	TEMASEK JUNIOR COLLEGE 2024 JC2 PRELIMINARY EXAMINATION Higher 2		TEMASEK JUNIOR COLLEGE
CANDIDATE NAME	MARK SCHEME	CLASS	
CENTRE NUMBER	S	INDEX NUMBER	
Chemistry			9729/04
Paper 4 Practical			26 August 2024
		2 h	ours 30 minutes

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Shift

Laboratory

Write your name, CG, centre number and index number 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 19 and 20.

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.

For E	For Examiner's Use		
1	/ 16		
2	/ 13		
3	/ 16		
4	/ 10		
Total	/ 55		

Answer all the questions in the spaces provided.

1 Determination of the formula of hydrated sodium thiosulfate.

In this experiment, you will determine the value of x in the formula of hydrated sodium thiosulfate, $Na_2S_2O_3 \cdot xH_2O$, where x is an integer.

You will first react IO_3^- ions with an excess of iodide ions, I^- , to form iodine, I_2 . The amount of iodine produced will then be determined by titration with thiosulfate ions, $S_2O_3^{2-}$.

$$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$$

FA 1 is 27.3 g dm⁻³ of hydrated sodium thiosulfate, $Na_2S_2O_3 \cdot xH_2O$.

FA 2 is 0.0150 mol dm⁻³ potassium iodate(V), KIO₃.

FA 3 is 0.500 mol dm⁻³ potassium iodide, KI.

FA 4 is 2.20 mol dm⁻³ hydrochloric acid, HC*l*.

Starch indicator

(a)(i) Procedure

- 1. Fill the burette with **FA 1**.
- 2. Pipette 25.0 cm³ of **FA 2** into a conical flask.
- 3. Use a measuring cylinder to add 10 cm³ of **FA 3** to the conical flask.
- 4. Use another measuring cylinder to add 20 cm³ of **FA 4** to the conical flask. The solution will turn brown.
- 5. Add **FA 1** from the burette until the solution in the conical flask turns pale yellow.
- 6. Add 10 drops of starch indicator to the conical flask. The solution will turn blue-black.
- 7. Continue to add more **FA 1** from the burette until the blue-black colour just disappears. This is the end point of the titration.
- 8. Repeat steps 2 to 7 until consistent results are obtained.

Keep FA 4 for use in Question 2. Keep FA 1 and FA 3 for use in Question 3.

Titration results

Final burette reading/ cm ³	20.50	41.00
Initial burette reading/ cm ³	0.00	20.50
Volume of FA 1 / cm ³	20.50	20.50

Correct headers with units [1]

All burette readings to 0.05 cm³ [1]

Correct calculation of titre volumes. At least 2 uncorrected titres to 0.10 cm³. [1]

(ii) From your titrations, obtain a suitable volume of **FA 1** to be used in your calculations. Show clearly how you obtained this volume.

Volume of **FA 1** used =
$$\frac{20.50 + 20.50}{2} = 20.50 \text{ cm}^3$$

Use consistent readings to correctly calculate volume of **FA 1**. Working must be shown or ticks put next to the two (or more) accurate titres selected. **[1]**

Accuracy [2]

2 marks if difference is ≤ 0.20 cm³

1 mark if difference is ≤ 0.40 cm³

0 mark if difference is > 0.40 cm³

Volume of **FA 1** =cm³ [3]

(b) (i) The equation for this reaction between iodate(V) and iodide is shown.

$$IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O$$

Calculate the amount of iodine that forms when 25.0 cm³ of **FA 2** reacts with 10 cm³ of **FA 3**. [1]

amount of IO_3^- in **FA 2** = $\frac{25}{1000} \times 0.0150 = 3.75 \times 10^{-4}$ mol

 $= 1.125 \times 10^{-3}$ mol

amount of I⁻ in **FA 3** =
$$\frac{10}{1000} \times 0.500 = 5.00 \times 10^{-3}$$
 mol

 IO_3^- is the limiting reagent.

 $IO_3^-\equiv 3I_2$

amount of I_2 formed = $3.75 \times 10^{-4} \times 3$

= 1.13×10⁻³mol[1] (allow 3 or 4 s.f.)

Use your titration results and the equation on page 2 to calculate the concentration of Na₂S₂O₃ in FA 1 in mol dm⁻³.

 $I_2 \equiv 2 \ S_2 O_3^{2-}$ amount of Na₂S₂O₃ = 2×1.13×10⁻³ = 2.26×10⁻³ mol [1] conc of Na₂S₂O₃ in **FA 1** = $\frac{2.26 \times 10^{-3}}{\frac{20.50}{1000}}$ = 0.110 mol dm⁻³ [1] (iii) Hence, determine the value of x in the formula of hydrated sodium thiosulfate, $Na_2S_2O_3 \cdot xH_2O$, used to prepare **FA 1**.

[A_r: Na, 23.0; S, 32.1; O, 16.0; H, 1.0]

 $M_{r} \text{ of } Na_{2}S_{2}O_{3}.xH_{2}O = \frac{27.3}{0.110} = 248.2 \text{ [1]}$ 2(23.0) + 2(32.1) + 3(16.0) + x(18.0) = 248.2x = 5 [1]

Value of x = [5]

Clear and logical working shown from (b)(i) to (iii) **[1]** All units shown from (b)(i) to (iii) **[1]** 2 d.p. for (a)(ii), 3 or 4 s.f. for (b)(i), (b)(ii), integer for x in (b)(iii) **[1]** Any working not attempted loses these marks.

(c) (i) Calculate the maximum percentage error in the volume of FA 1 used.

error for each burette reading = ± 0.05 cm³ Maximum percentage error = $\pm \frac{2x0.05}{20.50} \times 100$ = $\pm 0.488\%$ [1]

Maximum percentage error =% [1]

(ii) A student suggested that a more accurate value of x could be obtained if a 10.0 cm³ pipette is used to measure **FA 3** rather than the measuring cylinder.

State whether you agree with the student. Explain your answer.

Do not agree with the student as **FA 3** (KI) is **in excess**. An accurate measurement of **FA 3** volume does not affect the amount of iodine, the titre volume of $S_2O_3^-$ and the calculation of x value. [1]

[Total: 16]

2 In this experiment you will use a thermometric method to determine the concentration of a sample of alkali. You will mix varying volumes of acid with a fixed volume of the alkali and measure the temperature rises that occur.

5

You will use your experimental data to calculate the enthalpy change for the neutralisation of the acid with alkali.

- **FA 4** is 2.20 mol dm⁻³ hydrochloric acid, HC*l*.
- FA 5 is aqueous sodium hydroxide, NaOH.
- (a) Procedure

DO NOT WRITE IN THIS MARGIN

1. Use the thermometer to measure the initial temperature of **FA 5**.

initial temperature of FA 5 = 28.6 °C

- 2. Place a polystyrene cup inside a second polystyrene cup and place both cups in a 250 cm³ beaker.
- 3. For **Experiment 1**, use a measuring cylinder to transfer 20 cm³ of **FA 5** into the cup.
- 4. Using a second measuring cylinder, measure 18 cm³ of water and add 2 cm³ of FA 4 to the same measuring cylinder.
- 5. Transfer the solution in the second measuring cylinder into the cup containing FA 5.
- 6. Stir the mixture in the cup gently with the thermometer. Read and record the maximum temperature obtained.
- 7. Empty, rinse and shake dry the cup ready for use in **Experiment 2**.
- 8. Repeat the procedure using 20 cm³ of **FA 5** for each experiment and the volumes of water and FA 4 shown in table 2.1. In each case, measure and record the maximum temperature.

Experiment	Volume of water / cm ³	Volume of FA 4 / cm ³	Maximum temperature / ºC
1	18.0	2.0	30.0
2	14.0	6.0	32.6
3	10.0	10.0	34.8
4	6.0	14.0	34.8
5	2.0	18.0	34.8
6	8.0	12.0	34.9

Table 2.1

Carry out one further experiment which will enable you to determine more precisely the volume of FA 4 that gives the highest maximum temperature.

Record your measurements for all experiments in Table 2.1.

[3]

- [1] Six thermometer readings recorded
- [1] All thermometer readings recorded to nearest 0.1 °C
- [1] One appropriate extra volumes chosen

AND volume of water used + volume of **FA 4** = 20 cm^3

Volume of FA 4 chosen must be at least 0.50 cm³ from any other and must be between the first highest temperature and one of the adjacent temperatures.

(b) Plot a graph of the maximum temperature on *y*-axis and the volume of **FA 4** used on *x*-axis.

The scale on the *y*-axis should allow for extrapolation above the highest maximum temperature recorded.



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

Extrapolate (extend) both lines until they intersect.

Use your graph to determine the volume of FA 4 that reacts with 20.0 cm³ of FA 5.

volume of **FA 4** = 10.0 cm³ [4]

[1] Axes correctly labelled with temperature AND / $^{\circ}$ C or ($^{\circ}$ C) on the y-axis volume / FA 4 AND / cm³ or (cm³) on the x-axis AND suitable scales selected to occupy more than half of the available space on both axes

[1] All points recorded in the table are accurately plotted.

Those on the line must be exactly on the line; those not on the line must be in the correct half of the small square.

[1] Lines of best fit

Two straight lines of best fit drawn with a ruler.

The two lines must give a sharp intersection at (or above) the highest temperature.

There must be at least 3 points considered for the line of best fit where the maximum temperature is increasing.

Any points labelled anomalous are disregarded.

[1] Correct volume of FA 4 at intersection AND given to 1 (or 2) d.p.

Theory behind the graph



Before equivalence point: FA4 is limiting. As volume of FA4 increases, amt of water produced increases, ΔT increases proportionately $\rightarrow T_{\text{final}}$ increases proportionately since T_{initial} assumed to be constant.

After equivalence point: FA5 is limiting. Since vol of FA5 is constant throughout, amt of water produced is constant, so ΔT is constant and T_{final} is constant.

(c) (i) Calculate the amount of hydrochloric acid in the volume of FA 4 in (b).

If you were unable to determine an answer to (b) use 8.20 cm³ as the volume of **FA 4**. This is **not** the correct value.

amount of $HCl = 0.0220 \mod [1]$

Amount of $HCl = (2.2 \times 10)/1000 = 0.0220$ mol

(ii) Use your answer to (c)(i) and the information on page 6 to calculate the concentration of sodium hydroxide in FA 5.

concentration of NaOH = 1.10 mol dm⁻³ [1]

Amt of NaOH = amt of HCl = 0.0220 mol Vol of NaOH used = 20 cm³ (NOT 25 cm³) Concentration of NaOH = $0.0220 \times \frac{1000}{20} = 1.10$ mol dm⁻³

(iii) Calculate the energy released when the volume of **FA 4** in (b) is neutralised by sodium hydroxide. Show your working.

(Assume that 4.18 J of energy changes the temperature of 1.0 cm³ of solution by 1.0 $^{\circ}$ C.)

f **FA 4** in **(b)** is neutralised erature of 1.0 cm³ of solution energy released = 1070 J [2]

[1] Max temp change = 34.85 - 28.6 = 6.4 °C

[1] Energy released = 40(4.18)(6.4) = 1070 J

(iv) Use your answers to (c)(i) and (c)(iii) to calculate the enthalpy change of neutralisation, in kJ mol⁻¹ for 1.0 mol of hydrochloric acid.

enthalpy change = -48.6 kJ mol⁻¹ [1]

Amount of water formed = 0.0220 mol

Enthalpy change = $-\frac{1070}{0.0220}$ = -48636 J mol⁻¹ = -48.6 J mol⁻¹

(d) (i) The theoretical value of the enthalpy change of neutralisation is -57.6 kJ mol⁻¹ (strong acid – strong base neutralisation).

Calculate the percentage error in your value of the enthalpy change from (c)(iv). Show your working.

(Assume that the conditions under which you carried out your experiment in **(a)** are identical to the conditions used to determine the theoretical value.)

percentage error = 15.9 % [1]

% error = $\left| \frac{57.6 - 48.6}{57.6} \right| \times 100 = 15.6 \%$

(ii) Predict whether the enthalpy change of neutralisation for the reaction between
 FA 4 and potassium hydrogencarbonate is more or less exothermic than -57.6 kJ mol⁻¹. Explain your answer. [2]

[1] less exothermic

[1] KHCO₃ is a <u>weak base</u> and some <u>heat released</u> from the neutralisation is used to <u>dissociate the weak acid completely</u>

(iii) Suggest **one** modification to the procedure used in (a) that would give a more accurate value for the enthalpy change of neutralisation.

Do not suggest any modifications to apparatus in your answer. [1]

Any one of the following:

- Measure initial temperatures of water AND FA 4 before mixing
- Measure initial temperature for each experiment / FA 5
- Take more readings near the largest maximum temperature

Note: Answers merely stating "taking <u>more</u> readings / intervals of FA 4" without mention of "near max temp" are not accepted.

 Conduct experiment with smaller intervals of FA 4 (or specify smaller intervals, ie 1 cm³, 2 cm³)

[Total: 16]

3 Investigation of some inorganic reactions.

FA 6 is an aqueous solution containing 1 cation and 1 anion.

FA 7 is a solution containing a covalent compound.

You will perform tests to identify the cation and anion in **FA 6**. The volumes given are approximate and should be estimated rather than measured.

Test and identify any gases evolved.

(a) (i) Perform the tests described in Table 3.1 and record your observations in the table.

	tests	observations
1	To a 1 cm depth of FA 6 in a test-tube, add aqueous ammonia until there is no further change.	✓ Red-brown ppt,✓ insoluble in excess
2	To a 1 cm depth of FA 6 in a test-tube, add a 1 cm depth of FA 3 , KI(aq), then	✓ Solution turns red-brown/ orange-brown/ brown/ yellow-brown/ yellow
	add starch indicator	 Solution turns blue-black
3	To a 1 cm depth of FA 6 in a test-tube, add a 1 cm depth of FA 1 , Na ₂ S ₂ O ₃ (aq).	✓ Solution turns purple/ solution darkens
	Leave to stand until there is no further change, then	✓ On standing, solution becomes yellow/ colourless/ slight ppt obtained
		✓ (dirty) green ppt

Table 3.1

Every $2 \checkmark = 1 \text{ mark} (1 \text{ bonus } \checkmark)$

(ii) Identify the cation in **FA 6**. Use evidence from your observations in Table 3.1 to support your deduction. [1]

Cation: ✓ Fe³⁺ Evidence: ✓ Forms red brown ppt that is <u>insoluble</u> in excess NH₃(aq) 2 ✓ = 1 mark

(iii) Write a balanced equation of the reaction that takes place in test 2 of (a)(i). [1]

 $2Fe^{3+} + 2I^{-} \rightarrow 2Fe^{2+} + I_2[1]$

- (iv) Explain your observations in test 3 of (a)(i). [2]
- [1] **Fe³⁺ forms a complex with S**₂**O**₃²⁻ as a ligand, purple/violet colouration observed

[3]

- [1] [Fe³⁺ has been reduced by S₂O₃²⁻
 Fe²⁺ is present to form green ppt with NaOH
 Max 2 marks
- (b) The anion in **FA 6** is listed in the Qualitative Analysis Notes on pages 19 and 20. The anion is not carbonate, nitrate or nitrite.
 - (i) Devise and perform a series of simple tests to identify the anion in **FA 6**. You should use only the bench reagents provided. Record your tests and observations in the space below.

test	observations
To a 1 cm depth of FA 6 in a test-tube add a 1 cm depth of <u>aqueous silver nitrate</u> , then <u>add nitric acid</u> (or aqueous ammonia). [1]	White ppt, insoluble in HNO ₃ . [1] OR White ppt, soluble in NH ₃ (aq). Note, the formation of red-brown ppt of Fe(OH) ₃ will mask the solubility of white ppt.
To a 1 cm depth of FA 6 in a test-tube add a 1 cm depth of <u>aqueous barium nitrate</u> , then add <u>nitric acid</u> . [✓]	No ppt [✓]

[3]

(ii) Use your observations in (b)(i) to deduce the identity of the anion in FA 6. [1]

Chloride [1]

(c) Perform the tests described in Table 3.2 and record your observations in the table.

Table 3.2	
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	tests	observations
1	To a 1 cm depth of FA 7 in a test-tube, add 1 cm depth of FA 6 , followed by 1 cm depth of aqueous sodium hydroxide.	 ✓ Effervescence ✓ Gas relights glowing splint
2	To a 1 cm depth of FA 7 in a test-tube, add a 1 cm depth of dilute sulfuric acid, followed by 1 cm depth of FA 3 , KI(aq).	 Solution turns red-brown/ orange-brown/ yellow-brown/ yellow
	Then add starch indicator	✓ Solution turns blue-black

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[Total: 13]

4 Planning

lodine and propanone react together in aqueous acidic solution according to the equation:

$$CH_{3}COCH_{3}(aq) + I_{2}(aq) \rightarrow CH_{3}COCH_{2}I(aq) + H^{+}(aq) + I^{-}(aq)$$

The reaction is catalysed by hydrogen ions and hence the rate equation can be expressed as

$$Rate = k [CH_3COCH_3]^a [H^+]^b [I_2]^c$$

where a, b and c are the orders with respect to the species shown in the rate equation.

If CH₃COCH₃(aq) and H⁺(aq) are used in large excess in the reaction, the rate equation becomes

rate = $k' [I_2]^c$

where $k' = k [CH_3COCH_3]^a [H^+]^b$.

The order of reaction with respect to iodine can be determined experimentally using the continuous method, whereby the concentration of iodine is measured continuously at various time intervals by sampling, quenching, followed by titration with aqueous sodium thiosulfate.

(a) Aqueous sodium hydrogencarbonate is usually used as the quenching agent for the reaction above. Suggest why it is a suitable choice. [1]

NaHCO₃ <u>removes H⁺ ions</u> from the reaction mixture and thus <u>stops the reaction</u> so that the <u>amount of iodine remaining at that instant can be determined</u>. [1]

- (b) You may assume you are provided with
 - 50 cm^3 of 0.040 mol dm^{-3} iodine
 - 1.00 mol dm⁻³ propanone
 - 0.800 mol dm⁻³ sulfuric acid
 - 1.00 mol dm⁻³ sodium hydrogencarbonate
 - 0.010 mol dm⁻³ sodium thiosulfate
 - starch
 - the equipment normally found in a school or college laboratory.
 - (i) 25.0 cm³ each of propanone and sulfuric acid are separately measured and added to 50.0 cm³ of iodine. 10.0 cm³ of the reaction mixture is sampled at suitable time intervals.

Calculate the minimum volume of sodium hydrogencarbonate required to quench each sample. [2]

Given that 25.0 cm³ of CH₃COCH₃ and 25.0 cm³ of H₂SO₄ are used, Total volume of reaction mixture = 100.0 cm³

Since 10.0 cm³ of the mixture is sampled at suitable time intervals, Amount of H_2SO_4 in 10.0 cm³ of reaction mixture = (1/10)(25.0/1000)(0.800) = 2.0 x 10⁻³ mol [1]

Amount of H⁺ from $H_2SO_4 = 2.0 \times 10^{-3} \times 2 = 4.0 \times 10^{-3} \text{ mol}$ Minimum amount of NaHCO₃ to add to react with H⁺ = 4.0 x 10⁻³ mol

Minimum volume of NaHCO₃ needed

 $= 4.0 \times 10^{-3}/1 = 4.0 \times 10^{-3} \text{ dm}^3 = 4.0 \text{ cm}^3$ [1]

Alternative method:

Total no. of moles of H⁺ from H_2SO_4 & H⁺ produced (based on iodine, the limiting reagent)

 $= 4.0 \times 10^{-3} + 2.0 \times 10^{-4}$

= 4.2 x 10⁻³ mol

Minimum volume of NaHCO₃ needed

 $= 4.2 \times 10^{-3}/1 = 4.2 \times 10^{-3} \text{ dm}^3 = 4.2 \text{ cm}^3$

(ii) Plan an investigation to determine the order of reaction with respect to iodine using the continuous method.

In your plan you should include brief details of:

- the apparatus and procedure you would use to prepare a suitable volume of a standard solution of 1.00 mol dm⁻³ CH₃COCH₃(aq) from liquid propanone, specifying the volume of liquid propanone to be used,
- the quantities of all reagents you would use,
- the apparatus and the procedure you would follow,
- the measurements you would take to allow for a suitable volume-time graph to be drawn from time t = 2 min to t = 20 min.

 $[M_r \text{ of } CH_3COCH_3 = 58.0; \text{ density of } CH_3COCH_3 = 0.7845 \text{ g cm}^{-3}]$

Preparation of standard solution of 1.00 mol dm⁻³ propanone

Concentration of liquid propanone in mol dm⁻³ = $\frac{0.7845 \times 1000}{58.0}$ = 13.53 mol dm⁻³

Using a 250 cm³ volumetric flask, number of moles before dilution = no. of moles after dilution 13.53 x Volume of CH₃COCH₃(I) = 1 x 250 Volume of CH₃COCH₃(I) to measure = $\frac{250}{13.53} = \frac{18.48 \text{ cm}^3}{13.53}$

Procedure to prepare standard solution of propanone

- 1. Using a <u>burette</u>, measure 18.50 cm³ of liquid propanone into a <u>250 cm³</u> <u>volumetric flask.</u>
- 2. <u>Top up to the mark</u> with distilled water, <u>stopper</u> the volumetric flask and <u>shake</u> this solution to obtain a <u>homogeneous solution</u>.

Procedure for continuous method to investigate the kinetics of the reaction and titration

- Using a <u>50 cm³ measuring cylinder</u>, transfer <u>50.0 cm³</u> of I₂(aq) into a <u>250 cm³</u> <u>conical flask</u>. To the same conical flask, add <u>25.0 cm³</u> of H₂SO₄(aq) using <u>another 50 cm³ measuring cylinder.</u>
- Measure <u>25.0 cm³</u> of CH₃COCH₃(aq) using a <u>50 cm³ measuring cylinder</u>.
- Add the CH₃COCH₃(aq) into the same 250 cm³ conical flask in step 1. <u>Start</u> the stopwatch <u>immediately</u>. <u>Swirl</u> the mixture to ensure even mixing.
- Using a <u>10 cm³ pipette</u>, transfer <u>10.0 cm³</u> of the reaction mixture into a <u>250 cm³ conical flask</u>. At time 2 min, add <u>10.0 cm³ of NaHCO₃(aq)</u> measured using a <u>10 cm³ measuring cylinder</u> into the 250 cm³ conical flask.

[5]

Procedure for titration

- Immediately <u>titrate</u> the iodine present in the conical flask against Na₂S₂O₃(aq) from a <u>burette</u>, <u>until the solution turns pale yellow</u>. Add 1 cm³ <u>starch</u> from a dropper and continue the titration until the <u>blue-black solution</u> in the conical flask <u>turns colourless</u>.
- 6. <u>**Repeat**</u> steps 3-4 at 4, 8, 12, 16, 20 minutes.
- 7. <u>**Record**</u> the titration results in a suitable table.

[v] Calculation of volume of liquid propanone to measure

 $\sqrt{}$ Specified quantities/volumes to be measured

[v] Procedure to prepare standard solution of propanone

 $[\!\!\sqrt{}]$ Start stopwatch with simultaneous addition of propanone, with swirling for conical flask /stirring with glass rod for beaker

 $[\sqrt{}]$ Sampling and quenching

[$\sqrt{}$] Titration procedure, with the use of starch as indicator (and appropriate colour changes indicated)

[$\sqrt{$] Apparatus with capacity indicated where appropriate for measuring cylinder, pipette and volumetric flask.

[$\sqrt{}$] Repeat experiment at specific time intervals with a minimum of 5 points including t = 2 min.

[$\sqrt{}$] Recording of results

$9\sqrt{5} = 5m; 7-8\sqrt{5} = 4m; 5-6\sqrt{5} = 3m; 3-4\sqrt{5} = 2m; 2\sqrt{5} = 1m$

- (c) The order of reaction with respect to iodine is expected to be zero order.
 - (i) Sketch, on Fig. 4.1, the graph of volume of sodium thiosulfate against time you would expect to obtain. [1]



Fig. 4.1

Note: Be careful to distinguish between graphs for different reaction orders, and to differentiate concentration-time graphs from rate-concentration graphs.

(ii) Explain how the order of reaction with respect to iodine may be determined from your graph. [1]

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The volume of Na₂S₂O₃ used for titrating a sample of quenched aliquot at time t, is proportional to the concentration of I2 present in the reaction mixture at time t.

As the graph shows a downward sloping line with a constant gradient i.e. constant rate, the order of reaction with respect to iodine is zero since the reaction rate is independent of the concentration of iodine. [1]

[Total: 10]

Qualitative Analysis Notes [ppt. = precipitate]

(a) Reactions of aqueous cations

	reaction with		
cation	NaOH(aq)	NH₃(aq)	
aluminium, A <i>l</i> ³+(aq)	white ppt. soluble in excess	white ppt. insoluble in excess	
ammonium, NH₄⁺(aq)	ammonia produced on heating	_	
barium, Ba ²⁺ (aq)	no ppt. (if reagents are pure)	no ppt.	
calcium, Ca²+(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), Fe²+(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, Mg²⁺(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, Zn²+(aq)	white ppt. soluble in excess	white ppt. soluble in excess	

(b) Reactions of aqueous anions

anion	reaction
carbonate, CO ₃ ²-	CO ₂ liberated by dilute acids
chloride, C <i>l</i> ⁻(aq)	gives white ppt. with Ag ⁺ (aq) (soluble in $NH_3(aq)$)
bromide, Br⁻(aq)	gives pale cream ppt. with Ag ⁺ (aq) (partially soluble in $NH_3(aq)$)
iodide, I⁻(aq)	gives yellow ppt. with Ag ⁺ (aq) (insoluble in $NH_3(aq)$)
nitrate, NO₃⁻(aq)	NH ₃ liberated on heating with OH ⁻ (aq) and A <i>l</i> foil
nitrite, NO₂⁻(aq)	NH_3 liberated on heating with OH ⁻ (aq) and A <i>l</i> foil; NO liberated by dilute acids (colourless NO \rightarrow (pale) brown NO ₂ in air)
sulfate, SO4 ^{2–} (aq)	gives white ppt. with Ba ²⁺ (aq) (insoluble in excess dilute strong acids)
sulfite, SO ₃ ²⁻(aq)	SO ₂ liberated with dilute acids; gives white ppt. with Ba ²⁺ (aq) (soluble in dilute strong acids)

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(c) Test for gases

gas	test and test result
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

halogen	colour of element	colour in aqueous solution	colour in hexane
chlorine, Cl ₂	greenish yellow gas	pale yellow	pale yellow
bromine, Br ₂	reddish brown gas / liquid	orange	orange-red
iodine, I2	black solid <i>I</i> purple gas	brown	purple