



ANDERSON SERANGOON JUNIOR COLLEGE

2025 JC2 Preliminary Examination

NAME: _____ ()

CLASS: 25 / _____

CHEMISTRY

Paper 4 Practical

9729/04

19 August 2025

2 hours 30 minutes

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number 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.
Quantitative Analysis Notes are printed on pages 19 and 20.

Shift
Laboratory

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.

For Examiner's Use	
1	/ 19
2	/ 18
3	/ 8
4	/ 10
Total	/ 55

This document consists of **19** printed pages and **1** blank page.

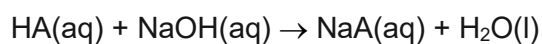
1 Determination of an enthalpy change of neutralisation, ΔH_{neut} , by thermometric titration

The enthalpy change of neutralisation between an acid and an alkali can be determined using thermometric titration. This involves using a fixed volume of alkali with progressive addition of small volumes of acid and monitoring the temperature of the reaction mixture during the process.

FA 1 is an aqueous solution of 1.80 mol dm^{-3} of a monobasic acid, HA.

FA 2 is aqueous sodium hydroxide, NaOH

You are to carry out a thermometric titration to determine the enthalpy change of neutralisation for the reaction given below.



Question continues on Page 4.

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- (a) Prepare a table in the space provided and record, to appropriate level of precision:
- all volumes of **FA 1** added, V
 - the maximum temperature, T , reached after each addition of **FA 1**.

It is important that the volume of **FA 1** recorded is the total volume you have added up to the point when the temperature reading was made.

Note: If you overshoot on an addition, record the actual total volume of **FA 1** added up to that point.

Procedure

1. Place a polystyrene cup inside a second polystyrene cup and place both cups in a glass beaker.
2. Fill the burette with **FA 1**.
3. Use a measuring cylinder to transfer 25 cm^3 of **FA 2** into the polystyrene cup.
4. Stir the **FA 2** solution in the cup gently with the thermometer. Read and record its temperature.
5. Use the burette to add 5.00 cm^3 of **FA 1** into the cup. Stir the mixture gently with the thermometer. Read and record both the maximum temperature and the actual total volume of **FA 1** added.
6. Repeat step 5 until a total of 45.00 cm^3 of **FA 1** has been added. For each addition of **FA 1**, read and record both the maximum temperature and the actual total volume of **FA 1** added up to that point.

Results

- (b) Plot a graph of temperature, T , on the y-axis, against total volume of **FA 1** added, V , on the x-axis on the grid in Fig.1.1. Your scale on the y-axis should allow for extrapolation above the highest temperature recorded.

Draw two lines of best fit, taking into account the points when the temperature of the mixture was rising and the points when the temperature was falling. Each line should have a shape best suited to its plotted points.

Extrapolate (extend) the two lines until they intersect.

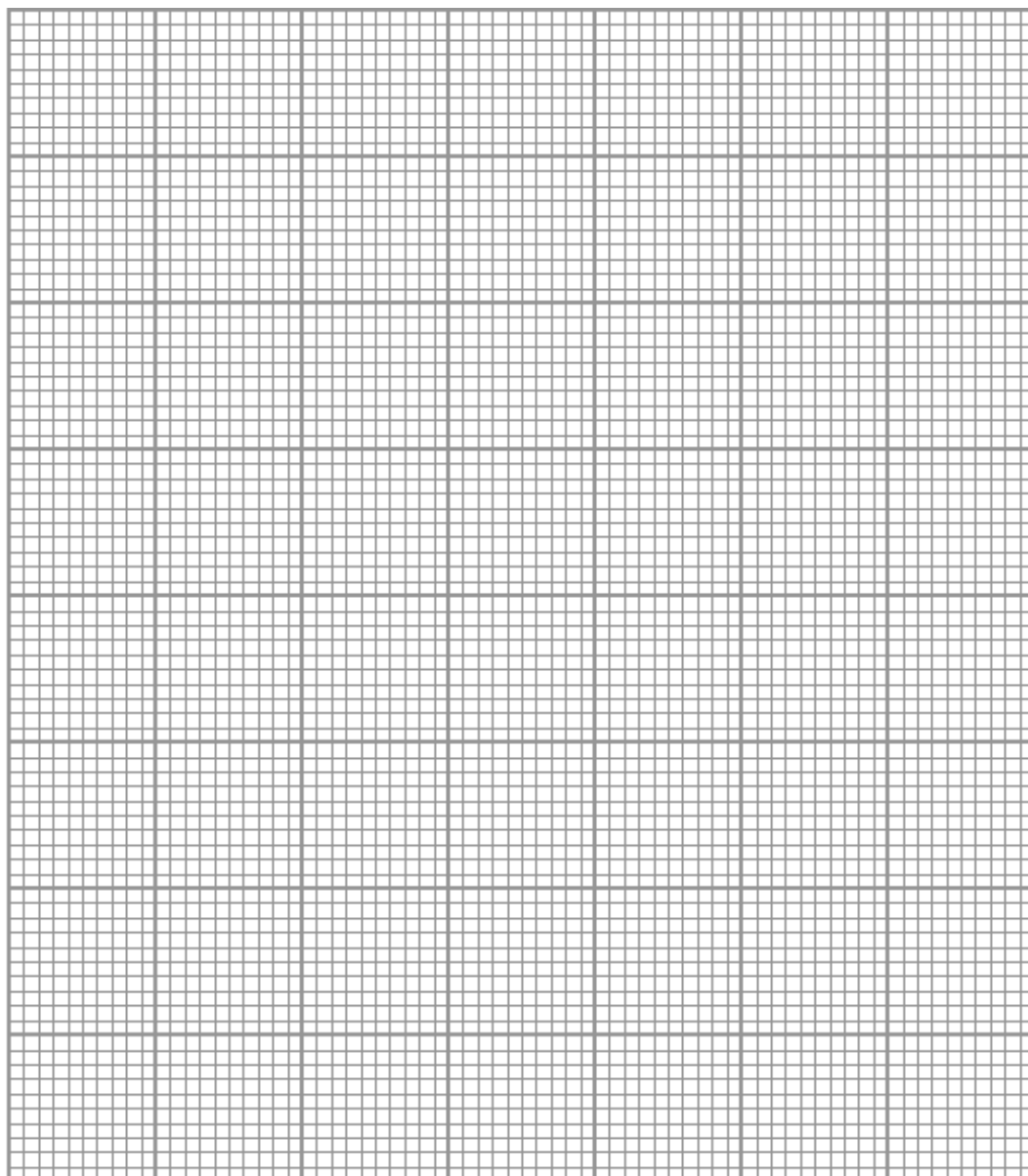


Fig. 1.1

[3]

- (c) From your graph, read the initial temperature of **FA 2**, T_{initial} , and the maximum temperature of the mixture, T_{max} .

Use these values to calculate the temperature change in the reaction, ΔT .

Read the volume of **FA 1** added, V_{neut} , at the maximum temperature of the mixture.

Record all these values below.

$T_{\text{initial}} = \dots\dots\dots$

$T_{\text{max}} = \dots\dots\dots$

$\Delta T = \dots\dots\dots$

$V_{\text{neut}} = \dots\dots\dots$

[4]

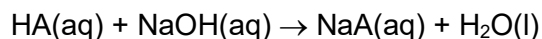
- (d) (i) Using your answers from (c), calculate the heat change, q , when **FA 1** has completely neutralised 25 cm³ of sodium hydroxide.

You should assume that the specific heat capacity of the solution is 4.18 J g⁻¹ K⁻¹, and that the density of the solution is 1.00 g cm⁻³.

$q = \dots\dots\dots$ [2]

- (ii) Calculate the enthalpy change of neutralisation, ΔH_{neut} , for the reaction.

The equation for the reaction is shown.



Include the sign of ΔH_{neut} in your answer.

$\Delta H_{\text{neut}} = \dots\dots\dots$ [4]

- (e) Apart from using a thermometer with a greater level of precision, suggest one improvement that could be made to improve the accuracy of results in (d)(ii).

.....

..... [1]

- (f) A student decided to perform the same experiment in (a) but used aqueous ammonia instead of aqueous sodium hydroxide.

Suggest what effect, if any, would replacing aqueous sodium hydroxide with aqueous ammonia have on the value of enthalpy change of neutralisation calculated in (d)(ii).

effect

.....

explanation

..... [2]

[Total: 19]

2 Determination of the amount of water of crystallisation in sodium sulfite crystals, $\text{Na}_2\text{SO}_3 \cdot x\text{H}_2\text{O}$

FA 3 is an aqueous solution of 126.0 g dm^{-3} of hydrated sodium sulfite with the formula $\text{Na}_2\text{SO}_3 \cdot x\text{H}_2\text{O}$.

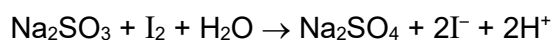
FA 4 is $0.100 \text{ mol dm}^{-3}$ iodine, I_2 .

FA 5 is $0.100 \text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.

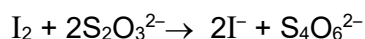
You are also provided with **Solution S**.

Solid sodium sulfite is often provided as the hydrated salt, $\text{Na}_2\text{SO}_3 \cdot x\text{H}_2\text{O}$, where x is an integer.

You will determine the value of x by using a solution of this sodium sulfite salt and reacting it with an excess of aqueous iodine.



The amount of iodine remaining will be determined by titration using a known concentration of sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.



(a) (i) Dilution of **FA 3**

FA 3 is too concentrated and needs to be diluted.

Use a burette to transfer 25.00 cm^3 of **FA 3** into a 100 cm^3 volumetric flask.

Make the solution up to the mark with deionised water. Label this solution **FA 6**.

Titration of **FA 6** against **FA 5**

1. Fill the burette with **FA 5**.
2. Use a pipette to transfer 10.0 cm^3 of **FA 6** into a 250 cm^3 conical flask.
3. Use another pipette to transfer 25.0 cm^3 of **FA 4** into the same conical flask.
4. Swirl the flask to mix the contents.
5. Run **FA 5** from the burette into the conical flask. Near the end-point, when the brown solution becomes pale, add about 1 cm^3 of **Solution S** using a teat pipette.
6. Continue adding **FA 5**. The end-point is reached when the solution first becomes colourless.
7. Record your titration results, to an appropriate level of precision, in the space provided on page 9.
8. Discard the reaction mixture.
9. Repeat steps 2 to 8 until consistent results are obtained.

Titration results

[3]

- (ii) From your titrations, obtain a suitable volume of **FA 5** to be used in your calculations. Show clearly how you obtained this volume.

Volume of **FA 5** =cm³ [3]

- (b) (i) Calculate the amount in moles of iodine present in 25.0 cm³ of **FA 4** added to the conical flask.

amount of iodine added to the conical flask = [1]

- (ii) Use your titration results to calculate the amount of excess iodine after reaction with sodium sulfite in the conical flask. Hence, calculate the amount of iodine that reacted with 10.0 cm³ of **FA 6**.

amount of excess iodine after reaction with sodium sulfite =

amount of iodine that reacted with 10 cm³ of **FA 6** =
[3]

- (iii) Calculate the amount of sodium sulfite present in 25 cm³ of **FA 3**.

amount of sodium sulfite in 25 cm³ of **FA 3** =[2]

- (iv) Determine the value of x in $\text{Na}_2\text{SO}_3 \cdot x\text{H}_2\text{O}$.
 [Ar: H, 1.0; O, 16.0; Na, 23.0; S, 32.1]

$x = \dots\dots\dots$ [4]

- (c) Most of the pipettes used in school or college laboratories have uncertainties (errors) of $\pm 0.03 \text{ cm}^3$.

Calculate the percentage error of the volumes measured by the pipettes you used in (a)(i).

Hence, state how the percentage uncertainty of a volume measured depends on the capacity of the pipette used.

.....

 [1]

- (d) Devise a simple test to confirm the presence of sulfite ions in **FA 3** solution. Your test should be based on Qualitative Analysis Notes on pages 19 - 20. You do **not** need to perform the test.

.....
 [1]

[Total: 18]

3 Organic Analysis

Before starting this analysis, please ensure that your Bunsen burner is turned off.

You are provided with the organic liquid samples of **FA 7**, **FA 8**, **FA 9** and **FA 10** with the molecular formulae shown.

- **FA 7** $\text{C}_3\text{H}_6\text{O}$
- **FA 8** $\text{C}_3\text{H}_6\text{O}$
- **FA 9** $\text{C}_3\text{H}_8\text{O}$
- **FA 10** $\text{C}_3\text{H}_6\text{O}_2$

You will perform some the tests described in Table 3.1.

Using the observations in Table 3.1, and the given molecular formulae, you will then deduce the identities of **FA 7**, **FA 8**, **FA 9** and **FA 10**.

In addition to having access to the usual bench reagents, you are also provided with the following:

- iodine solution, **FA 4**
- Fehling's solution
- 2,4–dinitrophenylhydrazine, 2,4–DNPH
- sodium carbonate

- (a) Perform the tests described in Table 3.1. Some tests have already been carried out and the observations have been recorded in the table. There is no need to carry out those tests.

Test and identify any gases evolved. If there is no observable change, record **no observable change**.

Use a fresh sample of each liquid in each test.

Table 3.1

tests	observations with			
	FA 7, C₃H₆O	FA 8, C₃H₆O	FA 9, C₃H₈O	FA 10, C₃H₆O₂
<p>1. Add 5 drops of organic liquid into a clean test-tube.</p> <p>To this test-tube, add about 1 cm depth of Fehling's solution. Prepare a hot water bath. Warm the mixture for about 2 minutes.</p>	No observable change			No observable change
<p>2. To a 1 cm depth of the organic liquid in a test-tube, add a few drops of 2,4-DNPH.</p>		Orange precipitate observed	No observable change	
<p>3. To a 1 cm depth of aqueous sodium hydroxide in a test-tube, add 1 cm depth of iodine solution, FA 4. Then add three drops of the organic liquid. Shake and warm the test-tube in a water-bath for about 2 minutes.</p>		No observable change		No observable change
<p>4. Place about 1 cm depth of the organic liquid in a test-tube.</p> <p>To this test-tube, add about 1 cm depth of aqueous sodium carbonate.</p>		No observable change	No observable change	
<p>5. Place about 1 cm depth of dilute sulfuric acid in a test-tube. Then add 2 drops of potassium manganate(VII).</p> <p>To this test-tube, add 3 cm depth of organic liquid.</p> <p>Shake and warm the test-tube in a water-bath.</p>	No observable change	Purple KMnO ₄ decolourises	Purple KMnO ₄ decolourises	No observable change

[3]

- (b) Complete Table 3.2, with the identities of **FA 7**, **FA 8**, **FA 9** and **FA 10**.
Give evidence from relevant observations in Table 3.1 to support your conclusions. You should also include deductions of functional groups or structural features for the observations.

Table 3.2

	identity	evidence
FA 7		
FA 8		
FA 9		
FA 10		

[4]

- (c) **FA 11** is an isomer of **FA 10**.
FA 11 is neutral and have a sweet odour.

Suggest a structural formula of **FA 11**.

[1]

[Total: 8]

4 Planning

The activation energy, E_a , for the reaction between dilute hydrochloric acid, $\text{HCl}(\text{aq})$, and aqueous sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$, can be determined by a 'sulfur clock' method.



The solid sulfur formed is seen as a pale-yellow suspension in the reaction mixture. The reactants are mixed and the time taken, t , for a fixed quantity of sulfur to be formed and obscure a laminated insert is recorded.

A measure of the initial rate of the reaction is $\frac{1}{t}$.

The activation energy, E_a , for the reaction may be determined by measuring the time for a fixed quantity of sulfur to obscure a laminated insert at different temperatures.

You may assume you are provided with:

- 600 cm³ glass beaker
- laminated insert
- 65 cm³ 0.100 mol dm⁻³ $\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$
- 65 cm³ 0.500 mol dm⁻³ $\text{HCl}(\text{aq})$
- the equipment normally found in a school or college laboratory

In order to calculate E_a , the following equation is used.

$$\ln\left(\frac{1}{t}\right) = \frac{-E_a}{R} \left(\frac{1}{T}\right) + c$$

where R is the molar gas constant and c is a constant for the reaction.

(a) Plan an experiment to collect 5 sets of data to plot a graph of $\ln(1/t)$ against $1/T$ where

- t is the time for the laminated insert to be obscured
- T is the reaction temperature in kelvin.

In your plan, you should use the solutions provided. The concentrations of the 2 reactants are chosen so that mixing equal volumes of them gives a mixture with a suitable mole ratio for this method.

Your plan should include brief details of

- the apparatus you would use
- the procedure you would follow
- the measurements you would take
- how the data measured would be used to determine values needed for the plotting of the graph.

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- (b) (i) Sketch the graph that you would expect to obtain on the axes in Fig. 4.1.

The equation for the graph is

$$\ln\left(\frac{1}{t}\right) = \frac{-E_a}{R}\left(\frac{1}{T}\right) + c$$

where R is the molar gas constant
and c is a constant for the reaction.

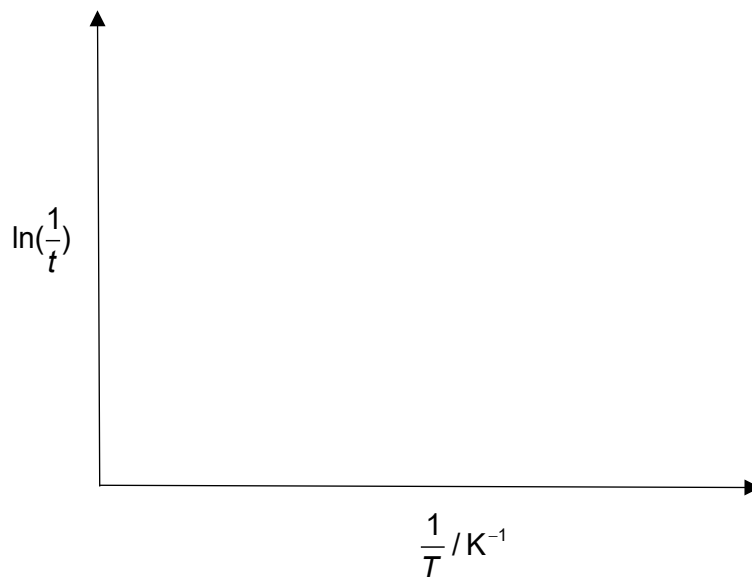


Fig. 4.1

[1]

- (ii) Describe how you will use your graph to determine the value of E_a .

.....

 [1]

[Total: 10]

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

<i>anion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$)
bromide, $\text{Br}^-(\text{aq})$	gives pale cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$)
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$)
nitrate, $\text{NO}_3^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
nitrite, $\text{NO}_2^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil NO liberated by dilute acids (colourless $\text{NO} \rightarrow$ (pale) brown NO_2 in air)
sulfate, $\text{SO}_4^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)
sulfite, $\text{SO}_3^{2-}(\text{aq})$	SO_2 liberated with dilute acids; gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in dilute strong acids)

(c) Tests for gases

<i>gas</i>	<i>test and test result</i>
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

<i>halogen</i>	<i>colour of element</i>	<i>colour in aqueous solution</i>	<i>colour in hexane</i>
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