NATIONAL JUNIOR COLLEGE
SH 2 Year − End Practical Examination
Higher 2

CANDIDATE NAME	

SUBJECT CLASS		REGISTRATION NUMBER	

CHEMISTRY

9729/04

Paper 4 Practical

Wednesday 28 August 2024

Candidate answer on the Question paper.

2 hours 30 minutes

READ THESE INSTRUCTIONS FIRST

Write your identification number and name.
Give details of the practical shift and laboratory where appropriate, in the boxes provided.
Write in 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 21 and 22.

The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's use	
1	/ 14
2	/ 20
3	/ 12
4	/ 9
Total	/ 55

This paper consists of **22** printed pages including this cover page.

1 Determination of a value for an enthalpy change of solution Via Hess's Law.

FA 1 is solid sodium hydrogencarbonate, $NaHCO_3$.
FA 2 is 1.00 mol dm^{-3} sulfuric acid, H_2SO_4.

Sodium hydrogencarbonate dissolves in water according to equation 1.

equation 1 $NaHCO_3(s) + aq \rightarrow Na^+(aq) + HCO_3^-(aq)$ ΔH_1

Both solid and aqueous sodium hydrogencarbonate react with sulfuric acid.

equation 2 $2NaHCO_3(s) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l) + 2CO_2(g)$ ΔH_2

equation 3 $2NaHCO_3(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l) + 2CO_2(g)$ ΔH_3

In this question, you will perform an experiment to determine a value for ΔH_2. You will use data provided to calculate ΔH_3 and hence a value for ΔH_1.

(a) Determination of the molar enthalpy change of reaction, ΔH_2

In this experiment, you will determine the maximum temperature change when a known mass of solid sodium hydrogencarbonate, **FA 1**, reacts with excess dilute sulfuric acid, **FA 2**.

In an appropriate format in the space provided on page 3, prepare tables in which to record for your experiment:

- all weighings to an appropriate level of precision,
- all values of temperature, T, to an appropriate level of precision.

Procedure

1. Weigh the capped bottle containing **FA 1**. Record this mass.
2. Place one polystyrene cup inside another polystyrene cup and place both in a glass beaker.
3. Use a 50 cm^3 measuring cylinder to transfer 30.0 cm^3 of **FA 2** into the polystyrene cup.
4. Stir the **FA 2** in the polystyrene cup with the thermometer. Read and record its initial temperature, T_i.
5. Slip the thermometer through the lid. Carefully transfer all the solid **FA 1** in the bottle to the **FA 2** in the polystyrene cup, in small portions, to avoid too much frothing. Secure the lid onto the cup.
6. Use the thermometer to stir the mixture. Observe the temperature until it shows the maximum change from the initial temperature. Record this temperature, T_m.
7. Reweigh the empty capped bottle. Record this mass.

Determine the maximum temperature change, ΔT, and the mass of **FA 1** used.

Results

mass of capped bottle / weighing bottle and **FA 1** / g	9.391
mass of capped bottle and residual **FA 1** OR mass of weighing bottle after transfer / g	5.465
mass of **FA 1** used / transferred / g	3.926

T_i / °C	31.2
T_m / °C	24.6
ΔT / °C	–6.6

[5]

(b) In the following calculations, you should assume that the specific heat capacity of the solution is 4.18 J g^{-1} K^{-1}, and the density of the solution is 1.00 g cm^{-3}.

(i) Use your results from **1(a)** to calculate the heat change for your experiment.

heat change (q_1) = $mc\Delta T$

= (30 x 1.00) x 4.18 x (temp drop)

= – ________ J

Ignore sign

heat change = ... [1]

(ii) Hence, determine a value for ΔH_2.

Include the sign of ΔH_2 in your answer.

[A_r: H, 1.0; C, 12.0; O, 16.0; Na, 23.0] M_r of $NaHCO_3$ = 84.0

$$\Delta H_2 = -\frac{q_1}{amt\ of\ NaHCO_3} \times 2$$

= + _______ J mol^{-1} or kJ mol^{-1} *with correct sign*

ΔH_2 = ... [1]

The results of an experiment where a solution of 0.690 mol dm^{-3} aqueous sodium hydrogencarbonate, $NaHCO_3(aq)$ was reacted completely with an excess of dilute sulfuric acid, **FA 2**, are shown in Table 1.1.

Table 1.1

volume of $NaHCO_3(aq)$ used / cm^3	50.0
initial temperature of $NaHCO_3(aq)$ / °C	27.6
volume of **FA 2** used / cm^3	25.0
initial temperature of **FA 2** / °C	31.2
minimum temperature / °C	28.4

(iii) Use the results given in Table 1.1 and the formula below to calculate the weighted average initial temperature, T_{av}, of the reaction mixture.

The formula for T_{av} is given as

$$T_{av} = \frac{(\text{vol. of } \textbf{FA 2} \times \text{initial temp. of } \textbf{FA 2}) + (\text{vol. of } NaHCO_3 \times \text{initial temp. of } NaHCO_3)}{\text{total volume of reaction mixture}}$$

$$T_{av} = \frac{(25 \times 31.2) + (50 \times 27.6)}{(25+50)} = 28.8\ °C$$

T_{av} = ... [1]

(iv) Hence, calculate a value for ΔH_3.

heat change (q_2) = $mc\Delta T$

= (25+50) x 1.00 x 4.18 x ($\lvert 28.4 - 28.8 \rvert$)

= 125.4 J [1]

n($NaHCO_3$) = $\frac{50}{1000} \times 0.69$ = 0.0345 mol

ΔH_3 = + (125.4 / 0.0345) x 2

= + 7269.6

= + 7270 J mol^{-1} or + 7.27 kJ mol^{-1} [1]

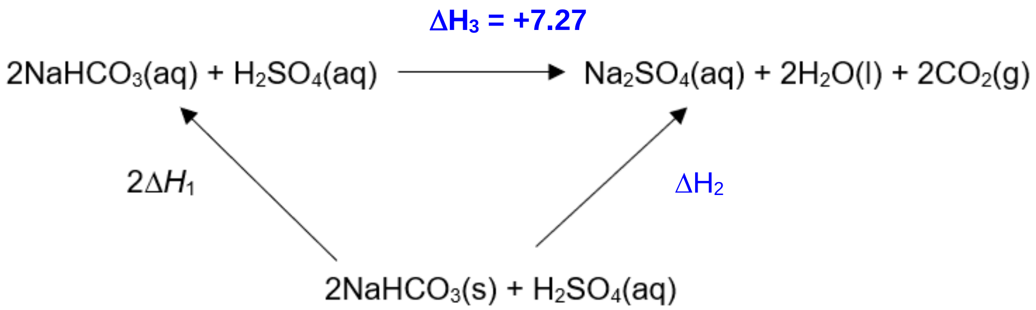
Final answer to 3 s.f. or 4 s.f. and

appropriate units for **(b)(i)**, **(b)(ii)**, **(b)(iii)**, **(b)(iv)** and **(c).** [1]

ΔH_3 = ... [4]

(c) Use your answers from **1(b)(ii)** and **1(b)(iv)** to calculate a value for ΔH_1 for the reaction shown in equation 1.

If you are not able to determine a value for **1(b)(ii)** and/or **1(b)(iv)**, you may use x and y to represent the respective enthalpy changes and proceed with this part of the question.



ΔH_1 = [$\Delta H_2 - \Delta H_3$] ÷ 2

= ________ J mol^{-1} or kJ mol^{-1}

[1]: correct application of Hess' Law

ΔH_1 = ………………………………………. [2]

[Total: 14]

2 To determine the order of reaction with respect to the concentration of iodine in the iodination of propanone reaction

FA 2 is 1.00 mol dm^{-3} sulfuric acid, H_2SO_4.
FA 3 is 1.00 mol dm^{-3} propanone, CH_3COCH_3.
FA 4 is an aqueous solution of iodine, I_2.
FA 5 is 0.0100 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
FA 6 is 0.50 mol dm^{-3} sodium hydrogencarbonate, $NaHCO_3$.

You are also provided with a starch indicator.

The equation in reaction 1 represents the reaction between CH_3COCH_3 and I_2.

reaction 1: $CH_3COCH_3(aq) + I_2(aq) \xrightarrow{H^+} CH_3COCH_2I(aq) + HI(aq)$

This reaction is first order with respect to both CH_3COCH_3 and H^+ ions.

You are to investigate the order of reaction with respect to I_2.

A reaction mixture containing an acidified solution of CH_3COCH_3 and I_2 is first prepared. At timed intervals, aliquots (portions) of this reaction mixture will be removed and quenched using excess $NaHCO_3$.

It is **not** essential that you complete the titration of one aliquot before extracting the next one from the reaction mixture.

The remaining amount of I_2 at different times can then be determined by titration against $Na_2S_2O_3$. $Na_2S_2O_3$ reacts with I_2 as shown in the equation in reaction 2.

reaction 2: $2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$

The required order of reaction can be obtained by graphical analysis of your results.

(a) Preparing and titration of the reaction mixture

Notes:
You will perform each titration **once** only. Great care must be taken that you do not exceed the end–point.

Once you have started the stopwatch, it must continue running for the duration of the experiment. You must **not** stop the stopwatch until you have finished this experiment.

You should aim to transfer your first aliquot approximately four minutes after starting the reaction.

You should aim **not** to exceed a maximum reaction time of 20 minutes for this experiment.

In an appropriate format in the space provided on page 8, prepare a table in which to record for each aliquot

- the time of transfer, *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 5** added.

Question 2 continues on the next page.

Safety:
Propanone is flammable. Transfer your titrated solutions into the **waste** bottle for later disposal. Keep this bottle stoppered when not in use.

Keep the conical flask labelled **reaction mixture** stoppered except when removing aliquots.

1. Fill a burette with **FA 5**.

2. Using a 25 cm^3 measuring cylinder, add the following to a 100 cm^3 beaker.
    - 25.0 cm^3 of **FA 2**
    - 25.0 cm^3 of **FA 3**

3. Using a 100 cm^3 measuring cylinder, transfer 50.0 cm^3 of **FA 4** into the 250 cm^3 conical flask, labelled **reaction mixture.**

4. Pour the contents of the 100 cm^3 beaker into this 250 cm^3 conical flask. Start the stopwatch, **insert the stopper** and swirl the mixture thoroughly to mix its contents.

5. Using a 10 cm^3 measuring cylinder, measure 10.0 cm^3 of **FA 6** into a second conical flask.

6. At approximately 4 minutes, using a 10.0 cm^3 pipette, remove a 10.0 cm^3 aliquot of the reaction mixture. **Immediately** transfer this aliquot into the second conical flask containing **FA 6** and swirl the mixture thoroughly.

    Note the time of transfer, *t*, to the nearest second, when half of the reaction mixture has been dispensed from the pipette. Replace the stopper in the reaction flask.

7. Titrate the iodine in the second conical flask with **FA 5**. When the colour of the solution turns pale yellow, add about 1 cm^3 of starch indicator. The solution will turn blue–black. The end–point is reached when the blue–black colour just disappears. Record your results.

8. Empty the contents of this conical flask into the waste bottle. Wash this conical flask thoroughly with water.

9. Repeat steps 5 to 8 until a total of **five** aliquots have been titrated and their results recorded.

Correct header with units

Include for transfer time, in min and s for each entry

t	t_d/ min	initial burette reading / cm^3	final burette reading / cm^3	Volume of **FA 6** / cm^3
4 min 18 s	4.3	0.00	17.40	17.40
8 min 2 s	8.0	18.00	34.30	16.20
12 min 0 s	12.0	30.00	44.90	14.90
16 min 0 s	16.0	0.00	13.70	13.70
20 min 0 s	20.0	14.00	26.40	12.40

Records **all**

- volumes to 0.05 cm^3
- transfer time, *t*, to consistent precision, i.e. nearest s
- correctly calculates decimal values of t_d and records to 1 d.p 1m

Do NOT award this mark if any final and initial burette readings are inverted or 50 is used as the initial burette.

5 sets of titration results and 1 aliquot is taken at between 3.5 min to 5 min (±30s) and student choses well–spaced values of time of transfer, where the longest time ≤ 20 min 1m

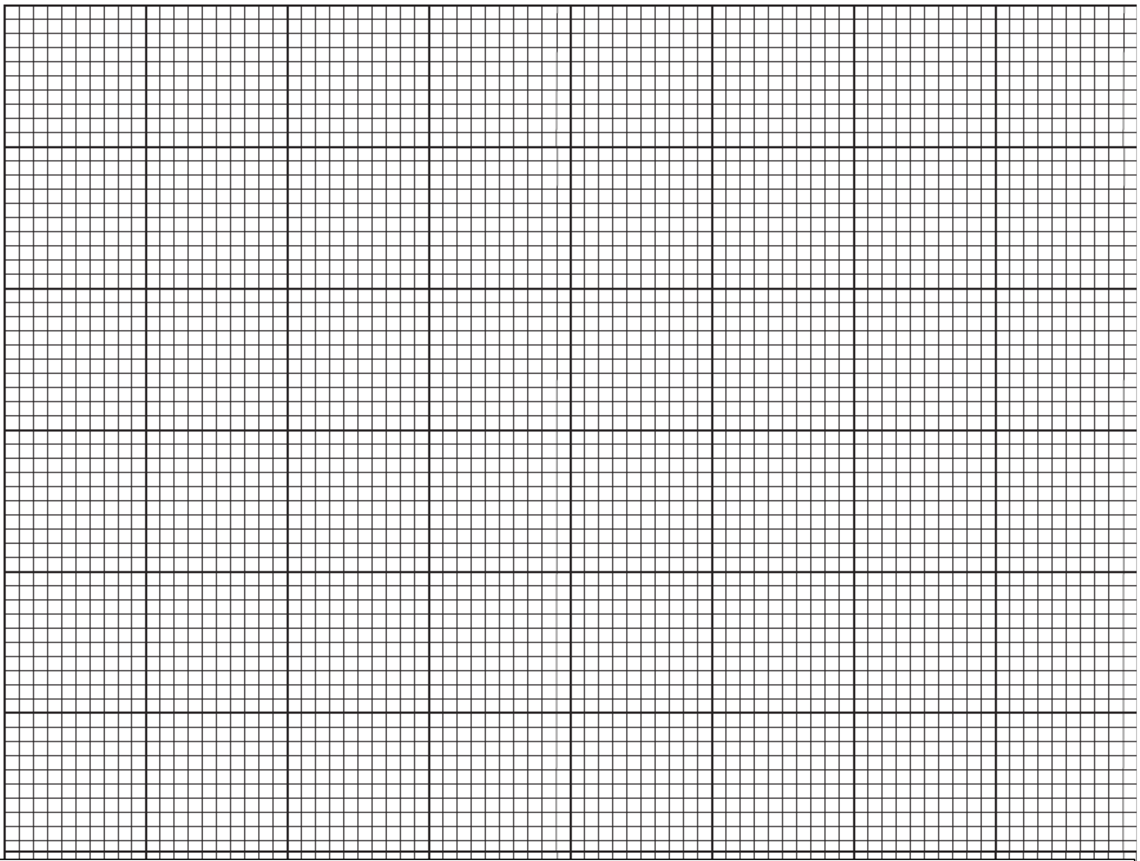
*Do **not** award this mark if any titres remain the same or rise as t_d increases.*

***Do not** allow this mark if there are any arithmetical errors in the table in calculating titres.*

[3]

(b) **(i)** On the grid in Fig. 2.1, plot a graph of the volume of **FA 5** added, on the *y*–axis, against decimal time, t_d, on the *x*–axis.

Draw the best–fit line taking into account all of your plotted points. Extrapolate (extend) this line to t_d = 0.0 min.



Axes correct way round **+** correct labels **+** scale + units the scale must be chosen so that the *y intercept* would fall within the scale range; **and**, that the plotted points occupy at least half the graph grid in the *x direction* (including x = 0) and the plotted points and the *y intercept* together occupy at least half the graph grid in the *y* direction.	1
Plotting – within ±½ small square. Check all points; put ticks if correct.	1
Graph line is straight and is the best-fit line. *Judge best-fit by scatter of points about the candidate's line, there must be a fair scatter of points either side of the line.*	1
At least four points are within ± 0.50 cm^3 (volume of **FA 6**) of straight-line graph; allow 1 outlier *DO NOT allow if more than one point is misplotted.*	1

Fig. 2.1

[4]

(ii) Deduce the order of reaction with respect to the $[I_2]$ in reaction 1. Explain your answer.

order……………………………………………………………………………………………

explanation……………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………… [1]

Student deduces the order with respect to $[I_2]$ to be **zero**

as graph line is straight OR gradient of the graph is constant, so **no change in rate as $[I_2]$ decreases.**

Do not allow this mark if the graph line is not straight.

(iii) Calculate the gradient of the line, showing your working clearly on the graph.

Clear indication of **correct** co-ordinates from graph **or** correct values of *volume* and of *time* used (read to ± ½ small square) **and** triangle drawn should be at least half the number of grids in x & y direction of the line drawn. Use darker pencil. 1

gradient correctly calculated (ignore sig figs for this mark).
(ECF if coordinates read off wrongly)
*Do not award this mark if coordinates, or volume and time values not given **or** if graph not straight line. Ignore missing working and incorrect/missing units.* 1

gradient = ………………………$cm^3\ min^{-1}$ [2]

(iv) The y–intercept of your line gives the volume of sodium thiosulfate required to completely react with the iodine present if an aliquot is taken at $t_d = 0.0$ min.

Read from your graph and record this volume of **FA 5**, $\boldsymbol{V_{max}}$. Use this value to calculate the concentration of iodine in **FA 4**.

volume of **FA 5**, $\boldsymbol{V_{max}}$ = …………………..cm^3

Line correctly extrapolated to meet *y*-axis. 1
and
$\mathbf{V_{max}}$ correctly read from intercept to within ± ½ small square

$nS_2O_3^{2-} = \mathbf{V_{max}} \times 10^{-3} \times 0.0100 = a$ mol 1
nI_2 (in 10 cm^3) = ½ a mol
nI_2 (in 100 cm^3 of **reaction mixture** / in 50 cm^3 of **FA 5**) = (½ a) × 10 = b mol
$[I_2]$ in **FA 5** = b × 1000/50 mol dm^{-3} 1

concentration of iodine in **FA 4** = ……………………mol dm^{-3} [3]

(c) Use the information provided on page 6 and your answer to **2(b)(ii)**, write an expression for the rate equation for reaction 1. Include the units for rate in your answer.

Rate = ……………………………………………………………………………… [2]

$rate = k[CH_3COCH_3][H^+]$
units for rate = mol dm^{-3} s^{-1}; *mol dm^{-3} min^{-1}*
allow ecf if student deduces order with respect to iodine to be other than zero
A lot of students thought that the qn is asking for the units of rate constant k.

(d) In step 6 of the experimental procedure, the aliquot is transferred into the second conical flask containing **FA 6**.
Explain why it is necessary to add **FA 6**, and how the titre values will be affected with the omission of **FA 6**.

FA 6 helps to quench the reaction by removing H^+ catalyst.

Omission of it will result in the further reaction of the iodine with propanone, causing titre value to be lower than actual.

[2]

(e) Suggest how you would carry out a modified experiment of the one that you performed in **2(a)** to verify the order with respect to propanone.
On the axes in Fig. 2.2, sketch the graph you have obtained in **2(b)(i)** and the graph you would expect to obtain from the modified experiment. Label both graphs clearly.

Explain your answer.

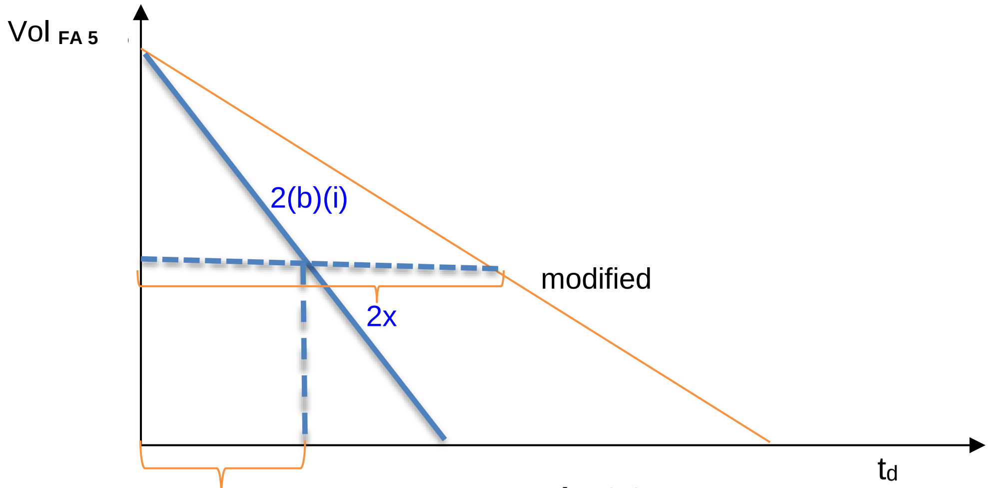


Fig. 2.2

Modification Use the same procedure and same volume for all solutions except for **FA 3** (propanone), where only 12.5 cm^3 of **FA 3** is added, top up to 25.0 cm^3 with deionised water. (to keep total volume constant)

explanation Gradient of the new graph is halved of the original since rate is proportional to the conc of propanone (1st order wrt propanone as given in Q2 pg 6, for the same change in $[I_2]$, modified expt takes double the time)

[3]

3 Qualitative Analysis

FA 7 is a solid oxide of an unknown metal cation **Z**. This oxide has an M_r **not** exceeding 140.

[A_r of *Al*: 27.0; Ba: 137.3; Ca: 40.1; Cr: 52.0; Cu: 63.5; Fe: 55.8; Mg: 24.3; Mn: 54.9; O: 16.0; Zn: 65.4]

FA 8 is solid potassium ethanedioate, $K_2C_2O_4$.

FA 9 is an aqueous organic compound containing one functional group.

You will perform tests to determine:

- the metal cation **Z** in **FA 7**
- the functional group present in **FA 9**

(a) Perform the tests described in Table 3.1, and record your observations in the table. Test and identify any gases produced.

Table 3.1

test	observations
(i) Add all of the solid **FA 8** into a test tube. Add 15 cm^3 of **FA 2** into this test tube. Using a hot water bath, gently warm the mixture in the test tube until all solid dissolves.	1. White solid dissolves to give a colourless solution.
(ii) Add a spatula of **FA 7** to the mixture. Filter the mixture into another test tube.	*2.* Effervescence/bubbles of gas *3.* Gas gives white ppt when bubbled through limewater. Gas is CO_2. *4.* Black residue *5.* Colourless/pale pink/yellow filtrate
(iii) To 1 cm depth of the filtrate in a test tube, add aqueous sodium hydroxide dropwise, until in excess.	*6.* Filtrate gives off-white/light brown ppt with NaOH(aq) *7.* Ppt is insoluble in excess *8.* Ppt rapidly turns brown on contact with air

[4]

(b) Write an equation that explains the observation to the chemical test carried out on the gas evolved in test **(a)(ii)**.

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

……………………………………………………………………………………………………[1]

(c) What is the chemical role of **FA 7** in the reaction between **FA 7** and **FA 8**? Support your answer using your observations from Table 3.1.

Oxidising agent, as ethanedioate/ethanedioic acid was oxidised to carbon dioxide.

…………………………………………………………………………………………… [1]

(d) **(i)** Identify the cation in the filtrate, using your observations from Table 3.1.

Mn^{2+}, as off-white ppt rapidly turns brown on contact with air, insoluble in excess NaOH. (from test (iii))

…………………………………………………………………………………… [1]

(ii) Hence, suggest the formula of the oxide of **Z** in **FA 7** and explain your reasoning by referring to your answer in **(c)** and the information provided on page 12.

1m: MnO_2

1m: FA 7 acted as an oxidising agent, so itself must have been reduced from a higher oxidation state to Mn^{2+},

MnO_2, the oxide with Mn in +4 oxidation state, has M_r = 86.9,

which is less than 140. [2]

(e) You are provided with an organic solution **FA 9** which contains one functional group.

Care: FA 9 is flammable. Do not use Bunsen burner for heating.
Use the hot water provided if heating is required.

FA 9 gives a positive test with 2,4–dinitrophenylhydrazine.

Devise one other confirmatory test using the bench reagents provided to identify the functional group present in **FA 9**.

Carry out the test. Record details of the test performed and observations made in Table 3.2.

Table 3.2

Confirmatory Test	*Observations*
To 1 cm depth of **FA 9** in a test-tube, **add** 1-2 cm depth of **dilute H_2SO_4 and** a few drops of **$KMnO_4$(aq)**. **Heat** in hot water-bath.	**Purple** $KMnO_4$ **decolourised**.
Prep of Tollen's: **To** 1 cm depth of **aqueous $AgNO_3$** in a test-tube, **add** 1 cm depth of **aqueous NaOH**. Then **add aqueous NH_3** until the precipitate just dissolves.	Brown Ag_2O ppt. dissolves to give a colourless solution of $Ag(NH_3)_2^+$(aq).
To this mixture, **add** 1 cm depth of **FA 9**. **Heat** the mixture in the hot water-bath.	A **silver mirror/grey ppt.** is formed.

Functional group present in **FA 9**: ……aldehyde……

[3]

[Total: 12]

4 **Planning**

The labels for a bottle of carbonic acid and a bottle of citric acid were mixed up. Carbonic acid is dibasic and citric acid is tribasic. The reaction between the acid and NaOH can be represented by this general equation

$$H_xA + xNaOH \rightarrow Na_xA + xH_2O, \text{ where } x = 2 \text{ or } 3$$

A series of experiments can be performed where increasing volumes of acid and decreasing volumes of NaOH(aq) are mixed and the temperature rise, ΔT, for each experiment is determined.

In each of the experiments using different volumes of H_xA (aq) and NaOH(aq), the total volume has to be kept constant. Since the total volume of mixture remains the same, the temperature rise, ΔT, is a direct measure of the heat liberated by the reaction. The maximum amount of heat is evolved when all the acid present is exactly neutralised by all the alkali present.

Plotting a graph of ΔT against the volume of H_xA (aq) used will give 2 straight lines of best–fit.

The total volume for each experiment should be kept constant at 60.0 cm^3.

You are to plan a series of **six** experiments so that a graph of ΔT against volume of acid can be plotted to determine the basicity of the acid.

You are provided with:

- 1.00 mol dm^{-3} sodium hydroxide, NaOH
- 1.00 mol dm^{-3} acid from one of the bottles, H_xA
- the equipment normally found in a school or college laboratory.

(a) **(i)** Calculate the volumes of acid required for complete reaction if the acid is dibasic and tribasic respectively.

- As H_xA and NaOH are equal in concentrations, their volume ratio in total volume of 60.0 cm^3 are their mole ratio.
- H_2A req 2 moles of NaOH for complete neutralisation. Hence volume ratio of H_2A : NaOH = 1:2. Thus volume of acid is $\frac{1}{3}$ (60) = 20.0 cm^3.
- H_3A req 3 moles of NaOH for complete neutralisation. Hence volume ratio of H_2A: NaOH = 1:3. Thus volume of acid is ¼ (60) = 15.0 cm^3. [1]

(ii) Using your answers in **(i)**, use the space provided below to tabulate the volumes of acid and NaOH in each experiment.

The intersection of the 2 straight lines likely to occur at either 15.0 cm^3 or 20.0 cm^3, thus there must be sufficient data points before and after this intersection points.

Expt	Vol of acid/ cm^3	Vol of NaOH/ cm^3
1	5.0	55.0
2	10.0	50.0
3	15.0	45.0
4	20.0	40.0
5	25.0	35.0
6	30.0	30.0

[1]

(b) In your plan to determine the basicity of H_xA, you should include brief details of:

- the apparatus you would use;
- the procedure you would follow;
- the measurements you would make to plot ΔT vs vol of acid. [4]

1. Place a clean and dry Styrofoam cup inside another Styrofoam cup placed in a 250cm^3 beaker.
2. Using a measuring cylinder, measure 5.0 cm^3 of acid, H_xA, into the Styrofoam cup.
3. Using another measuring cylinder, measure 55.0 cm^3 of NaOH.
4. Record the initial temperatures of each solution with a thermometer.
5. Pour the NaOH into the Styrofoam cup with H_xA and stir the mixture with the thermometer.
6. Record the highest temperature reached with the thermometer.
7. Wash the Styrofoam cup and dry with a paper towel.
8. Repeat Steps 1 to 6 with the volumes in the table in (a)(iii).

……………………………………………………………………………………………………

1m for logical flow where stating the apparatus is missing from procedure (illogical flow if water is added to make total volume constant b/w expts.

Apparatus [3A = 1 mark]:

- Styrofoam cup x 2 in beaker + lid ,
- measuring cylinder of suitable capacity/burette (volume must have corresponding d.p.) Cannot use pipette as it measures a fixed volume.
- thermometer

Procedure [3P = 1 mark; 0-2P = 0 marks]:

- Pour one of the solutions into a Styrofoam cup,
- Pour the other solution into same Styrofoam cup,
- Stir (with the thermometer)

Measurements [3M = 1 marks; 0-2M = 0 mark]

- Initial temperature of acid
- Initial temperature of NaOH
- Highest temperature reached after mixing

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(b) **(i)** Sketch on Fig. 4.1 you would expect to obtain from your results if the acid is a dibasic acid. Explain your answer.

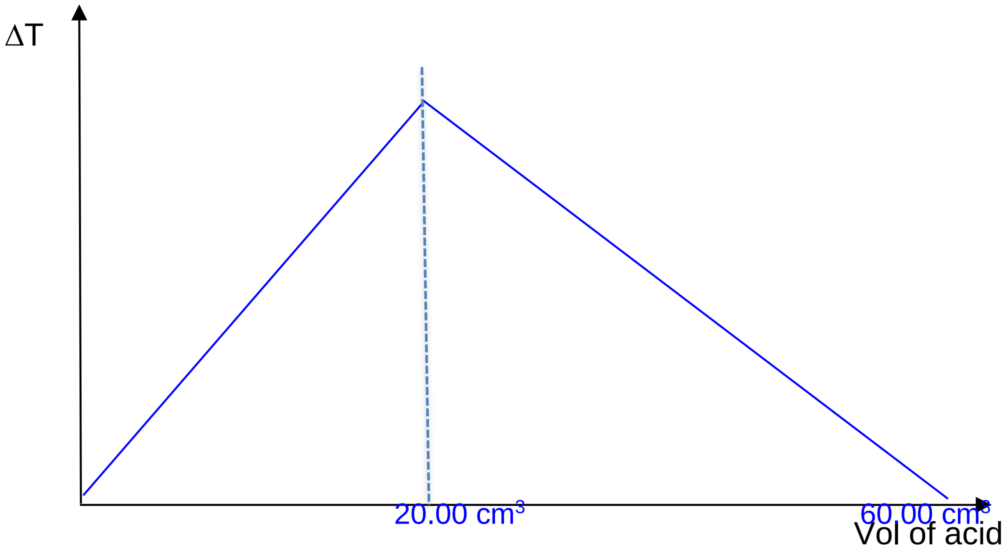

Fig 4.1

Explanation ……………………………………………………………………………………

ΔT should be zero when 0.0 cm^3 and 60.0 cm^3 of acid are added since no reaction can take place when the reaction mixture is 100% acid or NaOH.

For dibasic acid, the ΔTmax should occur at 20.0 cm^3 of acid.

Before ΔTmax, the reaction is limited by acid, thus more heat released with increasing amt of acid.

After ΔTmax, the reaction is limited by NaOH, thus less reaction takes place with decreasing volume of NaOH added.

[2]

(ii) Describe how you would make use of the graph to determine the value of enthalpy change of neutralisation, ΔH_{neut} .

$$\Delta H_{neut} = -\frac{60 \times 4.18 \times \Delta T_{max}}{0.02 dm^3 \times 1 mol dm^{-3} \times 2}$$

where amt of water = 2 x mol of dibasic acid

= mol of NaOH (0.04 x 1)

[1]

[Total: 9]

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 aq. 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