Catholic Junior College

JC2 Preliminary Examinations

Higher 2

CANDIDATE NAME	
CLASS	**2T**

CHEMISTRY

9729/04

Paper 4 Practical

August 2021

2 hour 30 minutes

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your name and class in the boxes above.

Give details of the practical shift and laboratory, where appropriate, in the boxes provided.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.

You may lose marks if you do not show your working or if you do not use appropriate units.

Qualitative Analysis Notes are printed on pages 15 and 16.

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	**/ 21**
2	**/ 18**
3	**/ 16**
Total	**/ 55**

This document consists of **16** printed pages and **0** blank page.

[Turn over

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

1 To determine the stoichiometry of two redox reactions.

FA 1 is 0.0395 mol dm^{-3} ammonium iron(II) sulfate, $(NH_4)_2SO_4.FeSO_4.6H_2O$.
FA 2 is 0.0150 mol dm^{-3} potassium manganate(VII), $KMnO_4$.
FA 3 is 0.0250 mol dm^{-3} hydrogen peroxide, H_2O_2.

You are also provided with dilute sulfuric acid, H_2SO_4.

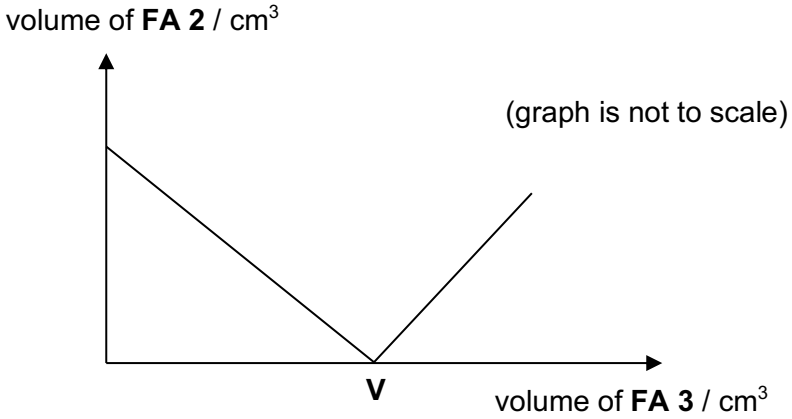
Potassium manganate(VII), **FA 2**, and hydrogen peroxide, **FA 3**, are both able to oxidise the $Fe^{2+}(aq)$ ions in acidified **FA 1**.

$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$$
$$Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^-$$

In the presence of acid, potassium manganate(VII), **FA 2**, can also oxidise hydrogen peroxide, **FA 3**, forming oxygen gas.

In this question, you will prepare five mixtures, each containing different volumes of **FA 3** added to 25.0 cm^3 portions of **FA 1**. This mixture will then be acidified by adding sulfuric acid and titrated against **FA 2**.

A graph of the results can then be drawn.



Graphical analysis of your results will enable you to determine

- the volume, **V**, of **FA 3** which reacts with 25.0 cm^3 of **FA 1**,
- the mole ratio for the reaction between $Fe^{2+}(aq)$ and $H_2O_2(aq)$, and
- the mole ratio for the reaction between $MnO_4^-(aq)$ and $H_2O_2(aq)$.

Each titration is to be performed **once only**, so great care should be taken that you do not overshoot the end-points.

Prepare a table in the space provided on page 4 to record, to an appropriate level of precision:

- volume of **FA 3** added in each mixture, V_{FA3},
- all burette readings,
- volume of **FA 2** added, V_{FA2}.

(a) Method

(i) Perform **Experiment 1 and 2** as described below. Record your results (V_{FA3}, all burette readings and V_{FA2}) to an appropriate level of precision, in your table.

Experiment 1

1. Fill the burette labelled **FA 3** with **FA 3**.
2. Fill the other burette with **FA 2**.
3. Pipette 25.0 cm^3 of **FA 1** into a 250 cm^3 conical flask.
4. Use a measuring cylinder to add 10 cm^3 of sulfuric acid into the conical flask.
5. Titrate the **FA 1** solution in the conical flask with **FA 2.**
   End-point is reached when a permanent **pale pink** colour is obtained.

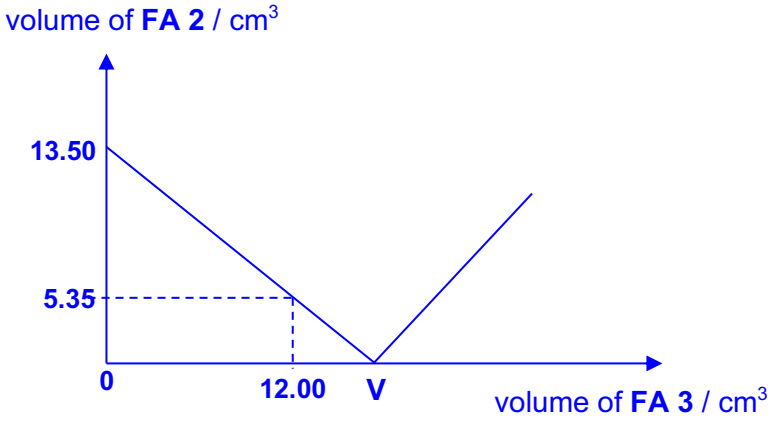
Experiment 2

In this experiment, a very small volume of **FA 2** will be required.

6. Repeat steps 3 to 5 but, at step 5, add 12.00 cm^3 of **FA 3** from the burette into the conical flask and then titrate the mixture with **FA 2**.

(ii) The volume of **FA 3** added in **Experiment 2** was insufficient to react with all the Fe^{2+} ions in **FA 1**. Use your results from **Experiment 1** and **2** to estimate a value for the volume of **FA 3** at point **V**.

(Sketching a graph of V_{FA2} against V_{FA3} or otherwise may help in calculating the volume of **FA 3** at point **V**.)



estimated vol of FA 3 = $\frac{13.500}{13.50-5.35}$ × 12.00

= 19.88 cm^3

estimated volume of **FA 3** at point **V** = ……**19.88 cm^3**…… [1]

(iii) Experiment 3 to 5

Use your answer from **(a)(ii)** to select **three** further volumes of **FA 3** in order to produce a graph of the type shown in page 1.

Repeat **Experiment 2** but use your selected volumes of **FA 3** at step 5 and then titrate each mixture with **FA 2**.

Results:

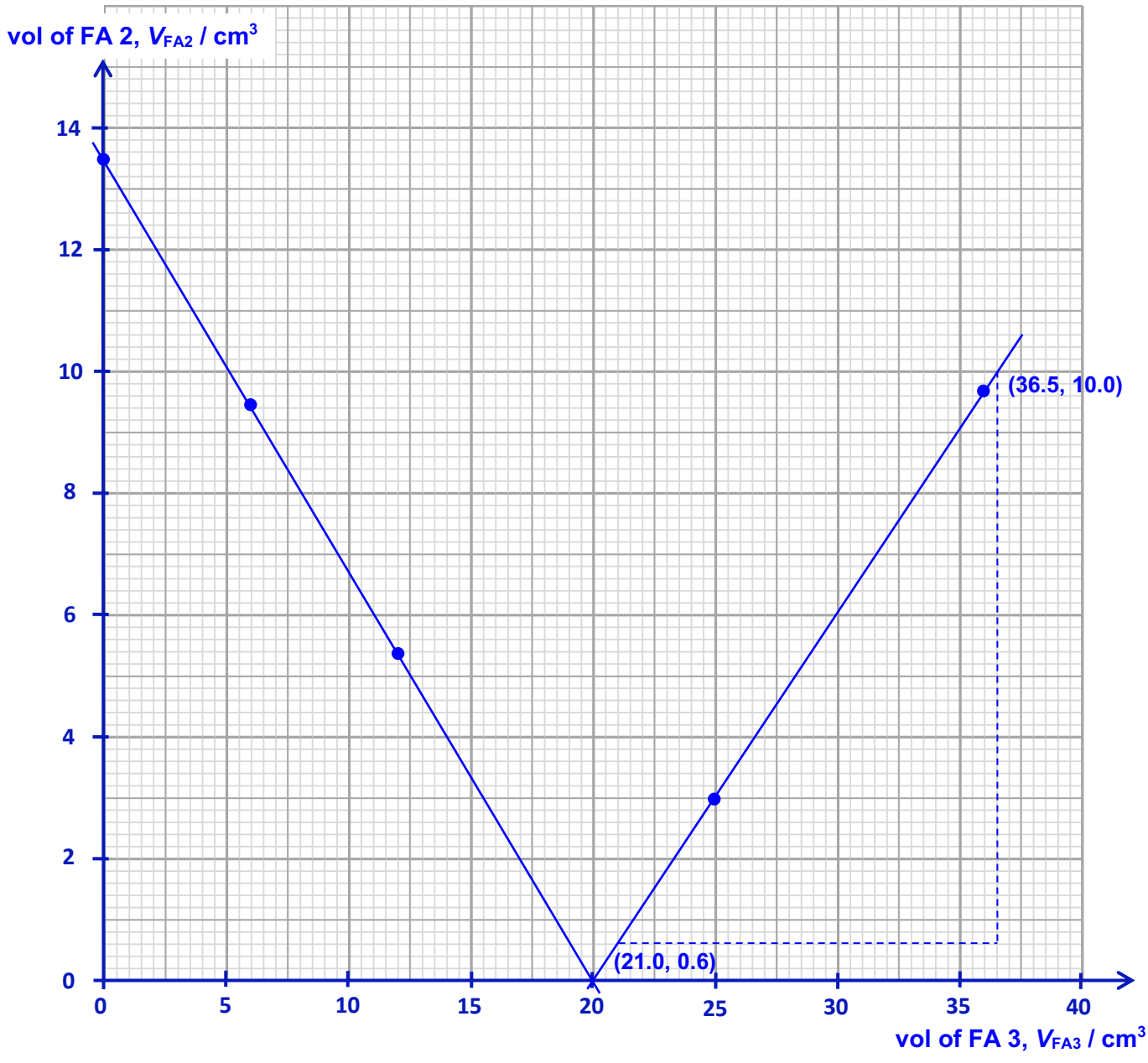
	Expt 1	Expt 2	Expt 3	Expt 4	Expt 5
vol. of **FA 3** added, V_{FA3} / cm^3	**0.00**	**12.00**	6.00	25.00	36.00
final burette reading / cm^3	13.50	21.85	31.45	6.95	16.30
initial burette reading / cm^3	0.00	16.50	22.00	4.00	6.60
vol. of **FA 2** added, V_{FA2} / cm^3	13.50	5.35	9.45	2.95	9.70

single table with appropriate headings and units
all burette readings to 2 d.p. (read to 0.05 cm^3)
choice of one V_{FA3} < predicted vol at V and two V_{FA3} > predicted vol at V
accuracy – max 2 marks

[5]

(b) Plot on the grid below, a graph of V_{FA2} on the *y*-axis against V_{FA3} on the *x*-axis.

Draw **two** best-fit straight line for the point before and after **V**. Hence, obtain a value for the volume at **V**.



volume of **FA 3** at point **V** = ... **20.00 cm^3** ..... [5]

- **axes correctly labelled, with units, plus sensible linear scale with plotted points cover about half of graph grid for both axes**
- **all points accurately plotted to within ½ small square and in correct small square**
- **both straight lines meet at x-axis and V correctly read from graph within ½ small square**
- **V correctly read from graph within ½ small square**
- **all but one of the plotted points within 1 small square of best-fit line**

(c) **(i)** Calculate the amount of H_2O_2 present in **V** cm^3 of **FA 3** and hence deduce the amount of H_2O_2 that will react exactly with 1.00 mol of Fe^{2+} ions. Give your answers to three significant figures.

amount of H_2O_2 = 0.0250 × $\frac{20.00}{1000}$
= 5.00×10^{-4} mol

0.0250 × $\frac{V}{1000}$
(must be 3 s.f.)

amount of H_2O_2 present in **V** cm^3 of **FA 3** = **5.00×10^{-4} mol** [1]

amount of Fe^{2+} in 25.0 cm^3 of FA 1 = 0.0395 × $\frac{25.0}{1000}$
= 9.88×10^{-4} mol
amount of H_2O_2 that react exactly with 1.00 mol of Fe^{2+}
= $\frac{5.00 \times 10^{-4}}{9.88 \times 10^{-4}}$ = 0.506 mol

above answer / 9.88×10^{-4}
(must be 3 s.f.)

amount of H_2O_2 that reacts exactly with 1.00 mol of Fe^{2+} ions = **0.506 mol** [1]

(ii) Calculate the gradient of the **line to the right of V** to three significant figures, showing clearly how you did this.

gradient = $\frac{10.0-0.6}{36.5-21.0}$ = $\frac{9.4}{15.5}$ = 0.606

gradient = **0.606** [2]

(iii) Use the following relationship to calculate the mole ratio for the reaction between H_2O_2 and MnO_4^- ions.

$$\text{gradient} = \frac{\text{mol of } MnO_4^- \times [\text{FA 3}]}{\text{mol of } H_2O_2 \times [\text{FA 2}]}$$

gradient = $\frac{\text{mol of } MnO_4^- \times [\text{FA 3}]}{\text{mol of } H_2O_2 \times [\text{FA 2}]}$

$\frac{\text{mol of } H_2O_2}{\text{mol of } MnO_4^-}$ = $\frac{[\text{FA 3}]}{[\text{FA 2}]} \times \frac{1}{\text{gradient}}$
= $\frac{0.0250}{0.0150} \times \frac{1}{0.606}$
= 2.75

mole ratio $H_2O_2 : MnO_4^-$ = **2.75 : 1** [1]

(d) Explain, in terms of the chemistry involved, the direction of the slope of your graph

(i) to the **left of V**

A negative slope is obtained because as more of H_2O_2, FA 3, is added, less of $Fe^{2+}(aq)$ is left and so, less $KMnO_4$, FA 2, is needed for oxidation. [1]

(ii) to the **right of V**

A positive slope is obtained because to the right of V, all the $Fe^{2+}(aq)$ has reacted with H_2O_2 and so, as more of H_2O_2, FA 3, is added, more $KMnO_4$, FA 2, is needed to oxidise the H_2O_2. [1]

(e) A student repeated the experiment described in **(a)** but used 0.0395 mol dm^{-3} hydrogen peroxide instead of **FA 3**.

Suggest what effect this would have on the value of **V**, explain your answer clearly.

Value of V will be smaller.

Since [H_2O_2] used is higher than concentration of FA3, smaller volume of H_2O_2 is needed to provide same amount of H_2O_2 to react with Fe^{2+} in 25.0 cm^3 of FA 1 [1]

(f) **(i)** One source of potential error in this experiment involves taking readings from a burette. A student carried out **Experiment 2** and recorded the initial and final burette readings as 16.50 cm^3 and 21.85 cm^3 respectively. Calculate, to three significant figures, the maximum percentage error in his titre value.

titre value = 21.85 – 16.50 = 5.35 cm^3

% error = $\frac{2 \times 0.05}{5.35}$ × 100 = 1.87 %

maximum percentage error = ……**1.87**….% [1]

(ii) Suggest one improvement to the method described in **(a)** which could significantly improve the accuracy of the experiment.

Repeat each titration for consistent titres (within ±0.10 cm^3 of each other). OR carry out more titrations with different volumes of FA 3 to get more data points for graph plotting. [1]

[Total: 21]

2 The enthalpy change for the reaction of sodium carbonate, Na_2CO_3, with water and carbon dioxide to form sodium hydrogencarbonate, $NaHCO_3$, cannot be determined directly. However both $Na_2CO_3(s)$ and $NaHCO_3(s)$ react with dilute hydrochloric acid.

Reaction 1 $NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) + CO_2(g)$ ΔH_1

Reaction 2 $Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$ ΔH_2

In this experiment you will determine the enthalpy change ΔH_1 for **reaction 1** and ΔH_2 for **reaction 2**, and then use your results to calculate ΔH_3 for the reaction:

$$Na_2CO_3(s) + H_2O(l) + CO_2(g) \rightarrow 2NaHCO_3(s) \qquad \Delta H_3$$

FA 4 is sodium hydrogen carbonate, $NaHCO_3$.
FA 5 is sodium carbonate, Na_2CO_3.
FA 6 is 2.0 mol dm^{-3} hydrochloric acid, HCl.

(a) Method

Experiment 1: $NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) + CO_2(g)$

- Use a measuring cylinder to transfer 25 cm^3 of the acid, **FA 6**, into a polystyrene cup supported in a 250 cm^3 beaker. The acid is in excess.
- Weigh the container with **FA 4** and record the balance reading.
- Place the thermometer in the acid and record its initial temperature.
- Carefully tip all the **FA 4**, in small portions, into the acid and stir to dissolve.
- Record the lowest temperature reached.
- Reweigh the container with any residual **FA 4** and record the balance reading and the mass of **FA 4** used.

Experiment 2: $Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl\ (aq) + H_2O(l) + CO_2(g)$

- Replace the wet polystyrene cup with a clean, dry polystyrene cup.
- Repeat **Experiment 1** but use **FA 5** in place of **FA 4** and record the highest temperature reached.
- Reweigh the container with any residual **FA 5** and record the balance reading and the mass of **FA 5** used.

Results

Record **all** weighings and temperature readings in the table below.

	Experiment 1	Experiment 2
mass of container + solid sample / g	**10.625**	**7.599**
mass of container + residual **solid** / g	**8.129**	**5.607**
mass of **solid** added / g	**2.496**	**1.992**
initial temperature, T_i, of **FA 6** / °C	**28.0**	**28.0**
final temperature, T_f / °C	**20.3**	**34.0**
temperature change, ΔT / °C	**–7.7**	**6.0**

[5]

all mass recorded consistently to 2 or 3 d.p. & all temperature readings recorded to 1 d.p.

Accuracy:

Experiment 1: max 2 marks

Experiment 2: max 2 marks

(b) **(i)** Calculate the heat energy absorbed when **FA 4** was added to the acid in **Experiment 1** and hence, the enthalpy change, in kJ mol^{-1}, when 1 mol of **FA 4**, $NaHCO_3$, reacts with the acid. [A_r: H, 1.0; C, 12.0; O, 16.0; Na, 23.0]
[Assume that 4.18 J of heat energy changes the temperature of 1.0 cm^3 of solution by 1.0 °C.]

heat absorbed = mc ΔT

= 25 × 4.18 × 7.7 **25 × 4.18 × ΔT_{expt1}**

= 804.6 J

heat energy absorbed =……**804.6**…… J

M_r of $NaHCO_3$ = 23.0 + 1.0 + 12.0 + 3(16.0) = 84.0

mol of $NaHCO_3$ = $\frac{2.496}{84.0}$ = 0.0297 mol

$\therefore$ ΔH_1 = +$\frac{804.6}{0.0297}$ J mol^{-1}

= +27090 J mol^{-1}

= +27.1 kJ mol^{-1}

enthalpy change, ΔH_1 = ……**+27.1**…… kJ mol^{-1}

[3]

(ii) Calculate the heat energy produced when **FA 5** was added to the acid in **Experiment 2** and hence, the enthalpy change, in kJ mol^{-1}, when 1 mol of **FA 5**, Na_2CO_3, reacts with the acid. [A_r: C, 12.0; O, 16.0; Na, 23.0].
[Assume that 4.18 J of heat energy changes the temperature of 1.0 cm^3 of solution by 1.0 °C.]

heat evolved = mc ΔT
= 25 × 4.18 × 6.0 **25 × 4.3 × ΔT_{expt2}**
= 627 J

heat energy produced =….**627**…..… J

M_r of Na_2CO_3 = 2(23.0) + 12.0 + 3(16.0) = 106.0
mol of Na_2CO_3 = $\frac{1.992}{106.0}$ = 0.0188 mol
∴ ΔH_2 = – $\frac{627}{0.0188}$ Jmol^{-1}
= – 33350 J mol^{-1}
= – 33.4 kJ mol^{-1}

enthalpy change, ΔH_2 = ….**–33.4**…… kJ mol^{-1}
[3]

(iii) Using your answers to **(b)(i)** and **(b)(ii)** and the equations for **Experiment 1** and **Experiment 2**, determine the enthalpy change for the reaction:

$$Na_2CO_3(s) + H_2O(l) + CO_2(g) \rightarrow 2NaHCO_3(s)$$

$+ 2HCl(aq)$ ΔH_2 → $2NaCl(aq) + 2H_2O(l) + 2CO_2(g)$ ← $+ 2\,HCl(aq)$ $2\Delta H_1$

By Hess' Law,

$\Delta H = \Delta H_2 - 2\Delta H_1$

$= (-33.4) - 2(+27.1)$

$= -87.6$ kJ mol^{-}

3 or 4 sf in all final answers

enthalpy change, ΔH_3 = ... **–87.6** ..... kJ mol^{-1} [2]

(c) Planning

You are provided with **FA 4**, solid sodium hydrogencarbonate, $NaHCO_3$, and distilled water.

Using only these materials, you are to plan and carry out an additional experiment to determine a further enthalpy change, ΔH_4, which can be put together with those from **Experiment 1** and **Experiment 2** to determine the enthalpy change for the reaction:

$$Na_2CO_3(s) + H_2O(l) + CO_2(g) \rightarrow 2NaHCO_3(aq)$$

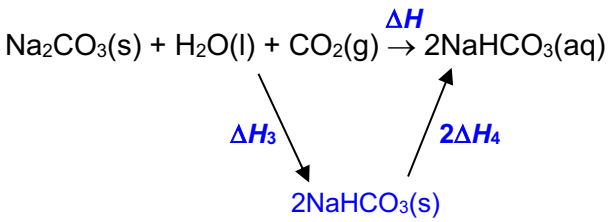
- Outline your plan as a series of numbered steps.

1. Use a measuring cylinder to transfer 25 cm^3 of distilled water into a plastic cup supported in a 250 cm^3 beaker. Record its initial temperature.
2. Weigh 3.00 g of **FA 4** and carefully tip all the **FA 4**, in small portions, into the water and stir to dissolve.
3. Record the lowest temperature reached.
4. Reweigh the container with any residual **FA 4** and record the balance reading and the mass of **FA 4** used.

- Carry out your plan and record your results, in a suitable form, in the space below.

mass of container + **FA 4** / g	**8.599**
mass of container + residual **FA 4** / g	**5.504**
mass of **FA 4** added / g	**3.095**
initial temperature of water / °C	**24.8**
lowest temperature reached / °C	**20.5**
temperature fall, ΔT / °C	**4.3**

- Show how you would use your results to determine the enthalpy change for the reaction:



heat absorbed = mc ΔT
= 25 × 4.18 × 4.3
= 449 J **calculates energy change for vol of solution used**

M_r of $NaHCO_3$ = 23.0 + 1.0 + 12.0 + 3(16.0) = 84.0

mol of $NaHCO_3$ = $\frac{3.095}{84.0}$ = 0.0368 mol

$\therefore$ ΔH_4 = $+\frac{449}{0.0368}$ J mol^{-1}
= +12200 J mol^{-1}
= +12.2 kJ mol^{-1} **calculates ΔH_4 including sign**

By Hess' Law,
$\Delta H = \Delta H_3 + 2\Delta H_4$
= (–87.6) + 2(+12.2) **adds 2 ΔH_4 to ans to (b)(iii)**
= –63.2 kJ mol^{-1}

[5]

[Total: 18]

3 Qualitative Analysis

You are provided with **FA 7**, an aqueous solution containing two cations and one anion.

In this question, you will carry out tests on **FA 7** to identify the ions present in the sample.

(a) Carry out the following tests and record your observations in the table. You should test and identify any gases evolved. If there is no observable reaction, write 'No observable change' in the observations column.

test	observations
Test 1 Place a drop of **FA 7** on the Universal Indicator (UI) paper and compare the colour against the UI colour chart provided.	**colour on UI paper corresponds to pH 2.**
Test 2 Place 1 cm depth of **FA 7** in a clean test-tube. Add an equal volume of dilute nitric acid slowly with shaking.	**yellow solution turns colourless** **No effervescence observed.**
Test 3 Place 1 cm depth of **FA 7** in a clean boiling tube. Add aqueous sodium hydroxide slowly with shaking until no further change is seen. Warm the mixture gently.	**red-brown ppt** **insoluble in excess** **pungent gas liberated turns damp red litmus paper blue. $NH_3(g)$ liberated.**
Test 4 Place 1 cm depth of potassium iodide in a clean test-tube. Add 8 drops of **FA 7**. Then add 3 drops of starch solution.	**solution turns orange / orange-brown / brown** **solution turns blue-black**
Test 5 Place 1 cm depth of hydrogen peroxide in a clean test-tube. Add an equal volume of **FA 7**. Make observations for about 2 minutes before recording your results.	**effervescence** **gas relights a glowing splint** **$O_2(g)$ liberated.**

[7]

(b) **(i)** Identity the two cations present in **FA 7** and provide evidence to support your answer.

cation 1 ..Fe^{3+}.....

evidence ..Test 3 - red-brown ppt insoluble in excess NaOH.....

.....

cation 2 ..NH_4^+.....

evidence ..Test 3 - $NH_3(g)$ liberated when warmed with NaOH.....

..... [2]

(ii) Explain, in terms of ions present, the pH of the **FA 7** solution observed in **3(a)**.

pH of FA 7 solution is about 2, showing that the solution is acidic and contains H^+ ions, due to hydrolysis of $Fe^{3+}(aq)$ and $NH_4^+(aq)$.

..... [1]

(iii) Suggest, with explanation, the nature of **FA 7** as observed in **Test 4**.

FA 7 is ..oxidising / an oxidising agent / oxidant.....

explanation ..FA 7 oxidised I^- ions to I_2 (brown solution).....

..... [1]

(iv) State the role of hydrogen peroxide in **Test 5**.

H_2O_2 acts as a reducing agent.

..... [1]

(c) The anions that may be present in **FA 7** are bromide, carbonate and sulfate.

(i) From the observations in **3(a)**, one of the above anion can be ruled out. Identify this anion and provide evidence to support your answer.

anion **not** present in **FA 7** ..carbonate, CO_3^{2}.....

evidence ..In Test 2, no effervescence of $CO_2(g)$ observed when dilute.....

nitric acid is added to FA 7. ..... [1]

(ii) Plan and carry out other tests to confirm the identity of the anion present in **FA 7**. Record your results in the table below. Draw a line after each test. You are **not** to identify the anion by elimination.

test	observations
Place 1 cm depth of **FA 7** in a clean test-tube. Add a few drops of aqueous silver nitrate.	**no ppt / no observable change.**
Place 1 cm depth of **FA 7** in a clean test-tube. Add a few drops of aqueous barium chloride.	**white ppt.**

anion present in **FA 7** is **sulfate, SO_4^{2-}** ……..

[3]

[Total: 16]

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

(b) Reactions of anions

ion	***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) Tests 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