHEMISTRY**

**9729/04**

**Paper 4 Practical**

**13 Aug 2025**

**2 hours 30 minutes**

**Additional Materials: Qualitative Analysis Notes**

### READ THESE INSTRUCTIONS FIRST.

Write your name and class on all the work you hand in.

Give details of the practical shift and laboratory in the boxes provided above.

Write in dark blue or black pen.

You may use a soft pencil for any diagrams or graphs.

Do not use staples, paper clips, highlighters, 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.**

The number of marks is given in the brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	15
2	16
3	14
4	10
Total	55

# 1. Determination of the value of $x$ in the hydrated copper(II) sulfate, $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$

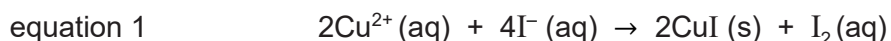
**FA 1** is  $0.150 \text{ mol dm}^{-3}$  sodium thiosulfate,  $\text{Na}_2\text{S}_2\text{O}_3$ .

**FA 2** is dilute sulfuric acid.

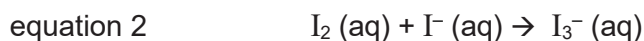
**FA 3** is  $1.00 \text{ mol dm}^{-3}$  potassium iodide, KI.

**FA 4** is a solution made by dissolving 32.5 g of  $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$  in  $1.00 \text{ dm}^3$  of solution.  
starch indicator

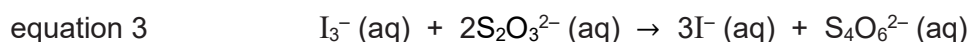
In this experiment you will perform titrations to determine the value of  $x$  in the formula for hydrated copper(II) sulfate,  $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$ , and its concentration in **FA 4**. You will first react a solution of  $\text{Cu}^{2+}$  ions with excess iodide ions,  $\text{I}^-$ . This reaction produces iodine as shown in equation 1.



$\text{I}_2$  has relatively low solubility in water. However, in the presence of excess  $\text{I}^-$ , the soluble triiodide ion,  $\text{I}_3^-$  is formed, as shown in equation 2.



The  $\text{I}_3^-$  ions formed may be titrated against a standard solution of  $\text{Na}_2\text{S}_2\text{O}_3$  as shown in equation 3.



## (a) Procedure

1. Fill the burette with **FA 1**.
2. Pipette  $25.0 \text{ cm}^3$  of **FA 4** into a  $250 \text{ cm}^3$  conical flask.
3. Use a  $10 \text{ cm}^3$  measuring cylinder to transfer  $10.0 \text{ cm}^3$  of **FA 2** to the same conical flask.
4. Use a second  $10 \text{ cm}^3$  measuring cylinder to transfer  $10.0 \text{ cm}^3$  of **FA 3** to the same conical flask. A white precipitate forms in a brown solution.
5. Add **FA 1** from the burette into this flask. Near the end-point, when the brown solution becomes pale, add about 10 drops of starch indicator.
6. Continue adding **FA 1** slowly. The end-point is reached when the **solution** first becomes colourless. The white precipitate remains.
7. Repeat steps 2 to 6 and step until consistent results are obtained.

**Results**

Initial burette reading /cm <sup>3</sup>	0.00	0.00	
Final burette reading /cm <sup>3</sup>	22.00	22.00	
Volume of <b>FA 1</b> /cm <sup>3</sup>	22.00	22.00	

**[5]**

- (b)** From your titrations, obtain a suitable volume of **FA 1** to be used in your calculations.

Show clearly how you obtained this volume

$$\frac{1}{2} (22.00 + 22.00) = 22.00$$

Volume of **FA 1** = ..... cm<sup>3</sup> **[1]**

- 1 (c) (i)** Calculate the number of moles of S<sub>2</sub>O<sub>3</sub><sup>2-</sup> in the volume of **FA 1** in **(b)**.

$$\begin{aligned} \text{Number of moles of S}_2\text{O}_3^{2-} &= 0.15 \times (22.00 / 1000) \\ &= 3.30 \times 10^{-3} \text{ mol} \end{aligned}$$

Number of moles of S<sub>2</sub>O<sub>3</sub><sup>2-</sup> in **FA 1** = ..... **[1]**

- (ii)** Calculate the number of moles of copper(II) ions in 25.0 cm<sup>3</sup> of **FA 4**.

$$\text{Number of moles of Cu}^{2+} = 3.30 \times 10^{-3} \text{ mol}$$

Number of moles of Cu<sup>2+</sup> in **FA 4** = ..... **[1]**

- (iii)** Calculate the value of **x** in CuSO<sub>4</sub>.**x**H<sub>2</sub>O.

[Ar: Cu, 63.5; S, 32.1; O, 16.0; H, 1.0]

$$[\text{Cu}^{2+}] = \text{ans in (ii)} / 0.025$$

$$= 0.132 \text{ mol dm}^{-3}$$

$$x = [32.5 / 0.132 - 159.6] / 18$$

**[Turn Over]**

$$= 4.8 \approx 5$$

$$x = \dots\dots\dots [1]$$

- 1 (c) (iv) Blue vitriol solution is the concentrated form of **FA 4**.

**FA 4** was prepared by diluting  $10.0 \text{ cm}^3$  of blue vitriol solution to  $250 \text{ cm}^3$  in a volumetric flask using deionised water.

Hence or otherwise, determine the concentration of  $\text{Cu}^{2+}$  in blue vitriol solution in  $\text{mol dm}^{-3}$ .

$$\begin{aligned} [\text{Cu}^{2+}] \text{ in blue vitriol solution} &= 0.132 \times (250/10) \\ &= 3.30 \text{ mol dm}^{-3} \end{aligned}$$

$$\text{Concentration of } \text{Cu}^{2+} \text{ in blue vitriol solution: } \dots\dots\dots \text{ mol dm}^{-3} [1]$$

- (d) A student performed a titration and obtained a titre volume of  $30.50 \text{ cm}^3$ . Calculate the maximum percentage error in the student's titre volume.

$$\begin{aligned} \text{Percentage error (uncertainty)} &= (\pm 0.05 \times 2 / 30.50) \times 100\% \\ &= \pm 0.328 \% \end{aligned}$$

$$\text{Maximum percentage error} = \dots\dots\dots [1]$$

- 1 (e) A student suggests that the experiment could be made more accurate if the volume of **FA 3** was measured using a burette.

Suggest a reason why this change would not improve the accuracy of the experiment.

The volume from the burette has a smaller error / more precise. However,  
**FA 3 is in excess.**

..... [1]

- (f) A laboratory technician accidentally prepared **FA 4** by dissolving 32.5 g of hydrated copper(II) sulfate in 250 cm<sup>3</sup> of water. Suggest how this mistake would affect the volume of **FA 1** required in the titration and the calculated value of **x** in CuSO<sub>4</sub>·xH<sub>2</sub>O.

Explain your answer.

**Higher volume of FA 1** would be required to reach the endpoint.  
**Calculated value of x would be lower.**

If FA 4 is more concentrated, the **amount of Cu<sup>2+</sup> in the solution would be higher.** [2]

This would lead to a **lower calculated molar mass** for CuSO<sub>4</sub>·xH<sub>2</sub>O. Since water content is determined from the difference between the hydrated and anhydrous molar masses, the **calculated value of x would be lower than the actual value.**

Eg:  $x = [32.5 / \text{bigger number} - 159.6] / 18$   
 = smaller value

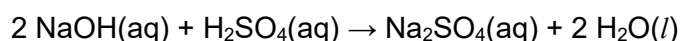
- 1 (g) The formation of the white CuI precipitate can make it harder to determine the end-point of the titration. Suggest another method to measure the amount of iodine produced without using titration.

Measure the colour intensity using colorimeter. The change in concentration of the coloured solution (i.e. the colour intensity of the solution) can be monitored by measuring the absorbance value (A) using a colorimeter. [1]

[Total: 15]

## 2 Determination of enthalpy change of neutralisation

You will determine the concentration of sulfuric acid by reacting with a known concentration of sodium hydroxide using a thermometric method. You are to also determine the enthalpy change of neutralisation per mole of water formed when these solutions react. The equation for the reaction is shown.



**FA 2** is dilute sulfuric acid,  $\text{H}_2\text{SO}_4$ .

**FA 5** is  $1.90 \text{ mol dm}^{-3}$  sodium hydroxide,  $\text{NaOH}$ .

In this question, you will carry out a series of experiments where different volumes of **FA 5** and **FA 2** are mixed together.

You will determine the temperature change of the mixture,  $\Delta T$ , of each experiment and then analyse your results graphically in order to determine the

- concentration of  $\text{H}_2\text{SO}_4$  in **FA 2**
- maximum temperature change,  $\Delta T_{\text{max}}$
- value for the enthalpy change of neutralisation,  $\Delta H_{\text{neut}}$

### (a) Procedure

1. Place a polystyrene cup inside a second polystyrene cup and place both cups in a glass beaker. The retort clamp provided may be used to clamp the beaker to prevent it from tipping.
2. Use a  $50 \text{ cm}^3$  measuring cylinder to transfer  $50.0 \text{ cm}^3$  of **FA 5** into the polystyrene cup.
3. Place the lid with a hole in the centre on the cup and insert the thermometer through the lid. Stir the **FA 5** solution gently with the thermometer. Read and record the initial temperature of the solution of **FA 5** as  $T_{\text{initial}}$ .

4. Place 10.0 cm<sup>3</sup> of **FA 2** into another 50 cm<sup>3</sup> measuring cylinder.
5. Transfer the **FA 2** from the measuring cylinder into the polystyrene cup and close the lid. Stir the mixture gently with the thermometer.
6. Read and record the maximum temperature of the mixture,  $T_{\max}$ , and the volume of **FA 2** added.
7. Rinse and dry the polystyrene cup and the thermometer with paper towel.
8. Repeat steps **1** to **7** using **5** different volumes of **FA 5**, mixing it with the appropriate volumes of **FA 2** to be used in each experiment such that the total volume of the reaction mixture is **60.0 cm<sup>3</sup>**.
9. Calculate  $\Delta T$  for each experiment.

In an appropriate format in the space provided, prepare a table in which to record for each experiment

- all volumes,  $V_{\text{FA 2}}$  and  $V_{\text{FA 5}}$ , to an appropriate level of precision
- all values of temperature,  $T_{\text{initial}}$ ,  $T_{\text{max}}$  and  $\Delta T$  to an appropriate level of precision.

### Results

$V_{\text{FA 2}} / \text{cm}^3$	$V_{\text{FA 5}} / \text{cm}^3$	$T_{\text{initial}} / ^\circ\text{C}$	$T_{\text{max}} / ^\circ\text{C}$	$\Delta T / ^\circ\text{C}$
10.0	50.0	28.8	34.0	5.2
20.0	40.0	28.8	38.0	9.2
25.0	35.0	28.8	39.9	11.1
35.0	25.0	28.8	40.1	11.3
45.0	15.0	28.8	37.1	8.3
55.0	5.0	28.8	34.0	5.2

[4]

- (b) Plot a graph of  $\Delta T$  against  $V_{FA\ 2}$  added on the grid in Fig. 2.1. Your scale on the y-axis should allow for extrapolation above the highest temperature change recorded. Label any points you consider to be anomalous.

Draw two lines of best fit, one for the rise in temperature and one for after the maximum temperature has been reached. Extrapolate (extend) both lines until they intersect.



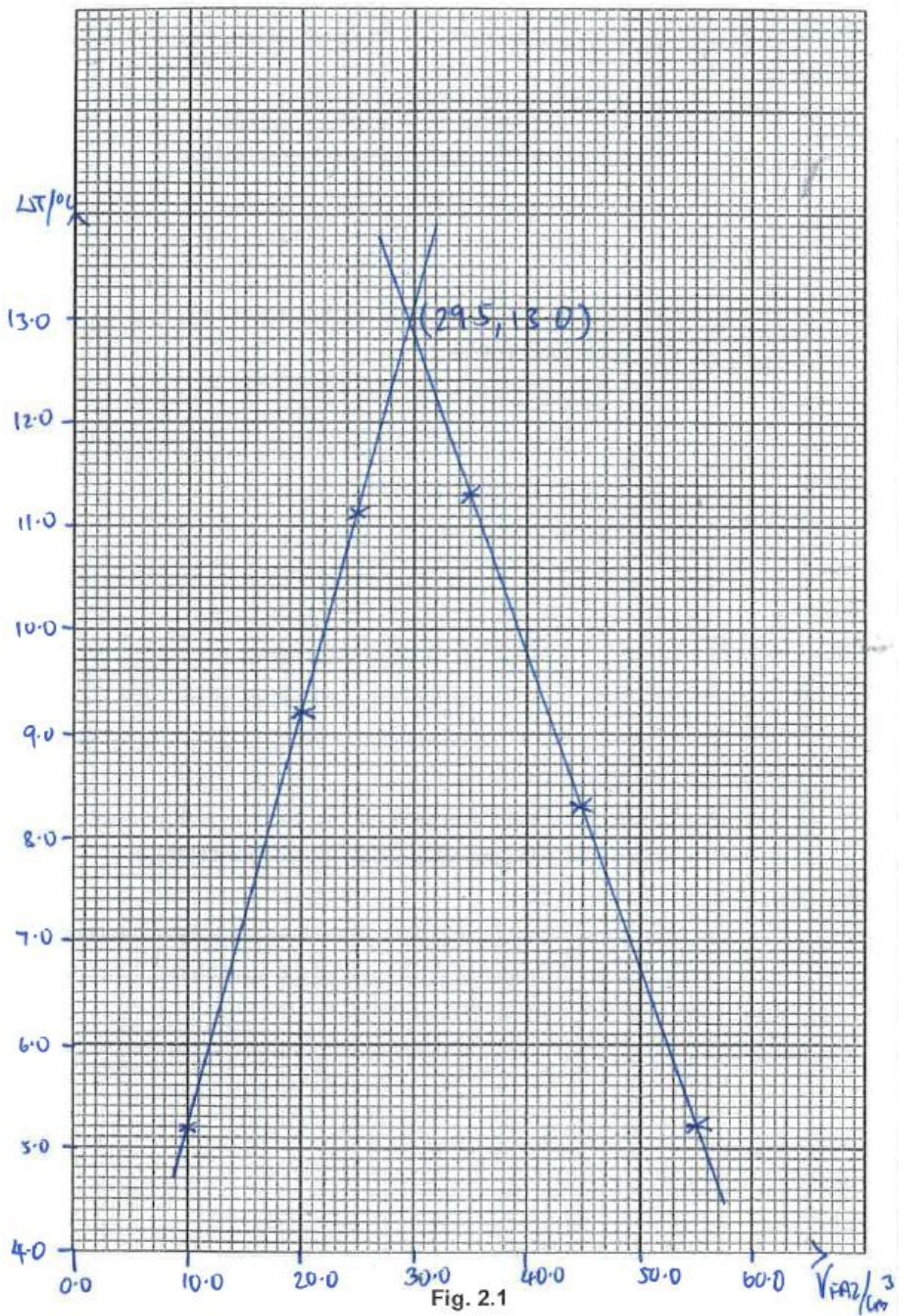


Fig. 2.1

[3]

[Turn Over

- 2 (c) (i) From Fig. 2.1, determine the maximum temperature change,  $\Delta T_{\max}$ , and the  $V_{\text{FA2}}$  required to achieve this maximum temperature change.

Maximum temperature change,  $\Delta T_{\max}$  : .....13.0..... °C

Volume of **FA 2**,  $V_{\text{FA2}}$  : .....29.5..... cm<sup>3</sup>

[2]

- (ii) Calculate the number of moles of **FA 5** reacted and hence, calculate the concentration of **FA 2**.

Amt of **FA 5** reacted =  $1.90 \times [(60.0 - 29.5)/1000] = 0.05795 \text{ mol}$

Amt of **FA 2** in 29.5 cm<sup>3</sup> =  $0.05795/2 = 0.02898 = 0.0290 \text{ mol}$

[**FA 2**] =  $0.02898 / (29.5/1000) = 0.982 \text{ mol dm}^{-3}$

[2]

Number of moles of **FA 5** reacted: .....

Concentration of **FA2**: ..... mol dm<sup>-3</sup>

- (iii) Calculate the heat change,  $q$ , at the point of neutralisation, in your experiment using the  $\Delta T_{\max}$  value you deduced in (c)(i).

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  $1.00 \text{ g cm}^{-3}$ .

$q = mc\Delta T = 60.0 \times 4.18 \times 13.0 = 3.260 \times 10^3 \text{ J}$

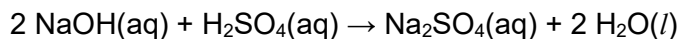
= 3.26 kJ

$q$ : .....

[1]

- 2 (c) (iv) Hence, 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.

Amt of  $\text{H}_2\text{O}$  formed = amt of **FA 5** reacted = 0.05795 mol

$$\Delta H_{\text{neut}} = - (3.26) / 0.05795 = - 56.3 \text{ kJ mol}^{-1}$$

$$\Delta H_{\text{neut}} = \dots\dots\dots [2]$$

- (d) A student repeated the same experiment but used  $\text{CH}_3\text{COOH}$  instead of  $\text{H}_2\text{SO}_4$  of the same concentration. Suggest and explain how the maximum temperature change will be affected.

The maximum temperature change will drop to less than  $\frac{1}{2}$  of the original temperature change.

$\text{CH}_3\text{COOH}$  is a monobasic weak acid while  $\text{H}_2\text{SO}_4$  is a dibasic strong acid, as the no. of moles of water formed for the neutralisation of  $\text{CH}_3\text{COOH}$  is halved,  $q$  is therefore halved, and the temperature change to be halved. [2]

In addition, the temperature change is less than half because some energy is taken in to dissociate the weak acid,  $\text{CH}_3\text{COOH}$ , resulting in slightly less than half the amount of heat to be released.

[Total: 16]

- 3 In this question, you are provided with the following solutions.

- **FA 6** which contains two cations and one anion.
- **FA 7** which contains one cation and one anion.
- **FA 8** which contains an aqueous solution of an organic compound.

You will perform tests to identify the ions in **FA 6** and **FA 7**.

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



[Turn Over

Test and identify any gases evolved.





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



- (a) (i) Carry out the following tests. Carefully record your observations in Table 3.1.

**Table 3.1**

	Tests	Observations
1	<p>Add 2 cm depth of <b>FA 6</b> into a test-tube. Add aqueous sodium hydroxide until there is no further change.</p> <p>Filter the mixture into a clean test tube.</p> <p>To the filtrate, add 8 drops of dilute nitric acid, dropwise with shaking.</p>	<p>Pale blue/ Blue ppt</p> <p>Insoluble in excess NaOH.</p> <p>The increase in temperature of the test tube is not considered as observation.</p>  <p>Residue: Pale blue/ blue ppt</p>  <p>Filtrate: colourless solution</p> <p>White ppt upon adding HNO<sub>3</sub></p>






		
2	<p>Add 2 cm depth of <b>FA 6</b> into a test-tube. Add aqueous ammonia until there is no further change.</p> <p>Filter the mixture into a clean test tube.</p>	<p>White/ Pale blue/ Blue ppt</p> <p>Partially dissolves in excess <math>\text{NH}_3</math> to give dark blue solution,</p> <p>Residue: Pale blue/blue ppt</p> <p>White ppt is not accepted here as the ppt appeared to be blue.</p>   <p>Filtrate: Dark blue solution</p> 
3	<p>Add 2 cm depth of <b>FA 6</b> into a test-tube. Add dilute nitric acid until there is no further change.</p>	<p>No observable change.</p>

			
4	Add 2 cm depth of <b>FA 6</b> into a test-tube. Add aqueous barium nitrate until there is no further change. Add dilute nitric acid until there is no further change.	<p>White ppt in blue solution</p> <p>Blue ppt is not accepted as the white ppt is in blue solution. To see more clearly, students can pour out the ppt on a filter paper to observe the true colour of ppt.</p> <p>Insoluble in excess nitric acid</p>  <p>Students must learn how to write “no observable change” at appropriate times. For this case, it is solubility in <math>\text{HNO}_3</math> as students are instructed to add <math>\text{HNO}_3</math> until no further change.</p>	

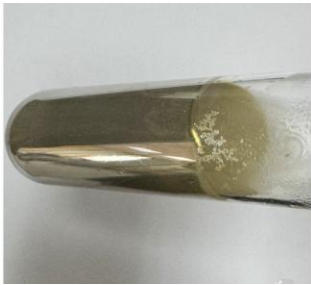
- (a) (ii) Carry out the following tests. Carefully record your observations in Table 3.2.

**Table 3.2**

Tests		Observations
5	Add 2 cm depth of <b>FA 7</b> into a test-tube. Add aqueous sodium hydroxide until there is no further change. Warm the mixture.	<p>No ppt.</p> <p>Effervescence observed.</p> <p>Gas evolved turned damp red litmus paper blue.</p>

	<p>Many students wrote “no observable change” for this test, showing lack of understanding this step is typical for the testing of ammonium ion.</p>	<p>Gas evolved is <math>\text{NH}_3</math>.</p> 
6	<p>Add 2 cm depth of <b>FA 7</b> into a test-tube. Add aqueous barium nitrate until there is no further change.</p> <p>Add dilute nitric acid until there is no further change.</p>	<p>No observable change.</p>
7	<p>Add 2 cm depth of <b>FA 7</b> to a test-tube. Add a 1 cm depth of aqueous silver nitrate.</p> <p>Add aqueous ammonia to the mixture, with shaking, until the aqueous ammonia is in excess.</p> <p>Filter if necessary and use the resulting filtrate for <b>Test 8</b>.</p>	<p>White ppt</p> <p>Soluble in excess <math>\text{NH}_3</math>, giving colourless solution.</p>   <p>Some students wrote the solubility as insoluble or partially soluble as the ppt is very thick. For such cases, students can consider separating into two portions to observe that ppt dissolved in excess ammonia.</p>

[3]

8	Add 1 cm <sup>3</sup> of the resulting filtrate from <b>Test 7</b> into a clean and dry boiling tube. Add 1 drop of sodium hydroxide and 10 drops of <b>FA 8</b> . Shake well and warm the mixture in a beaker of hot water for five minutes.	<p>Silver mirror observed.</p> 
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- 3 (b) (i) Identify the ions present in **FA 6** and **FA 7**.

Cations in **FA 6**: ..... and .....

Anion in **FA 6**: .....

Cation in **FA 7**: .....

[3]

Anion in **FA 7**: .....

Cations in **FA 6**: Cu<sup>2+</sup> and Al<sup>3+</sup>

Anion in **FA 6**: SO<sub>4</sub><sup>2-</sup>

Cation in **FA 7**: NH<sub>4</sub><sup>+</sup>

Anion in **FA 7**: Cl<sup>-</sup>

- (ii) Explain, with the aid of a suitable equation, the observations when dilute nitric acid was added to the resulting filtrate in **Test 1**. [2]



When dilute nitric acid was added, [OH<sup>-</sup>] dropped and by Le

Chatelier's Principle, position of equilibrium shifted left to increase

[OH<sup>-</sup>], resulting in the formation of the white ppt Al(OH)<sub>3</sub>.

- (c) (i) Based on your observations in **Test 8**, identify the functional group present in **FA 8**.

Functional group present in **FA 8**: aldehyde

[1]

If students cannot see the silver mirror, this mark will be affected.

- (ii) Briefly explain the role of the resulting filtrate from **Test 7** in **Test 8**.

The resulting filtrate acted as an oxidising agent in Test 8 as the

Ag<sup>+</sup> was reduced to Ag.

[1]

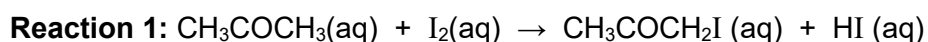


[Total: 14]

**4 Planning**

You are to plan a series of experiments to verify that the order with respect to iodine in the iodination of propanone is zero.

The iodination of propanone is catalysed by acid, to form iodopropanone, as shown in the equation below.



You may assume that you are provided with:

- propanone,  $\text{CH}_3\text{COCH}_3$
- dilute sulfuric acid,  $\text{H}_2\text{SO}_4$
- aqueous solution of iodine,  $\text{I}_2$
- sodium thiosulfate,  $\text{Na}_2\text{S}_2\text{O}_3$
- sodium hydrogencarbonate,  $\text{NaHCO}_3$
- starch indicator
- stopwatch
- the equipment normally found in a school or college laboratory

The order with respect to  $[\text{I}_2]$  may be confirmed by preparing a reaction mixture containing  $\text{H}_2\text{SO}_4$ ,  $\text{I}_2$  and a large excess of  $\text{CH}_3\text{COCH}_3$ .

Portions of the reaction mixture are

- removed at timed interval,
- quenched by adding to an excess of  $\text{NaHCO}_3$ ,
- titrated against a standard solution of  $\text{S}_2\text{O}_3^{2-}$ .

- 4 (a)** Plan a procedure to collect sufficient data to allow a graph of volume of  $\text{S}_2\text{O}_3^{2-}$  against time to be drawn.

You should plan to make a reaction mixture containing

- $25.0 \text{ cm}^3$  of aqueous propanone,  $\text{CH}_3\text{COCH}_3$ ,

[Turn Over]

- 25.0 cm<sup>3</sup> of dilute sulfuric acid, H<sub>2</sub>SO<sub>4</sub>,
- 40.0 cm<sup>3</sup> of aqueous iodine, I<sub>2</sub>.

This reaction mixture contains a large excess of propanone.

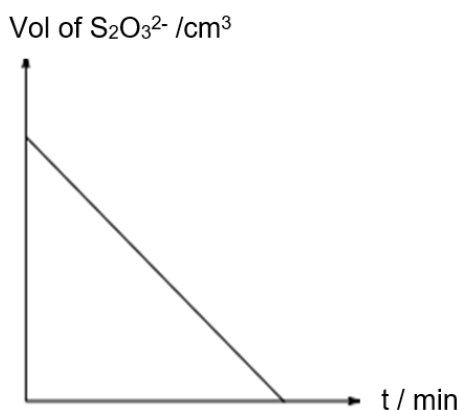
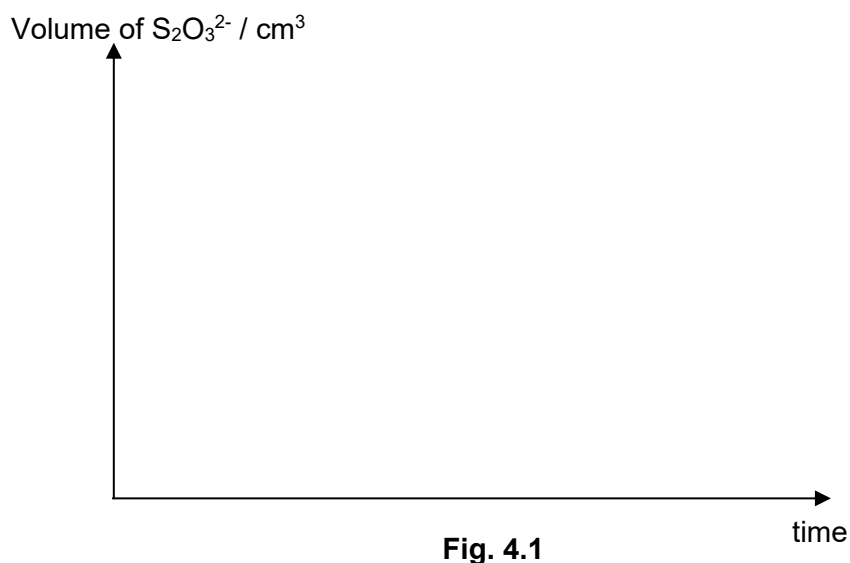
In your plan you should include brief details of:

- apparatus you would use,
- the procedure you would follow,
- the measurements you would make.

In your plan it is **not** necessary to refer to concentrations or to perform calculations.

- 1) Using a 50.0 cm<sup>3</sup> measuring cylinder, add 25.0 cm<sup>3</sup> of propanone to a 250 cm<sup>3</sup> beaker.
- 2) Using a 50.0 cm<sup>3</sup> measuring cylinder, add 25.0 cm<sup>3</sup> of sulfuric acid, H<sub>2</sub>SO<sub>4</sub> into the same beaker.
- 3) Using another 50.0 cm<sup>3</sup> measuring cylinder, add 40.0 cm<sup>3</sup> of iodine into another 250 cm<sup>3</sup> beaker.
- 4) Pour the contents of the 250 cm<sup>3</sup> beaker into this 250 cm<sup>3</sup> beaker. Start the stopwatch.
- 5) Swirl the flask thoroughly if the reaction mixture is in 250 cm<sup>3</sup> conical flask/ use glass rod to stir if use beaker was used.
- 6) Using another 10.0 cm<sup>3</sup> of measuring cylinder, add 10.0 cm<sup>3</sup> of NaHCO<sub>3</sub> (quenching agent) into the 2<sup>nd</sup> 250 cm<sup>3</sup> conical flask.
- 7) At 2/X minutes, use a 10.0 cm<sup>3</sup> pipette to remove a 10.0 cm<sup>3</sup> aliquot of the reaction mixture into 2<sup>nd</sup> 250 cm<sup>3</sup> conical flask (containing NaHCO<sub>3</sub>).
- 8) Record the time of transfer.
- 9) Titrate the iodine in this solution with Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> using a burette. Add about 1 cm<sup>3</sup> of starch indicator when the colour of the solution turns pale yellow.
- 10) The end-point is reached when the dark blue-black colour just disappears. Record your titration results.
- 11) Repeat point 6 to 9 for the remaining 4/5 experiments at about 3-5 minute intervals.

- 4 (b) Sketch on Fig. 4.1 the graph you would expect to obtain from carrying out your plan. Explain how you would verify if the order of reaction with respect to iodine is zero.



Graph + Explanation

[1]

Since Volume of  $\text{I}_2 \propto [\text{S}_2\text{O}_3^{2-}]$

Graph is a straight line with constant gradient/  $[\text{I}_2]$  decreases at a constant rate since the gradient is constant. Hence it is zero order reaction with respect to iodine.

- (c) Explain why the concentration of iodine used is very much lower than the concentration of propanone.

The low concentration of iodine means that very little propanone and acid are reacted away from the reaction mixture and hence the **concentration of propanone remain effectively constant.** Hence, the **order of reaction**

[1]

with respect to iodine can be determined because any change in the rate is due to the change in concentration of iodine.

- 4 (d) Suggest **two** reasons why aqueous  $\text{NaHCO}_3$  is preferred over aqueous  $\text{NaOH}$  as the reagent for quenching the reaction mixture.

$\text{NaHCO}_3$  will effervesce so when effervescence finishes it shows that all  $\text{H}^+$  ions have been removed. [2]

$\text{NaOH}$  will react with  $\text{I}_2$  (redox reaction) or  $\text{CH}_3\text{COCH}_3/\text{I}_2$  (iodomethane test)

[Total: 10]

**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

**(b) Reactions of anions**

<b><i>anion</i></b>	<b><i>reaction</i></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 on warming with dilute acids; gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in dilute strong acids)

**(c) Tests for gases**

<b><i>gas</i></b>	<b><i>test and test result</i></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><i>halogen</i></b>	<b><i>colour of element</i></b>	<b><i>colour in aqueous solution</i></b>	<b><i>colour in hexane</i></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