VICTORIA JUNIOR COLLEGE
PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME ……..

CT GROUP ……..

CHEMISTRY 9729/04

Paper 4 Practical **31 Aug 2020**

Candidates answer on the Question Paper. **2 hours 30 minutes**

Additional Materials: As listed in the instructions below

READ THESE INSTRUCTIONS FIRST

Write your name and CT group 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 a 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 14 and 15.

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	**/ 12**
2	**/ 13**
3	**/ 17**
4	**/ 13**
Total	**/ 55**

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

1 **X** is a solid sample of sodium ethanedioate, $Na_2C_2O_4$ and ethanedioic acid, $H_2C_2O_4$, a weak acid.

FA 1 is prepared by dissolving 2.00 g of **X** in a 250 cm^3 volumetric flask and making up to the mark with deionised water.
FA 2 is 0.0100 mol dm^{-3} sodium hydroxide, NaOH(aq).
FA 3 is 0.0200 mol dm^{-3} potassium manganate(VII), $KMnO_4$(aq).

Titration of FA1 against FA2

(a)
1. Fill a burette with **FA 2**.
2. Pipette 25.0 cm^3 of **FA 1** into a conical flask.
3. Add 2−3 drops of thymolphthalein indicator to the conical flask.
4. Titrate **FA1 against FA 2** until a distinct colour change is observed.
5. Carry out as many titrations as you deem necessary to obtain consistent results.
6. Record in an appropriate form all of your burette readings and the volume of **FA 2** added in each titration.

Final burette reading / cm^3	20.50	41.60
Initial burette reading / cm^3	0.00	21.00
Volume of **FA 2** used / cm^3	20.50	20.60

[4]

(b) (i) From your titration results, obtain a suitable volume of **FA 2** to be used in your calculations. Show clearly how you obtained this volume.

Average volume of **FA 2** used
= (20.50 + 20.60) ÷ 2
= 20.55 cm^3

25.0 cm^3 of **FA 1** required ……20.55…… cm^3 of **FA 1**. [1]

The equation for the reaction between sodium hydroxide and ethanedioic acid in this experiment is shown below:

$$H_2C_2O_4 + 2NaOH \rightarrow Na_2C_2O_4 + 2H_2O$$

(ii) Calculate the amount of ethanedioic acid in 25.0 cm^3 of **FA 1**.

Amount of NaOH required
= $0.0100 \times 20.55 \times 10^{-3}$
= 2.06×10^{-4} mol

Amount of $H_2C_2O_4$ present in 25.0 cm^3
= ½ × no. of moles of NaOH required
= $½ \times 2.06 \times 10^{-4}$
= 1.03×10^{-4} mol

Amount of $H_2C_2O_4$ in 25.0 cm^3 of **FA 1** = 1.03×10^{-4}…… mol [1]

(c) When 25.0 cm^3 of **FA1** was titrated with **FA 3**, 25.05 cm^3 of **FA 3** was required to reach the end−point.

(i) Calculate the amount of potassium manganate(VII), **FA 3**, required to react with 25.0 cm^3 of **FA 1**.

Amount of $KMnO_4$ required
$= 0.0200 \times 25.05 \times 10^{-3}$
$= 5.01 \times 10^{-4}$ mol

Amount of $KMnO_4$ = ….5.01×10^{-4}…. mol [1]

(ii) The equation for the reaction between acidified manganate(VII) ions and ethanedioate ions is shown in **equation 1** below.

equation 1 $2MnO_4^-(aq) + 5C_2O_4^{2-}(aq) + 16H^+(aq) \rightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(l)$

Calculate the total amount of ethanedioate ions in 25.0 cm^3 of **FA 1**.

Total amount of $C_2O_4^{2-}$ present in 25.0 cm^3
$= \frac{5}{2} \times$ no. of moles of MnO_4^- required
$= \frac{5}{2} \times 5.01 \times 10^{-4}$
$= 1.25 \times 10^{-3}$ mol

total amount of $C_2O_4^{2-}$ in 25.0 cm^3 of **FA 1** = ….1.25×10^{-3}…. mol [1]

(iii) Use your answers from **(b)(ii)** and **(c)(ii)** to calculate the amount of ethanedioate ions which came from the sodium ethanedioate in 25.0 cm^3 of **FA 1**.

Amount of $C_2O_4^{2-}$ from $Na_2C_2O_4$ in 25.0 cm^3
$= (1.25 \times 10^{-3}) - (1.03 \times 10^{-4})$
$= 1.15 \times 10^{-3}$ mol

amount of $C_2O_4^{2-}$ from $Na_2C_2O_4$ in 25.0 cm^3 of **FA 1** = ….1.15×10^{-3}…. mol [1]

(iv) Calculate amount of sodium ethanedioate in **FA 1**.

- Amount of $Na_2C_2O_4$ in **FA 1**
  $= 1.15 \times 10^{-3} \times \frac{250}{25.0}$
  $= 1.15 \times 10^{-2}$ mol

amount of $Na_2C_2O_4$ in **FA 1** = ….1.15×10^{-2}…. mol [1]

(v) Hence, calculate the percentage by mass of sodium ethanedioate in sample **X**.
[A_r: Na, 23.0; C, 12.0; O, 16.0]

Mass of $Na_2C_2O_4$ in **FA 1**
$= 1.15 \times 10^{-2} \times (2 \times 23.0 + 2 \times 12.0 + 4 \times 16.0)$
$= 1.15 \times 10^{-2} \times 134.0$
$= 1.54$ g

- Percentage by mass of $Na_2C_2O_4$ in **X**
  $= 1.54/2.00 \times 100\%$
  $= 77.0\%$

Percentage by mass of sodium ethanedioate in **X** = ….77.0%…. [2]
[Total: 12]

2 To study the kinetics of the Mn^{2+} catalysed reaction between MnO_4^- and $C_2O_4^{2-}$

FA 3 is 0.0200 mol dm^{-3} potassium manganate(VII), $KMnO_4(aq)$.
FA 4 is 0.200 mol dm^{-3} $Na_2C_2O_4(aq)$.
FA 5 is 2.00 mol dm^{-3} sulfuric acid, H_2SO_4.
FA 6 is 0.200 mol dm^{-3} $MnSO_4(aq)$.
FA 7 is 0.400 mol dm^{-3} KI(aq).
FA 8 is 0.00400 mol dm^{-3} $Na_2S_2O_3(aq)$.

In this experiment, you will determine the order of reaction with respect to MnO_4^- for the reaction between MnO_4^- and $C_2O_4^{2-}$, catalysed by Mn^{2+} ions. The mechanism for the catalysed reaction is shown by **step 1** and **step 2** below:

Step 1: $8Mn^{2+}(aq) + 2MnO_4^-(aq) + 16H^+(aq) \rightarrow 10Mn^{3+}(aq) + 8H_2O(l)$

Step 2: $10Mn^{3+}(aq) + 5C_2O_4^{2-}(aq) \rightarrow 10CO_2(g) + 10Mn^{2+}(aq)$

(a) (i) With reference to the mechanism above and the uncatalysed reaction in **equation 1**, explain why the addition of Mn^{2+} will speed up the reaction.

- **The steps in the catalysed reaction have lower activation energy as they involved oppositely charged species unlike the uncatalysed reaction which involved two anions which will experience electrostatic repulsion. Hence, Mn^{2+} can provide a pathway with lower activation energy.**

[1]

Preparation and titration of the reaction mixture

Notes: Read through the instructions carefully before starting any practical work.

You will perform each titration **once** only. Great care must be taken that you do not overshoot the end-point.
Once you have started the stopwatch, it must continue running for the duration of the experiment. You must **not** stop it until you have finished the experiment.
You should aim **not** to exceed a maximum reaction time of **15** minutes for this experiment.

1. Fill a burette with **FA 8**.

2. Use a measuring cylinder to place the following in a 250 cm^3 conical flask.
   - 50 cm^3 of **FA 4**
   - 5 cm^3 of **FA 5**
   - 15 cm^3 of **FA 6**
   - 45 cm^3 of deionised water

3. Use a measuring cylinder to add 50 cm^3 of **FA 3** into the conical flask in step 2. Start the stopwatch simultaneously and swirl the mixture thoroughly to mix its contents. This is the reaction mixture.

4. Use a measuring cylinder to add 10 cm^3 of **FA7** into a 100 cm^3 conical flask.

5. Use a teat pipette (dropper) to withdraw a 10 cm^3 aliquot (portion) of the reaction mixture and then transfer it to a 10 cm^3 measuring cylinder.

6. **Immediately** pour this aliquot of the reaction mixture into the 100 cm^3 conical flask and vigorously swirl the mixture. Read and record the time of transfer in minutes and seconds, to the nearest second, when the aliquot is added.

7. **Immediately** titrate the iodine formed in the 100 cm^3 conical flask with **FA8** until the solution turns pale yellow. Add 10 drops of starch indicator to 100 cm^3 conical flask and the solution will turn blue-black. Continue the titration until the blue-black colour just disappears.

8. Wash out the 100 cm^3 conical flask with water.

9. Quickly repeat steps 4 to 8 until a total of **five** aliquots have been titrated.

10. In the space provided below, prepare a table and records the following for each aliquot
    - the time of addition of **FA 7**, *t*, in minutes and seconds
    - the decimal time, t_d, in minutes, to 0.1 min, for example, if *t* = 4 min 33 s then t_d = 4 min + 33/60 min = 4.6 min
    - the burette readings and the volume of **FA 8** added

Results

time of transfer, *t*	time of transfer, t_d / min	Initial burette reading /cm^3	Final burette reading /cm^3	$V_{FA\ 8}$ /cm^3
2 min 0 s	2.0	0.00	42.80	42.80
5 min 0 s	5.0	0.00	24.80	24.80
8 min 0 s	8.0	24.80	39.30	14.50
11 min 0 s	11.0	0.00	8.80	8.80
14 min 0 s	14.0	8.80	13.90	5.10

[4]

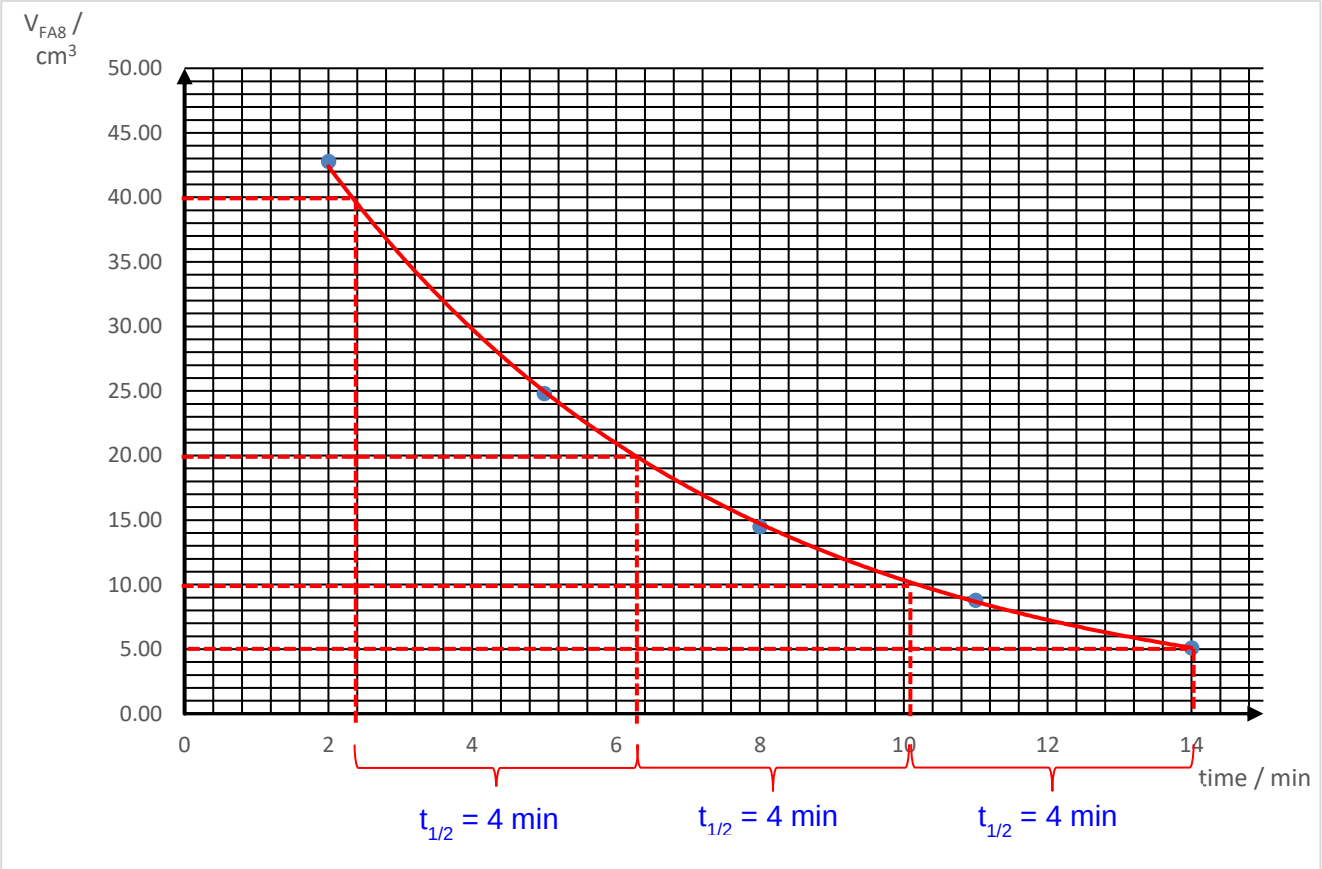
(ii) Explain why a large excess of **FA 4** was added in step 2 of the procedure.

- A large excess of $C_2O_4^{2-}$ was used so that its **concentration remains almost constant (pseudo zero order reaction w.r.t. $C_2O_4^{2-}$)** during the experiment.

[1]

(iii) Plot a graph of the volume of **FA8** on the y−axis, against decimal time, t_d, on the x−axis on the grid below**.**

Draw the most appropriate best−fit curve taking into account all of your plotted points.



[3]

During the experiment, **FA 7** was added to aliquots of the reaction mixture to stop the reaction. The reaction stops because **FA 7** reacts with all the MnO_4^- present in the aliquot. The I_2 evolved is then titrated with **FA 8**.

(iv) State and explain the relationship between the concentration of MnO_4^- and volume of **FA 8** in this experiment.

- Concentration of MnO_4^- is **proportional** to V_{FA8}.
  This is because the **amount or concentration of MnO_4^-** is **proportional to the amount or concentration of iodine**, which is in turn **proportional to the volume of $S_2O_3^{2-}$ since the volume of each aliquot is the same.**

[1]

(v) It has been claimed that the reaction is first order with respect to MnO_4^-.

State whether you agree or disagree with this claim. Use evidence from your graph to support your answer.

- **I agree with the claim.**
  From the graph, time needed for $V_{FA\ 8}$ to fall from 40 cm^3 to 20 cm^3, from 20 cm^3 to 10 cm^3 and from 10 cm^3 to 5 cm^3 is about 4 min. Hence the reaction has a constant half−life.

[2]

(b) The uncertainty associated with a burette reading is ± 0.05 cm^3. Calculate the percentage uncertainty of your least accurate titre obtained in experiment **(a)**.

$$\%\ \boldsymbol{uncertainty} = \frac{2(0.05)}{\boldsymbol{smallest}\ V_{FA7}} \times 100 = \frac{2(0.05)}{0.50} \times 100 = 20\%$$

[1]
[Total: 13]

3 Qualitative analysis

(a) **FA 9** is a double salt which contains two cations and a single anion from those listed in the Qualitative Analysis Notes on pages 15 and 16.

Carry out the following tests carefully and record your observations in **Table 3.1**.

Unless otherwise stated, the volumes given below are approximate and should be estimated rather than measured. Test and identify any gases evolved.

Table 3.1

test	observations
(i) Place a spatula full of **FA 9** into a **dry** boiling tube. Heat the boiling tube gently and then strongly. Test for any gas evolved.	• **On gentle heating, green solid turned white. Water condensed on the sides of the boiling tube.** • **On strong heating, (white) solid turned yellow. NH_3 gas evolved turned damp red litmus blue.**
Place a small spatula of **FA 9** into a new boiling tube. Add about 6 cm depth of water to dissolve the solid. Use portions of this solution, aqueous **FA 9**, for tests **(ii)** – **(iv)**.	

test	observations
(ii) To a 1 cm depth of aqueous **FA 9** in a test−tube, add aqueous sodium hydroxide. Allow to stand.	• **Green ppt, insoluble in excess NaOH(aq).** **Green ppt turned brown on standing (in air).**
(iii) To a 1 cm depth of aqueous **FA 9** in a test−tube, add dilute nitric acid followed by aqueous barium nitrate.	• **No gas evolved on adding HNO_3.** **White ppt formed with $Ba(NO_3)_2$.**
(iv) To a 1 cm depth of aqueous **FA 9** in a test−tube, add 5 drops of **FA 4** and shake the mixture. Add dilute H_2SO_4 to the mixture.	• **Colourless solution turned yellow.** • **Yellow solution turned colourless (or decolourised).**

[6]

(b) Identify the two cations and the single anion in **FA 9** from your observations.

Cations: • **NH_4^+ and Fe^{2+}** Anion: • **SO_4^{2-}** [2]

(c) Suggest an explanation for your observations in test **(ii)**, in terms of the chemical changes occurring and identity of products formed. [2]

$Fe^{2+}(aq) + 2OH^-(aq) \rightleftharpoons Fe(OH)_2(s)$

- **Green ppt. of $Fe(OH)_2$ is formed when its ionic product exceeded the K_{sp} value.**
- **$Fe(OH)_2$ is oxidised by O_2 in the air to brown $Fe(OH)_3$ on standing as the reaction has a positive cell potential.**

(d) A student claimed that **FA 9** contains an ion which is a reducing agent.

(i) Describe a test, using only the bench reagents provided, which will allow you to verify the claim made by the student. [1]

- **To 1 cm depth of FA 9, add a few drops of $H_2SO_4(aq)$, followed by an equal volume of $KMnO_4(aq)$.**

(ii) Perform the test you have described in **(d)(i)**. Record and use your observations to explain whether the claim made by the student is correct. [1]

- **Purple $KMnO_4$ decolourised / Purple solution turned yellow. The student is correct. FA 9 contains a reducing agent which reduced MnO_4^- to Mn^{2+}.**

(e) Investigation of some reactions of FA 10

FA 10 is a neutral organic compound with 2 functional groups. It has a molecular formula $C_9H_9NO_2$ and it can form intramolecular hydrogen bonding.

The following tests, **(i)** to **(iv)** have been carried out on **FA 10** and their observations are recorded in **Table 3.2**.

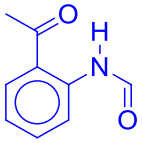
Table 3.2

test	observations
(i) To 2 cm^3 of 2,4−DNPH, add 3 drops of **FA 10**.	An orange precipitate is formed
(ii) To 5 drops of **FA10**, add 5 drops of iodine solution. Then add dilute sodium hydroxide until the colour of iodine is discharged. Warm in a water bath.	A pale yellow ppt is formed.
(iii) To a 1 cm depth of aqueous silver nitrate in a test−tube, add a few drops of aqueous sodium hydroxide and then add aqueous ammonia slowly until the grey precipitate that forms just dissolves. To this solution, add 1 cm depth of **FA 10** and leave to stand in a warm water bath.	No observable change
(iv) To a 2 cm depth of **FA 10**, add an equal volume of HC*l*(aq). Heat the solution.	Two immiscible layers formed. A homogeneous solution is obtained.

(f) State and explain the chemical change iodine underwent during the reaction in test **(ii)**.

- **Iodine undergoes reduction. Oxidation state of iodine is reduced from 0 in I_2 to —1 in iodide and CHI_3.** [1]

(g) Based on the information given above, deduce a structure for **FA 10**, and give 3 pieces of evidence from the observations in **Table 3.2** to explain your deduction, including the chemistry of the reactions.

- **FA 10 has a ketone which undergoes condensation with 2,4−dinitrophenylhydrazine in test (i) to give an orange precipitate.**
- **FA 10 has either $CH_3CO–$ or $CH_3CH(OH)–$ since oxidative cleavage occurred in test (ii) to form iodoform (pale yellow ppt.)**
- **FA 10 does not have aldehyde since there is no silver formed in test (iii).**
- **FA 10 contains amide which undergoes acid hydrolysis in test (iv) to form a soluble compound.**
- **FA 10 is** 

[4]
[Total: 17]

4 **Planning**

There are four colourless solutions, labelled as **A1, A2, B1** and **B2.**
A1 and **A2** could be 1.0 mol dm^{-3} H_2SO_4 or 2.0 mol dm^{-3} H_2SO_4.
B1 and **B2** are either 1.0 mol dm^{-3} NaOH or 1.0 mol dm^{-3} $Ba(OH)_2$.

(a) By using only the chemicals above, suggest how $Ba(OH)_2$ can be identified. Support your answer with the aid of an equation including state symbols.
Do not carry out this experiment.

- **Add a few drops of A1 (or A2) to 2 cm^3 of B1. Repeat this with B2. The solution which gives a white precipitate is $Ba(OH)_2$.**
- **$Ba(OH)_2(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s) + 2H_2O(l)$**

[2]

Heat is evolved when dilute H_2SO_4 and aqueous NaOH are mixed. The maximum temperature change of the mixture depends on the amount of water formed and its total volume. Using appropriate volumes of reagents, the maximum temperature change can be used to identify the two solutions, **A1** and **A2**.

(b) Write a balanced equation for the complete reaction of aqueous H_2SO_4 and aqueous NaOH.

- **$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$**

  Or $NaOH(aq) + \frac{1}{2} H_2SO_4(aq) \rightarrow \frac{1}{2} Na_2SO_4(aq) + H_2O(l)$

[1]

(c) Plan an investigation to identify **A1** and **A2** by determining the maximum temperature change, ΔT_{max} when the two acids, **A1** and **A2** are separately neutralised by aqueous sodium hydroxide.

The total volume of the resultant mixture should be constant for all experiments.

You may assume that you are only provided with:

- 250 cm^3 of 1.0 mol dm^{-3} NaOH(aq)
- 250 cm^3 of 1.0 mol dm^{-3} H_2SO_4(aq)
- 250 cm^3 of 2.0 mol dm^{-3} H_2SO_4(aq)
- a thermometer
- Styrofoam cup
- common apparatus in the laboratory

Note: No pH indicators are provided.

In your plan, you should include brief details of:

- the apparatus you would use,
- the quantities of reagents you would use,
- the procedure you would follow and the measurements you would make,
- how you would determine the identity of **A1** and **A2.**

Assume that 4.18 J of heat energy raises the temperature of 1.0 cm^3 of the mixture by 1.0 °C.

Procedure:

1. **Using a measuring cylinder, transfer 20 cm^3 of A1 into the dry Styrofoam cup provided and record its initial temperature, T_{A1}.**

2. **Using another measuring cylinder, measure 80 cm^3 of NaOH and record its initial temperature as T_{NaOH}.**

3. **Add 80 cm^3 of NaOH into the Styrofoam cup containing A1 quickly, stirring the solution with the thermometer and record the highest temperature, T_f reached.**

4. **Maximum temperature rise, $\Delta T_{max} = T_f - T_i$**

5. **Rinse and dry the cup.**

6. **Repeat steps 1 to 5, replacing A1 with A2.**

Identification of A1 and A2:

Determine the weighted average initial temperature, given by T_i = $\dfrac{20T_{A1} + 80T_{NaOH}}{100}$

$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

H_2SO_4 is the limiting reagent in both experiments, heat evolved will be doubled when twice the amount of water is produced.

Heat evolved = $mc\Delta T_{max}$

Since total volume is constant, heat evolved α ΔT_{max}

When 2 mol dm^{-3} H_2SO_4 is used, ΔT_{max} should be doubled. Hence A1 and A2 can be identified.

[6]

(d) Show how the enthalpy change of neutralisation, ΔH_{neu} can be calculated from the data of one of the experiments in your plan.

Heat evolved= $mc\Delta T$
= 100 x 4.18 x ΔT_{max}
= $418\Delta T_{max}$ J

Amount of water = $20 \times 10^{-3} \times 1.0 \times 2$
= 4.00×10^{-2} mol

$\Delta H_{neu} = -mc\Delta T / n_{water}$

$= -\dfrac{418\Delta T_{max}}{4.00 \times 10^{-2}}$

$= -10450\Delta T_{max}$ J mol^{-1}

[2]

(c) Explain whether the enthalpy change of neutralisation will be more exothermic, less exothermic or remain the same in the following situations:

(i) hydrochloric acid was used instead of sulfuric acid;

Enthalpy change of neutralisation is the same since both are strong acids and so are fully dissociated in water.

[1]

(ii) ethanedioic acid was used instead of sulfuric acid.

- **Enthalpy change of neutralisation is less exothermic for $H_2C_2O_4$. Ethanedioic acid is a weak acid and is only partially dissociated in waer. Part of the energy is used to dissociate ethanedioic acid completely during neutralisation.**

[1]
[Total:13]

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

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 → (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