



MINISTRY OF EDUCATION, SINGAPORE
in collaboration with
CAMBRIDGE ASSESSMENT INTERNATIONAL EDUCATION
General Certificate of Education Advanced Level
Higher 2

CANDIDATE
NAME



CENTRE
NUMBER

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INDEX
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CHEMISTRY

9729/04

Paper 4 Practical

October/November 2022

2 hours 30 minutes

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name 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.
DO NOT WRITE ON ANY BARCODES.

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	

This document consists of **16** printed pages and **4** blank pages.



Singapore Examinations and Assessment Board



Cambridge Assessment
International Education



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

1 Identification of two cations

FA 1 is an aqueous solution containing two cations.

FA 2 is 20 cm³ aqueous sodium hydroxide.

You will perform tests to identify the two cations in **FA 1**.

You are **not** expected to identify the anions.

Unless otherwise stated, the volumes given below are approximate and should be estimated rather than measured.

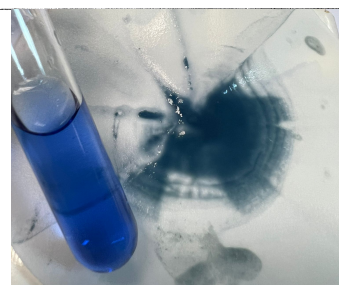
Test and identify any gases evolved.

If there is no observable change, write **no observable change**.

(a) (i) Carry out the following tests. Carefully record your observations in Table 1.1.

Table 1.1

tests		observations
1	Add 1 cm depth of FA 1 into a clean boiling tube. Add 2 cm depth of FA 2, aqueous sodium hydroxide, slowly with shaking, to FA 1. Add all the remaining FA 2 to the contents of the boiling tube and shake the boiling tube. Filter the mixture into a clean boiling tube. While waiting, proceed to test 2.	Blue green ppt formed upon addition of NaOH(aq) Blue green ppt remains insoluble in green solution Green filtrate Residue is blue ppt
2	Add 2 cm depth of FA 1 into a clean test-tube. Add aqueous ammonia, slowly with shaking, until 4 cm depth of aqueous ammonia has been added. Filter the mixture into a clean test-tube.	Blue green ppt formed upon addition of NH₃(aq). Grey green ppt remains insoluble in excess NH₃(aq) Deep blue filtrate Residue is grey green ppt



[4]



- (ii) Identify the two cations in **FA 1** and state the evidence for each cation by completing Table 1.2.

Table 1.2

cation	evidence

[2]

- (b) (i) Carry out the following test on **FA 1**.

test	observations
To 2 cm depth of FA 1 in a clean test-tube, add 2 cm depth of dilute sulfuric acid and one small spatula of powdered zinc. Filter the mixture into a clean test-tube.	Upon addition of Zn powder, vigorous effervescence of gas is observed. The gas "pops" with a lighted splint. A red suspension is observed. Green filtrate. Residue is a mixture of red brown solid and grey solid

[2]

- (ii) Explain the reaction between powdered zinc and **FA 1** in 1(b)(i).

.....

..... [1]



Total: 9]



2 Determination of an enthalpy change of neutralisation by thermometric titration

FA 3 is 1.00 mol dm^{-3} sodium hydroxide, NaOH .

FA 4 is aqueous sulfuric acid, H_2SO_4 .

You are to carry out a thermometric titration to determine the enthalpy change of neutralisation per mole of water formed when these solutions react. This involves adding volumes of aqueous sulfuric acid to a fixed volume of aqueous sodium hydroxide and measuring the temperature of the resulting solution.

(a) Prepare a table in the space provided on page 6 and record, to the appropriate level of precision:

- all volumes of **FA 4** added, V
- the maximum temperature, T , reached after each addition of acid, **FA 4**.

It is important that the volume of **FA 4** 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 4** added up to that point.

Procedure

1. Place a polystyrene cup inside a second polystyrene cup and place both cups in a glass beaker. The retort clamp provided may be used to clamp the beaker to prevent it from tipping.
2. Use the pipette labelled **FA 3** to transfer 25.0 cm^3 of **FA 3** into the first polystyrene cup.
3. Fill the burette labelled **FA 4** with **FA 4**.
4. Stir the **FA 3** in the cup gently with the thermometer. Read and record its temperature.
5. Use the burette to add 2.00 cm^3 of **FA 4** to the cup and stir the mixture gently with the thermometer. Read and record both the maximum temperature and the actual total volume of **FA 4** added.
6. Repeat step 5 until a total of 24.00 cm^3 of **FA 4** has been added. For each addition of **FA 4**, read and record both the maximum temperature and the actual total volume of **FA 4** added up to that point.





Results

Total Vol of FA4 added/cm ³	Temp/°C
0.00	28.0
2.00	31.0
4.00	32.8
6.00	34.2
8.00	35.4
10.00	36.4
12.00	37.2
14.00	36.6
16.00	35.8
18.00	35.0
20.00	34.4
22.00	34.0
24.00	33.6

[3]

- (b) Plot a graph of temperature, T , on the y -axis, against total volume of **FA 4**, V , on the x -axis on the grid in Fig. 2.1. 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) both lines until they intersect.



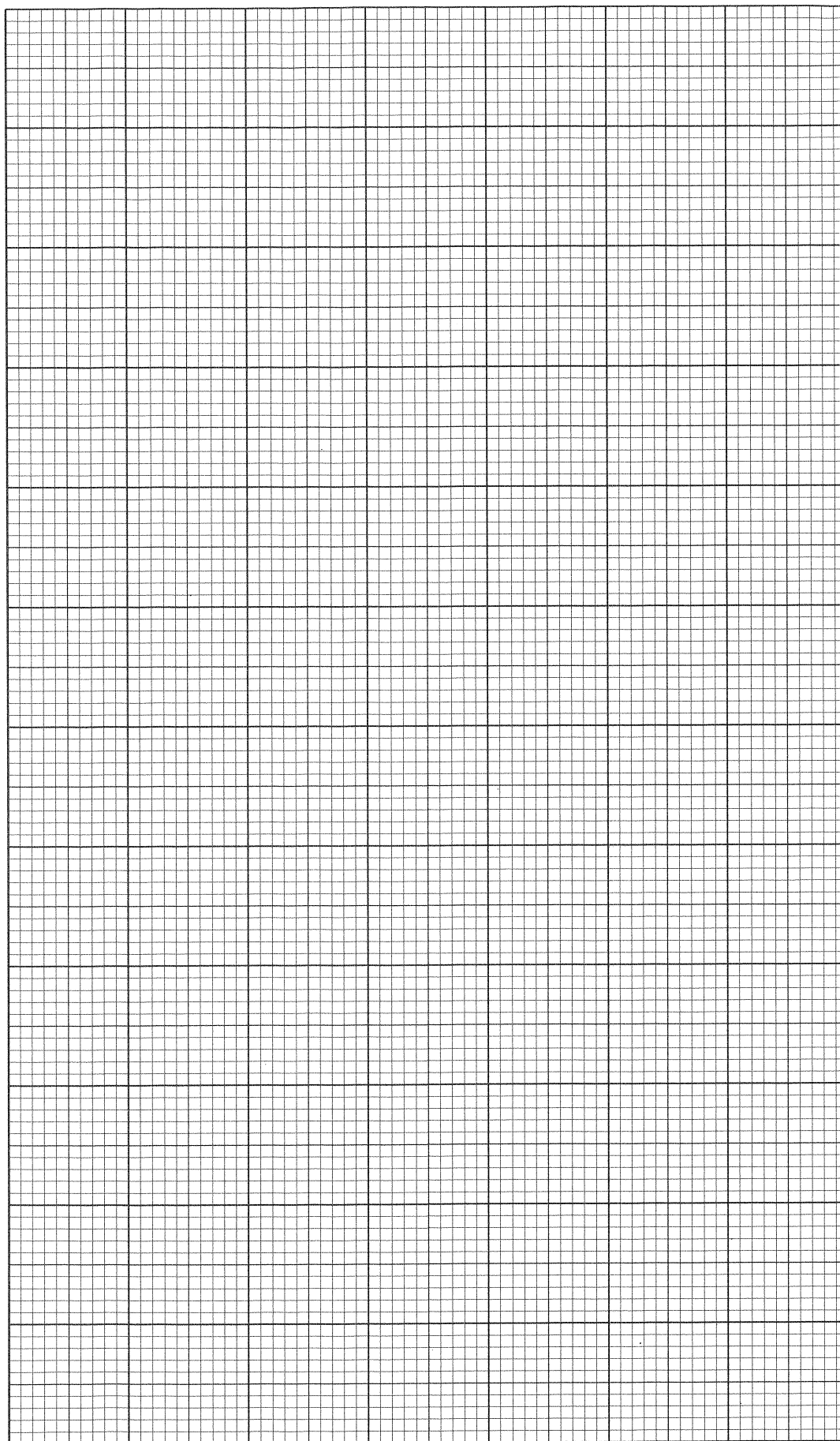


Fig. 2.1

[3]





- (c) From your graph, read the initial temperature of **FA 3**, 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 4** 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]

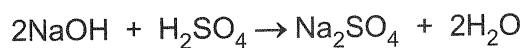
- (d) Calculate the heat change, q , at the point of neutralisation in your experiment, using the values you calculated in (c).

You should assume that the specific heat capacity of the solution is $4.18 \text{ J g}^{-1} \text{ K}^{-1}$, and that the density of the solution is 1.0 g cm^{-3} .

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

- (e) Calculate the enthalpy change of neutralisation, ΔH_{neut} , per mole of water formed.

The equation for the reaction is shown.



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

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



- (f) The enthalpy change of neutralisation for potassium hydroxide reacting with hydrochloric acid is the same as that for sodium hydroxide reacting with sulfuric acid. Explain why.

.....

 [2]

- (g) (i) Suggest why the magnitude of ΔH_{neut} obtained by this method is lower than the magnitude of the true ΔH_{neut} .

.....
 [1]

- (ii) Suggest **two** improvements to the method that would give a more accurate value for ΔH_{neut} .

.....

 [2]

- (h) Your value of V_{neut} could be used to calculate the concentration of the sulfuric acid. Explain why a conventional titration using an indicator gives a more accurate volume of neutralisation for this calculation.

.....
 [1]

[Total: 22]





3 Determination of the formula of an organic acid

FA 3 is 1.00 mol dm^{-3} sodium hydroxide, NaOH.

FA 5 is an aqueous solution of 6.00 g dm^{-3} of an organic acid with the formula $\text{HOOC}(\text{CH}_2)_n\text{COOH}$.

You are to dilute a sample of **FA 3** and titrate **FA 5** with this diluted sample to find:

- the concentration of the acid in **FA 5** in mol dm^{-3}
- the M_r of the acid and hence the value of n .

Solution **I** is thymolphthalein.

(a) (i) Procedure

- Using the pipette labelled **FA 3**, transfer 25.0 cm^3 of **FA 3** into a 250 cm^3 volumetric flask.
- Make the solution up to the mark with deionised water and shake well to mix.
- Label this solution **FA 6**.
- Fill a clean burette with **FA 6**.
- Using a clean pipette, transfer 25.0 cm^3 of **FA 5** into a 250 cm^3 conical flask.
- Add a few drops of solution **I** to the conical flask. Replace the cap on the container of **I** after use.
- Run **FA 6** from the burette into the conical flask. The end-point is reached when the solution changes from colourless to a permanent **pale** blue colour.
- Record your titration results in Table 3.1.
- Repeat steps 5 to 8 until consistent results are obtained.

Results

Table 3.1

final burette reading/ cm^3	25.50	25.40			
initial burette reading/ cm^3	0.00	0.00			
volume of FA 6 added/ cm^3	25.50	25.40			

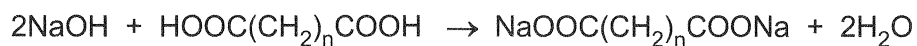
[5]

- (ii) From your titration results, obtain a suitable volume of **FA 6** to be used in your calculation. Show clearly how you obtained this volume.

volume of **FA 6** = cm^3 [1]



(b) (i) The equation for the reaction in the titration is shown.



Calculate the concentration of $\text{HOOC}(\text{CH}_2)_n\text{COOH}$ in **FA 5** in mol dm^{-3} .

concentration of **FA 5** = mol dm^{-3} [2]

(ii) Determine the M_r of $\text{HOOC}(\text{CH}_2)_n\text{COOH}$ and hence the value of n .
[A_r : H, 1.0; C, 12.0; O, 16.0]

M_r of $\text{HOOC}(\text{CH}_2)_n\text{COOH}$ =

n = [2]

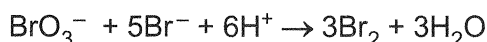
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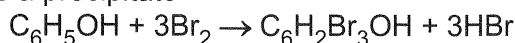
4 Planning: Measuring the activation energy for a reaction

Bromate(V) ions react with bromide ions in the presence of an acid to form bromine.



The rate of the reaction may be followed by a 'bromine clock' method, by adding two other substances:

- a small amount of phenol, which reacts immediately with the bromine produced, removing it from solution as a precipitate



- methyl red indicator, which is decolourised by bromine.

As soon as all the phenol has been used up by the bromine released, excess bromine decolourises the methyl red indicator so there is a sudden change in colour from red to colourless.

The activation energy, E_a , for the reaction may be calculated by measuring the time for the solution to turn colourless at different temperatures.

You may assume you are provided with:

- 75 cm³ of 0.10 mol dm⁻³ potassium bromide, KBr
- 75 cm³ of 0.02 mol dm⁻³ potassium bromate, KBrO₃
- 75 cm³ of 0.2 mol dm⁻³ sulfuric acid, H₂SO₄
- solid phenol, C₆H₅OH (**corrosive** and **toxic by skin absorption**)
- methyl red indicator
- the equipment normally found in a school or college laboratory.

- (a) Describe how you would make 75 cm³ of a solution of phenol of approximate concentration 0.01 mol dm⁻³ for your experiment. State any safety precautions you would take.

[A_r: H, 1.0; C, 12.0; O, 16.0]

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.....

.....

[4]




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

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

- In your plan you should use the solution of phenol you planned to make and the solutions provided. The concentrations of the reactants and phenol solution 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.

[illegible]

- (c) (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.

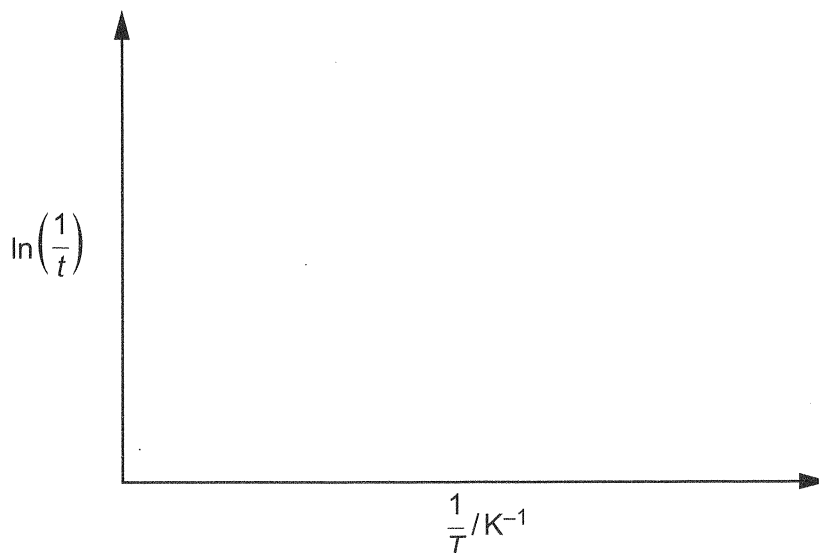


Fig. 4.1

[1]

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

.....

.....

..... [1]

[Total: 14]

