	TEMASEK JUNIOR COLLEGE 2023 JC2 PRELIMINARY EXAMINATION Higher 2	TEMASEK JUNIOR COLLEGE
CANDIDATE NAME		
CIVICS GROUP		
CENTRE NUMBER	S INDEX NUMBER	
Chemistry		9729/04
Paper 4 Practica	al de la constante de la const	28 August 2023
	2	hours 30 minutes

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

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

F	For Examiner's Use				
1					
2					
3					
4					
Total	/ 55				

This document consists of **17** printed pages and **3** blank pages.

Answer all the questions in the spaces provided.

1 In this experiment you are to determine the relative formula mass of an iron(II) salt by titration with potassium manganate(VII).

FA1 is the iron (II) salt.

FA 2 is 0.0100 mol dm⁻³ potassium manganate(VII), KMnO₄.

FA 3 is 1.0 mol dm⁻³ sulfuric acid, H₂SO₄.

Method

(a) Preparing a solution of FA 1

- 1. Weigh accurately about 4.0 g of **FA 1** into the plastic vial labelled **FA 1** and record the mass in the space below.
- 2. Transfer all the weighed **FA 1** into a 250 cm³ beaker.
- 3. Use a measuring cylinder to add approximately 100 cm³ of **FA 3** to the beaker. Stir until all the solid has dissolved.
- 4. Transfer the solution into the 250 cm³ volumetric (graduated) flask labelled **FA 4**.
- 5. Wash out the beaker thoroughly using distilled water and add the washings to the volumetric flask. Make the solution up to the mark using distilled water.
- 6. Shake the flask thoroughly to mix the solution before using it for your titrations. Label this solution of the iron(II) salt as **FA 4**.

(b) Titration of FA 4 against FA 2

1. Fill the burette with **FA 2**.

Retain the burette containing FA 2 for Q2.

- 2. Pipette 25.0 cm³ of **FA 4** into a conical flask.
- 3. Use a measuring cylinder to add 20 cm³ of **FA 3** to the flask.
- 4. Titrate **FA 4** with **FA 2** until the solution changes to a permanent pink colour.
- 5. Record your titration results, to an appropriate level of precision, in the space provided below.
- 6. Repeat steps 2 to 5 until consistent results are obtained.

(i) Titration results

[2]

(ii) From your accurate titration results, obtain a suitable value to be used in your calculations.

Show clearly how you have obtained this value.

volume of **FA 2** = [4]

(c) Calculations

(i) Calculate the number of moles of potassium manganate(VII) present in the volume of **FA 2** calculated in (b)(ii).

	moles of $KMnO_4 =$	[1]
(ii)	The half-equation for the reduction of a manganate(VII) ion is:	
()	MnO_4^- + $8H^+$ + 5e $\longrightarrow Mn^{2+}$ + $4H_2O$	
	Write the complete balanced ionic equation for the oxidation of iron(II) ion to iron(III) by manganate(VII) ions.	
		[1]
(iii)	Calculate the number of moles of iron(II) ions present in 25.0 cm ³ of solutio 4 .	n FA

- moles of Fe^{2^+} in 25.0 cm³ of **FA 4** = [1]
- (iv) Calculate the number of moles of iron(II) ions present in 250 cm³ of solution **FA 4**.

(v) Calculate the relative formula mass of the iron(II) salt.

relative formula mass = [3]

(d) A student conducted the above experiments and obtained an average titre value of 19.30 cm^3 .

The errors (uncertainties) associated with **each reading** using a graduated flask, pipette and burette are ± 0.15 cm³, ± 0.10 cm³ and ± 0.05 cm³ respectively.

Calculate the maximum total percentage error (uncertainty) of this mean titre volume.

volume.	DO NOT WE
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	[1] z

[Total: 16]

.....

Question 2 continues on the next page.

2 Glucose, C₆H₁₂O₆, is a sugar that can act as a reducing agent. You will investigate how an increase in temperature affects the rate of the redox reaction between glucose and acidified potassium manganate(VII).

FA 2 is 0.010 mol dm⁻³ potassium manganate(VII), KMnO₄.

FA 3 is 1.0 mol dm⁻³ sulfuric acid, H₂SO₄.

FA 5 is an aqueous solution containing 32.8 g dm⁻³ glucose, C₆H₁₂O₆.

distilled water

You will measure the time it takes for the purple colour to disappear. Your table of results on page 8 should include the rate of reaction for each experiment.

(a) Method

Experiment 1

- 1. Add 10.00 cm^3 of **FA 2** from the burette (in question 1) into the 250 cm³ beaker.
- 2. Use the 100 cm³ measuring cylinder to transfer 50.0 cm³ of **FA 3** into the beaker containing **FA 2**.
- 3. Use the same measuring cylinder to transfer 50.0 cm³ of distilled water into the same beaker.
- 4. Place the beaker on the tripod and heat its contents to between 65 °C and 70 °C.
- 5. While the solution in the beaker is heating pour 25.0 cm³ of **FA 5** into the 25 cm³ measuring cylinder.
- 6. When the temperature of the contents of the beaker has reached between 65 °C and 70 °C, turn off the Bunsen burner and **carefully** place the hot beaker onto the white tile.
- 7. Record the initial temperature, T_{i_i} of the solution in the beaker.
- 8. Add the 25.0 cm^3 of **FA 5** and **immediately** start timing.
- 9. Stir the contents of the beaker once and stop timing as soon as the solution turns colourless. Record the time to the nearest second.
- 10. Record the final temperature, T_f , of the solution as soon as it is colourless.
- 11. Calculate and record the average temperature, T_{avg,} of the reaction mixture to one decimal place.
- 12. Repeat Experiment 1 at four different temperatures, between room temperature and 70 °C, each time using a clean and dry beaker. Record all your results in a table on page 8.

Results

DO NOT WRITE IN THIS MARGIN

The rate of reaction can be calculated as shown.

Rate = $\frac{1000}{1000}$

reaction time

Calculate the rate of reaction to 3 sf for each experiment and include this in your table.

[4]

[4]

(b) Plot a graph of rate (y-axis) against average temperature (x-axis) on the grid on page 9. Select a scale on the x-axis to include an average temperature of 15.0 °C. Label any points you consider anomalous.

Draw a line of best fit and extrapolate it to 15.0 °C.

(c) Use your graph to calculate the time to the nearest second that the reaction would have taken if the average temperature had been 52.5 °C. Show on the grid how you obtained your answer.

Time = ______ s [2]

(d) Explain, by referring to your graph or your table of results, how the rate of reaction is affected by an increase in temperature.

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(e) Calculate the maximum percentage error in the reaction time recorded for Experiment1. Assume the error of the timer is ±1s.

maximum percentage error in **Experiment 1** = % [1]

(f) Suggest two ways to improve the accuracy of the results for this investigation.

1:	
2:	
	[2]
	[Total: 14]

Question 3 continues on the next page.

3 Qualitative Analysis

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **describe at an appropriate** juncture of your observations.

You should indicate clearly at what stage in a test a change occurs. No additional tests for ions present should be attempted.

If any solution is warmed, a boiling tube MUST be used.

Rinse and reuse test-tubes and boiling tubes where possible.

Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.

(a) **FA 6** and **FA 7** are aqueous solutions of equal concentrations, in mol dm^{-3} . Each contains one anion and one cation. The cation is the same in both **FA 6** and **FA 7**.

Half-fill the 250 cm³ beaker with water. Heat the water to about 80 °C and then **turn off the Bunsen burner**. This is the hot water bath needed for the tests below.

To about 2 cm depth of aqueous silver nitrate in a test-tube, add a few drops of aqueous sodium hydroxide to give a grey / brown precipitate. Then add aqueous ammonia dropwise until the precipitate **just** disappears. This solution is Tollens' reagent and is needed in a test below.

(i) Carry out the tests on separate samples of FA 6 and FA 7 and complete the table.Precaution : FA 6 should be kept stoppered at all times.

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test	obsen	vations
	FA 6	FA 7
To a 1 cm depth of solution in a		
test-tube in a test-tube rack, add a spatul	а	
measure of sodium carbonate.		
To a 1 cm depth of solution in a test-tube	,	
add a few drops of acidified potassium		
manganate(VII).		
Place the test-tube in the hot water bath.		
To a 1 cm depth of Tollens' reagent in a		
test-tube, add a few drops of solution.		
Place the test-tube in the hot water bath		
and leave for several minutes.		
		[0]
(ii) From your observations in (i),	identify the cation present	in both FA 6 and FA 7.
cation		[1]
(iii) From your observations in (i),6?	what can be deduced abou	ut the anion present in FA
		[1]
(iv) Place a 1 cm depth of FA 6 ar	nd FA 7 separately in two te	est-tubes.
Measure and record the temp	erature of the two solutions	
FA 6 °	C FA7	°C
To each solution, add an appr and record the maximum temp	oximately 2 cm length of m perature reached in each te	agnesium ribbon. Measure st-tube.
FA 6 + Mg	°C FA 7 + Mg	°C
		[2]

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(v) Explain why there is a difference in the temperature rise for the reactions of magnesium with solutions **FA 6** and **FA 7**.

(b) **FA 8** is a solution containing a mixture of two cations from those listed on page 19.

You are to plan a series of experiments that will enable you to identify the cations present. You should then carry out your plan, record all the observations you made in a suitable table and identify the cations present.

Cations present are _____ and _____

[5]

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[Total: 14]

4 Planning

Magnesium methanoate, $Mg(HCOO)_2$ has been used in studies to develop a multiresidue method for determining pesticides in fruits and vegetables.

A saturated solution of magnesium methanoate has a solubility of approximately 150 g dm⁻³ at room temperature. 50 cm³ of the saturated solution was diluted to 250 cm³. This diluted solution "is"**FB'1**:

You are to conduct an experiment to determine the exact solubility of the saturated solution of magnesium methanoate by titrating against acidified potassium manganate (VII) as shown below.

 $[M_r \text{ of } Mg(HCOO)_2 = 114.3]$

 $5HCOO^{-} + 2MnO_{4}^{-} + 11H^{+} \rightarrow 5CO_{2} + 2Mn^{2+} + 8H_{2}O$

You may assume you are provided with:

- 250 cm³ of **FB1**, the diluted magnesium methanoate, Mg(HCOO)₂, solution
- 0.02 mol dm⁻³ aqueous potassium manganate (VII), KMnO₄
- 100 cm³ of 1.0 mol dm⁻³ sulfuric acid, H_2SO_4
- 250 cm³ volumetric flask
- the equipment normally found in a school or college laboratory
- (a) Verify that the approximate concentration of $HCOO^-$ in **FB1** is 0.525 mol dm⁻³.

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[1]

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(b) The concentration of $HCOO^-$ in part (a) is unsuitable for titration with $KMnO_4$.

Dilution is required in the volumetric procedure in order to obtain a reliable titre value.

Calculate a suitable volume of **FB 1** to be further diluted taking into account the equipment found in the college laboratory.

\Box		16 DO NOT WRITE IN THIS MARGIN	7
		[2]	•
	(c)	Plan an experiment to to determine the exact solubility of the saturated solution of magnesium methanoate, taking into account your answers in (b) .	
		Your plan should include details of:	
		then apparatus you would use	
N		the procedure you would follow	D
THIS MARG		the measurements you would take	O NOT WRI
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	[4]

- (d) A student diluted x cm³ of **FB 1** to 250 cm³ and obtained y cm³ of KMnO₄ for the titration.
 - (i) Calculate the concentration of HCOO⁻ in **FB 1**.

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(ii) Hence, calculate the concentration of HCOO⁻ in the saturated solution of magnesium methanoate.

(iii) Determine the solubility product of magnesium methanoate.

[Turn over

[1]

[1]

[Total: 11]

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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, 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), 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, 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 aqueous anions

anion	reaction
carbonate, CO ₃ ²⁻	CO ₂ liberated by dilute acids
chloride, C <i>I</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 Al 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, SO ₄ ^{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)

(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, I ₂	black solid <i>I</i> purple gas	brown	purple