TEMASEK JUNIOR COLLEGE

2023 JC2 PRELIMINARY EXAMINATION

Higher 2

CANDIDATE NAME	**ANSWER**
CIVICS GROUP	/
CENTRE NUMBER	**S**
INDEX NUMBER	

Chemistry **9729/04**

Paper 4 Practical **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.

Shift
Laboratory

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

This document consists of 18 printed pages and **2** blank page.

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).

FA 1 is the iron (II) salt.

FA 2 is 0.0100 mol dm^{-3} potassium manganate(VII), $KMnO_4$.

FA 3 is 1.0 mol dm^{-3} sulfuric acid, H_2SO_4.

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 cm^3 beaker.

3. Use a measuring cylinder to add approximately 100 cm^3 of **FA 3** to the beaker. Stir until all the solid has dissolved.

4. Transfer the solution into the 250 cm^3 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**.

Mass of plastic vial/g	6.01
Mass of plastic vial and FA 1/g	9.91
Mass of plastic vial and residue/g	6.01
Mass of FA 1 used/g	3.90

[2]

[1] Table with correct headings and units

[1] All readings to 2 or 3 d.p

(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 cm^3 of **FA 4** into a conical flask.
3. Use a measuring cylinder to add 20 cm^3 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

Titration No.	1	2
Final burette reading / cm^3	22.10	43.45
Initial burette reading / cm^3	0.70	22.10
Volume FA 2 used / cm^3	21.40	21.35
	✓	✓

[1] Table with correct headings and units

[1] All readings to 2 d.p

[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. [4]

Average volume of FA 2 used = (21.40 + 21.35)/2 cm^3 = 21.38 cm^3

[1] Show correct working using consistent readings

Accuracy:

[3m] supervisor reading ± 0.03 cm^3 g^{-1}

[2m] supervisor reading ± 0.06 cm^3 g^{-1}

[1m] supervisor reading ≤ 0.10 cm^3 g^{-1}

DO NOT WRITE IN THIS MARGIN

(c) Calculations

(i) Calculate the number of moles of potassium manganate(VII) present in the volume of **FA 2** calculated in **(b)(ii)**. [1]

Amount of MnO_4^- = 21.38/1000 x 0.01 mol = 2.14 x 10^{-4} mol [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]

$MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 5Fe^{3+}\ 4\ H_2O$

(iii) Calculate the number of moles of iron(II) ions present in 25.0 cm^3 of solution **FA 4**. [1]

$MnO_4^- \equiv 5Fe^{2+}$

Amount of Fe^{2+} in 25.0 cm^3 = 2.14 x 10^{-4} x 5 mol = 1.07 x 10^{-3} mol [1]

(iv) Calculate the number of moles of iron(II) ions present in 250 cm^3 of solution **FA 4**. [1]

Amount of Fe^{2+} in 250 cm^3 = 1.07 x 10^{-3} x 10 mol = 1.07 x 10^{-2} mol [1]

(v) Calculate the relative formula mass of the iron(II) salt. [3]

Amount of salt = 1.07 x 10^{-2} mol

Mass of salt weighed = 3.90 g

M_r = 3.90/1.07 x 10^{-2} = 364.5 **[1]**

[1] Shows working in all calculations. All calculations must be relevant although they may not be complete or correct. Any calculation not attempted loses this mark.

[1] Shows appropriate significant figures (3 or 4 sf) and units in all final answers. Any calculation not attempted loses this mark.

(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 cm^3, ±0.10 cm^3 and ±0.05 cm^3 respectively.

Calculate the maximum total percentage error (uncertainty) of this mean titre volume. [1]

Maximum % error = ± (0.15/250 + 0.10/25.0 + **2**x0.05/19.30) x 100

= ± (6 x 10^{-4} + 4 x 10^{-3} + 5.18 x 10^{-3}) x 100

=± 0.978 [1]

[Total: 16]

DO NOT WRITE IN THIS MARGIN

2 Glucose, $C_6H_{12}O_6$, 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), $KMnO_4$.

FA 3 is 1.0 mol dm^{-3} sulfuric acid, H_2SO_4.

FA 5 is an aqueous solution containing 32.8 g dm^{-3} glucose, $C_6H_{12}O_6$.

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 cm^3 beaker.
2. Use the 100 cm^3 measuring cylinder to transfer 50.0 cm^3 of **FA 3** into the beaker containing **FA 2**.
3. Use the same measuring cylinder to transfer 50.0 cm^3 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 cm^3 of **FA 5** into the 25 cm^3 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, 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

The rate of reaction can be calculated as shown.

$$\text{Rate} = \frac{1000}{\text{reaction time}}$$

Calculate the rate of reaction to 3 sf for each experiment and include this in your table. [4]

Expt	Initial Temp	Final Temp	Average	Time /s	Rate / s^{-1}

	/ °C	/ °C	Temp / °C		
1	69.0	67.0	68.0	11	90.9
2	59.0	54.0	56.5	26	38.5
3	49.0	45.5	47.3	55	18.2
4	40.0	38.0	39.0	112	8.93
5	29.5	30.0	29.8	335	2.99

[1] Table to show 5 experiment data with 5 headings + units

[1] Temp readings recorded to .0 or .5 **and** all times as integers. All average temperatures correctly calculated to 1 d.p.

[1] All rates correctly calculated to 3 s.f. All rates increase with increase temperature.

[1] Selected initial temperatures in Experiment 2 to 5 that are at least 5 °C apart and none above 70 °C.

(b) Plot a graph of rate (y-axis) against average temperature (x-axis) on the grid opposite. 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. [4]

[1] Axes correctly labelled and scale chosen so graph occupies more than half the available length for both axes including 15 °C on the x-axis

Points in 6 large squares on y-axis and y-axis must not go below 0

[1] All points from data (min 4 expt) accurately plotted within ½ small square (any point that is supposed to be on the line must be on the line and any point that is supposed to be inside a small square must not be on the boundary line.

[1] Line of best curve

[1] Curve extrapolated to 15 °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. [2]

[1] Correct reading of rate within ½ small square ad two construction lines shown

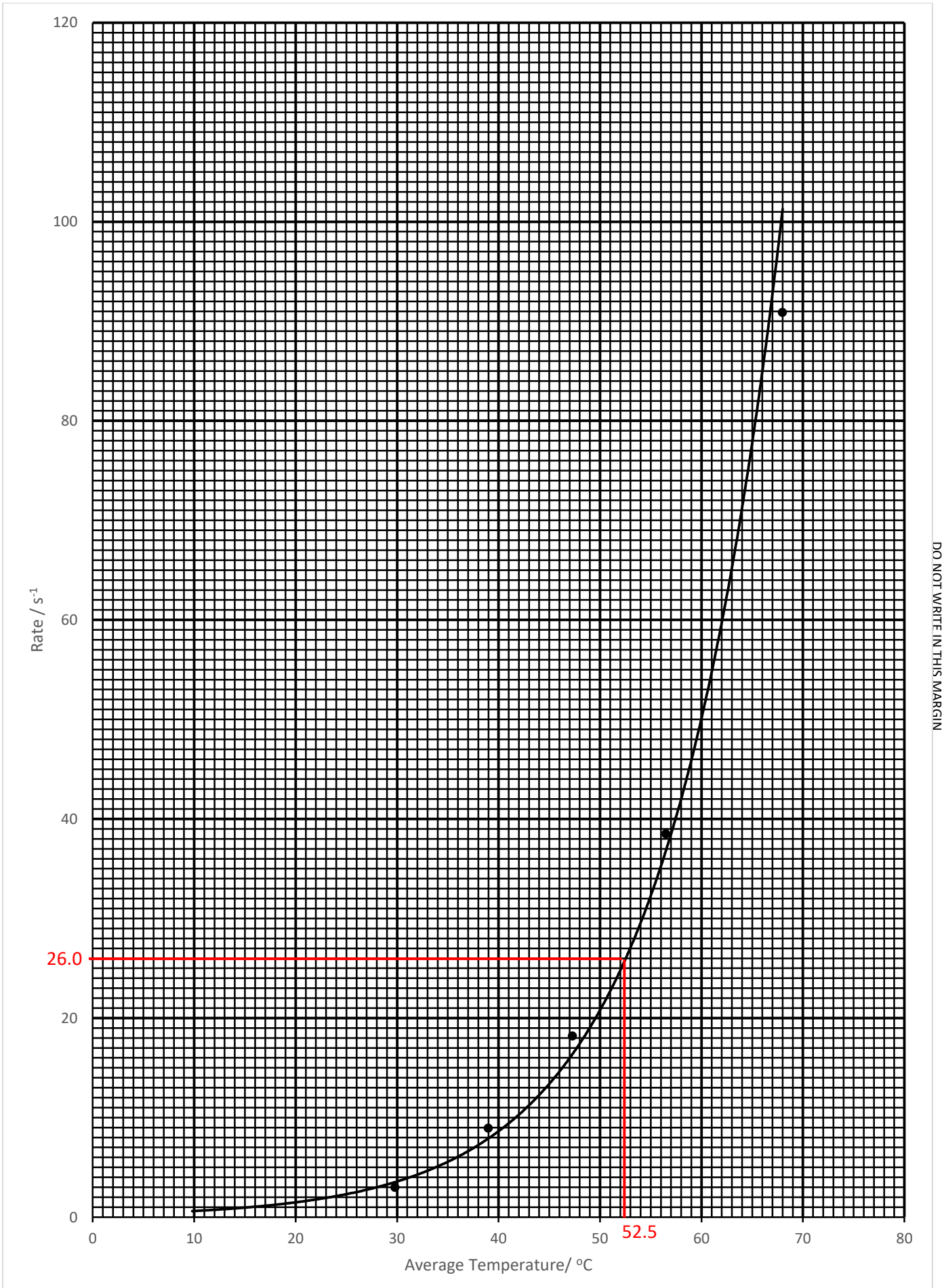
When average temperature = 52.5 °C, from the graph, rate = 26.0

[1] Time = $\frac{1000}{rate} = \frac{1000}{26}$ = 38 s

(d) Explain, by referring to your graph or your table of results, how the rate of reaction is affected by an increase in temperature. [1]

[1] The rate of reaction increases with temperature or rate is proportional to temperature.

[1]



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

[1] Maximum percentage error = $\pm \frac{1}{time} \times 100 = \pm \frac{1}{11} \times 100 = \pm 9.09\%$

(f) Suggest **two** ways to improve the accuracy of the results for this investigation. [2]

Any 2 of the following

- Use thermostatically controlled water bath (to heat both reagents / keep reagents at const T).
- Use more precisely calibrated thermometer (allow more precise but not more accurate or more sensitive) not 'use a digital thermometer'
- Use light sensor / colorimeter (to avoid subjective judgement of colour fade).
- Use burette / measuring cylinders calibrated to greater precision (to measure volumes of FA3 and FA5)

[Total: 14]

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 cm^3 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.

test	*observations*	
	FA 6	**FA 7**
To a 1 cm depth of solution in a test-tube in a test-tube rack, add a spatula measure of sodium carbonate.	✓ **Effervescence.** ✓Colourless, acidic gas evolved. Gives **white ppt.with $Ca(OH)_2$.**	✓**Effervescence.** ✓Colourless, acidic gas evolved. Gives **white ppt. with $Ca(OH)_2$.**
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.	✓**Purple** solution ✓Solution turns colourless / **decolourise**	✓**Purple** solution ✓**No decolourisation / remains purple**
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.	✓Grey/black ppt or silver mirror obtained	(White ppt accepted) ✓No grey/black ppt or silver mirror obtained

9-10 ✓ **3m**; 5-8 ✓ **2 m** ; 2-4 ✓ **1m** [3]

(ii) From your observations in **(i)**, identify the cation present in **both FA 6** and **FA 7**. [1]

cation ....H^+..... **[1]**

(iii) From your observations in **(i)**, what can be deduced about the anion present in **FA 6**? [1]

[1] Can be oxidized / reducing agent/ contains aldehyde group

(iv) Place a 1 cm depth of **FA 6** and **FA 7** separately in two test-tubes.

Measure and record the temperature of the two solutions.

FA 6 ✓.....28.0..... °C **FA 7** ✓.....28.0..... °C

To each solution, add an approximately 2 cm length of magnesium ribbon. Measure and record the maximum temperature reached in each test-tube.

FA 6 + Mg ✓.....36.0..... °C **FA 7** + Mg ✓.....40.0..... °C

[2]

2✓ **1m** (Temperature with Mg must be higher than that without Mg)

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

[1] FA 6 is a weak/weaker acid. The **[1]** heat released from the reaction of the acid with

Mg is used to further dissociate the acid and hence the temperature measured is lower than that of FA 7.

[2]

(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.

Test	Observation
✓To 1 cm depth of FA 8, **add NaOH(aq)** dropwise until in excess. ✓**Warm** the mixture.	✓**White ppt. soluble in excess NaOH** to give a colourless solution. ✓Colourless, pungent, alkaline gas evolved. **Turned damp red litmus blue.**
✓To 1 cm depth of FA 8, **add NH_3(aq)** dropwise until in excess.	✓**White ppt. soluble in excess NH_3(aq)** to give a colourless solution.

3✓ : 1m

Cations present are ……**[1]** ……Zn^{2+}……and……**[1]** …NH_4^+……

[5]

[Total: 14]

DO NOT WRITE IN THIS MARGIN

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 cm^3 of the saturated solution was diluted to 250 cm^3. 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* of $Mg(HCOO)_2$ = 114.3]

$$5HCOO^- + 2MnO_4^- + 11H^+ \rightarrow 5CO_2 + 2Mn^{2+} + 8H_2O$$

You may assume you are provided with:

- 250 cm^3 of **FB1**, the diluted magnesium methanoate, $Mg(HCOO)_2$, solution
- 0.02 mol dm^{-3} aqueous potassium manganate (VII), $KMnO_4$
- 100 cm^3 of 1.0 mol dm^{-3} sulfuric acid, H_2SO_4
- 250 cm^3 volumetric flask
- the equipment normally found in a school or college laboratory

DO NOT WRITE IN THIS MARGIN

(a) Verify that the approximate concentration of $HCOO^-$ in **FB1** is 0.525 mol dm^{-3}. [1]

Saturated $[Mg(HCOO)_2] = \frac{150}{114.3}$ = 1.312 mol dm^{-3}

Diluted $[Mg(HCOO)_2]$ = 1.312 x $\frac{50}{250}$ = 0.2624 mol dm^{-3}

$Mg(HCOO)_2 \equiv 2HCOO^-$

Diluted $[HCOO^-]$ = 2 x 0.2624 = **0.525 mol dm^{-3}**

[1] for correct working i.e. ÷ by 114.3, x 2 mole ratio and dilute 5 times.

(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. [2]

Mole ratio: $5HCOO^- \equiv 2MnO_4^-$
Method 1 : Calculate [$HCOO^-$]

Assuming a titre volume of 25 cm^3 of MnO_4^- ,

Amount of MnO_4^- = 25/1000 x 0.02 = 5.00 x 10^{-4} mol

Mole ratio: $5HCOO^- \equiv 2MnO_4^-$

Amount of $HCOO^-$ = 5/2 x 5.00 x 10^{-4} = 1.25 x 10^{-3} mol mol

Assume using a 25 cm^3 pipette,

[$HCOO^-$] = n/v = $\frac{0.00125}{0.025}$ = **0.0500 mol dm^{-3}** **[1]**

Dilution factor = $\frac{0.525}{0.0500}$ = 10.5

Using a 250 cm^3 volumetric flask for dilution,

Volume of $Mg(HCOO)_2$ to be diluted = 250/10.5 = **23.80 cm^3** [or round up to whole number].
[1] for answer

Method 2: Calculate volume of MnO_4^- needed
Assume using 25 cm^3 pipette,

Amount of $HCOO^-$ in 25 cm^3 = $\frac{25.00}{1000}$ x 0.5248 = 0.01313 mol

Amount of MnO_4^- = 2/5 x 0.01313 =0.00525 mol

Volume of MnO_4^- = c/v = $\frac{0.00525}{0.02}$ = **0.262 dm^3 or 262 cm^3** **[1]**

This volume of MnO_4^- in the burette exceeds the burette capacity hence is not suitable.

Hence, there is a need to dilute the given concentration of $Mg(HCOO)_2$.

Assuming a titre value of 25 cm^3 is suitable[accept any range between 20-30 cm^3],

Dilution factor = $\frac{262}{25}$ = 10.5

Using a 250 cm^3 volumetric flask for dilution,

Volume of $Mg(HCOO)_2$ to be diluted = 250/10.5 = **23.80 cm^3** [or round up to whole number].
[1] for answer

(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
- the procedure you would follow
- the measurements you would take

[4]

Dilution

1. **Using a burette, transfer 23.80 cm^3 of filtrate (range over 23.80 cm^3) into a 250 cm^3 volumetric flask**

2. **Top up to the mark with distilled water and shake** to obtain a homogenous solution

3. Label this solution FA1 / diluted $Mg(HCOO)_2$

Titration

1. **Pipette 25.0 cm^3** of **diluted $Mg(HCOO)_2$/ FA1 into a conical flask**
2. **Using a measuring cylinder, add 25 cm^3 of dilute H_2SO_4** (an excess) into the conical flask.
3. **Fill a burette** with **$KMnO_4$**.
4. **Titrate the diluted $Mg(HCOO)_2$/ FA1 with $KMnO_4$** until 1 drop of the titre turns the mixture from **colourless to pale/permanent pink**. Record your titre value.
5. **Repeat the titration for consistent results** (i.e. results with a difference of ±0.10 cm^3 or less).

D: [1] For dilution procedure

P: [2] For titration procedure (including addition of H_2SO_4, colour change and repeat until consistent results) ;

A: [1] for choice of apparatus and state quantities (If Dilution procedure not written, mark awarded for correct titration apparatus)

(d) A student diluted ***x*** cm^3 of FB1 to 250 cm^3 and obtained ***y*** cm^3 of $KMnO_4$ for the titration.

(i) Calculate the concentration of $HCOO^-$ in FB1. [2]

Let the average titre value of MnO_4^- = ***y*** cm^3

Amount of MnO_4^- = 0.020 x y/1000 = 2×10^{-5} ***y***

[1] Amount of $HCOO^-$ in 25 cm^3 = 5/2 x (2×10^{-5} ***y***) = 5×10^{-5}

Amount of $HCOO^-$ in 250 cm^3 = No mol of $HCOO^-$ in ***x*** cm^3 (volume diluted)

= 250/25 x 5×10^{-5} ***y*** = 5.0×10^{-4} ***y***

[1] $[HCOO^-] = \frac{0.0005y}{x/1000} = \frac{0.5y}{x}$ mol dm^{-3}

(ii) Hence, calculate the concentration of $HCOO^-$ in saturated solution of magnesium methanoate.
[1]

[1] $[HCOO^-] = \frac{0.0005y}{x/1000} \times 5 = \frac{2.5y}{x}$ mol dm^{-3}

(iii) Determine the solubility product of magnesium methanoate. [1]

$[Mg^{2+}] = ½ [HCOO^-] = ½ \times (\frac{0.0005y}{x/1000}) \times 5 = \frac{1.25y}{x}$ mol dm^{-3}

[1] $K_{sp} = [Mg^{2+}] [HCOO^-]^2$

$= (\frac{1.25y}{x})(\frac{2.5y}{x})^2$ mol^3 dm^{-9}

$= \frac{125}{16}\frac{y^3}{x^3}$ mol^3 dm^{-9} **[with correct units]**

[Total: 11]

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

DO NOT WRITE IN THIS MARGIN

(b) Reactions of aqueous anions

anion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, Cl^-(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, NO_3^-(aq)	NH_3 liberated on heating with OH^-(aq) and Al foil
nitrite, NO_2^-(aq)	NH_3 liberated on heating with OH^-(aq) and Al 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 / purple gas	brown	purple