Name:		Index Number:		Class:	

CATHOLIC HIGH SCHOOL

Preliminary Examination
Secondary 4 (O-Level Programme)

End-of-Year Examination
Year 4 (Integrated Programme)

CHEMISTRY

6092/03

Paper 3 Practical

2 August 2024

1 hour 50 minutes

Candidates answer on the Question Paper
Additional Materials: -

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class 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.

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 page 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	/ 18
2	/ 11
3	/ 7
4	/ 4
Total	/ 40

1 Sodium carbonate can occur as a hydrated solid with the formula $Na_2CO_3 \bullet \mathbf{n}H_2O$. In these crystals, one formula unit of sodium carbonate, Na_2CO_3, combines with **n** molecules of water.

There are two methods to determine the value of **n**.

Each method involves sodium carbonate reacting with excess hydrochloric acid to release carbon dioxide.

$$Na_2CO_3 \bullet \mathbf{n}H_2O(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + (\mathbf{n} + 1)H_2O(l)$$

You will carry out one method each in Experiment 1 and Experiment 2. You will only determine the value of **n** in hydrated sodium carbonate, $Na_2CO_3 \bullet \mathbf{n}H_2O$, in Experiment 1.

Read all the instructions below carefully before starting the experiments in Question 1.

Instructions

(a) (i) Experiment 1

You will perform a titration to measure the volume of hydrochloric acid that neutralises an aqueous solution of hydrated sodium carbonate, $Na_2CO_3 \bullet \mathbf{n}H_2O$.

P is 0.100 mol/dm^3 hydrochloric acid.
Q is an aqueous solution containing 14.3 g/dm^3 of hydrated sodium carbonate, $Na_2CO_3 \bullet \mathbf{n}H_2O$.
R is bromophenol blue indicator.

Method

Fill the burette with **P**.

Use the pipette to transfer 25.0 cm^3 of **Q** into a conical flask.

Add a few drops of **R** into the flask.

Add **P** from the burette, swirling the flask constantly.

At the end-point, one drop of **P** produces a yellow colour that does not disappear on swirling.

Record your titration results in the space provided, repeating the titration as many times as you consider necessary to achieve consistent results.

Results

[5]

(ii) Use your titration results to obtain the average volume of **P** used.
Show clearly how you obtained this volume.

average volume of **P** = …… cm^3 [1]

(b) **(i)** Calculate the amount, in moles, of hydrochloric acid present in the average volume of **P**.

amount of hydrochloric acid = …….…… mol [1]

(ii) Use the equation to deduce the amount, in moles, of Na_2CO_3 present in 25.0 cm^3 of Na_2CO_3•**n**H_2O.

amount of Na_2CO_3 = …… mol [1]

(iii) Hence, calculate the amount, in moles, of Na_2CO_3 present in 1.00 dm^3 of Na_2CO_3•**n**H_2O.

amount of Na_2CO_3 in 1.00 dm^3 = …… mol [1]

(iv) Calculate the value of **n** in the sample of Na_2CO_3•**n**H_2O.

[A_r: C, 12; H, 1; O, 16; Na, 23]

n = …… [3]

(c) The pH range over which bromophenol blue changes colour is 3.0 to 4.6.

The pH range over which phenolphthalein changes colour is 8.0 to 9.8.

A student repeated Experiment 1 using phenolphthalein instead of bromophenol blue.

State and explain the effect, if any, on the student's calculated value of **n**.

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…… [2]

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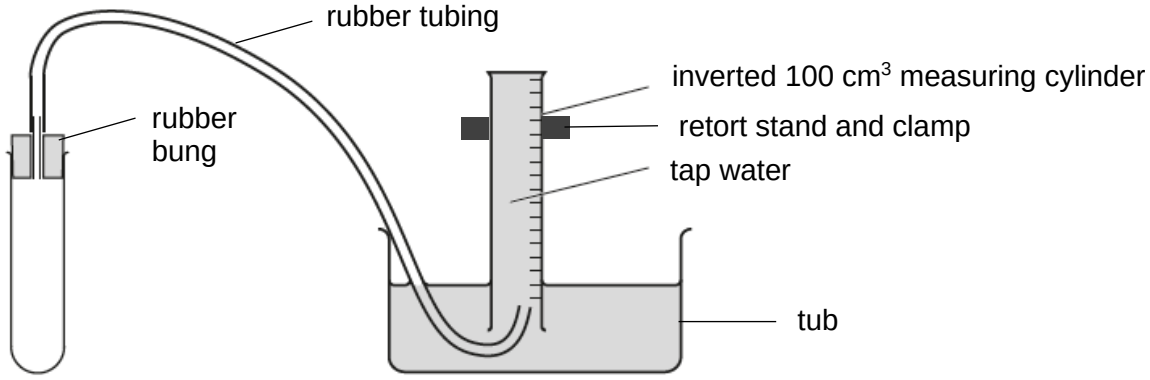
(d) Experiment 2

You will measure the volume of carbon dioxide released when hydrated sodium carbonate, Na_2CO_3•**n**H_2O, reacts with excess hydrochloric acid.

X is 2.0 mol/dm^3 hydrochloric acid, HC*l*.
Y is hydrated sodium carbonate, Na_2CO_3•**n**H_2O in solid form.

Method

- Fill the tub with tap water to approximately two-third depth.
- Fill the 100 cm^3 measuring cylinder completely with tap water. Using your palm to firmly cover the top of the measuring cylinder, invert the measuring cylinder and place it in the water in the tub.
- Remove your palm. Check that there are no air bubbles in the measuring cylinder and clamp the measuring cylinder so the open end is just below the surface of the water.
- Using the 50 cm^3 measuring cylinder, transfer 35 cm^3 of **X** into a boiling tube. Check that the rubber bung fits tightly into the mouth of the boiling tube and place the end of the rubber tubing into the inverted 100 cm^3 measuring cylinder.



- Weigh the plastic container and **Y** and record the mass.
- Remove the rubber bung from the boiling tube. Carefully add **Y** from the container into the boiling tube and replace the rubber bung immediately. Swirl the boiling tube.
- Allow the reaction to come to completion. Record the volume of gas collected.
- Weigh the empty plastic container and record the mass.
- Calculate the mass of **Y** used in the reaction.
- You may begin the experiments for **Question 2** on page 8 while you are waiting for the reaction to complete.

Results

mass of container and **Y** / g	
mass of empty container / g	
mass of **Y** used / g	
volume of gas / cm^3	

[2]

(e) **(i)** The volume of gas obtained in **Experiment 2** is smaller than expected.

Other than solubility of carbon dioxide gas, suggest the **main** source of error in the experiment.

……..……..

…….…….... [1]

(ii) Suggest an improvement you could make to the experiment to reduce this source of error.

……..……..

…….…….... [1]

[Total: 18]

2 You will carry out reactions using two compounds of manganese.

T is solid potassium manganate(VII), $KMnO_4$.
S is an aqueous manganese(II) salt.

Read all the instructions carefully before starting the experiments in Question 2.

Instructions

(a) Carefully transfer half a spatula of **T** to a clean and dry test-tube. Heat the sample in the test-tube strongly for about 1 minute.

After heating, leave the test-tube to cool and keep it for **Test 1** in **(b)(i)**. You may wish to start **Test 2** in **(b)(i)** while you wait.

Record all your observations including testing the gas produced.

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……..… [2]

(b) **(i)** Carry out the following tests on **T** and **S**. Test and identify any gases evolved. Record your observations in the table. If no change is observed for a test, write 'no observable changes'.

The volumes given below are approximate and should be estimated rather than measured.

test	*instructions*	*observations*
1	To the cooled test-tube from **(a)**, add distilled water, a little at a time, to a depth of approximately 4 cm. Shake the test-tube and then leave the contents in the test-tube to stand.	
2	To half a spatula of **T** in a clean boiling tube, add a 2 cm depth of distilled water, followed by an equal volume of dilute sulfuric acid. Use a glass rod to stir the mixture to dissolve **T**. **Keep this solution for use in Test 3.**	

test	*instructions*	*observations*
3	To a 1 cm depth of aqueous iron(II) sulfate in a clean test-tube, add an equal volume of the solution from **Test 2**.	
4	To a 1 cm depth of **S** in a clean test-tube, add aqueous ammonia slowly with shaking until no further change is seen.	
5	To a 1 cm depth of **S** in a clean test-tube, add an equal volume of dilute nitric acid and then add a few drops of aqueous silver nitrate.	
6	To a 1 cm depth of **S** in a clean test-tube, add an equal volume of dilute nitric acid and then add a few drops of aqueous barium nitrate.	

[5]

(ii) Deduce the type of reaction that occurs in **Test 3**. Explain your answer.

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…….. [2]

(iii) Deduce the identity of the **anion** present in **S**. State which test provides evidence for your conclusion.

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…….. [1]

(iv) Another student repeated **Test 5** in a reverse order, such that he added a few drops of aqueous silver nitrate, followed by an equal volume of dilute nitric acid.

Explain if this would affect the conclusion from **Test 5**.

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…….. [1]

[Total: 11]

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3 A student wants to investigate the enthalpy change of neutralisation, between aqueous sodium hydroxide of known concentration and a dilute organic acid.

sodium hydroxide + dilute organic acid → salt + water

The student uses the following method.

A is 1.90 mol/dm^3 sodium hydroxide, NaOH.
B is a solution containing 312.5 g/dm^3 of the dilute organic acid.

1. Measure 25.0 cm^3 of **A** into a well-insulated Styrofoam cup using a pipette.
2. Add 10 cm^3 of **B** in portions using a measuring cylinder into the same cup.
3. Measure and record the highest temperature reached after every addition.

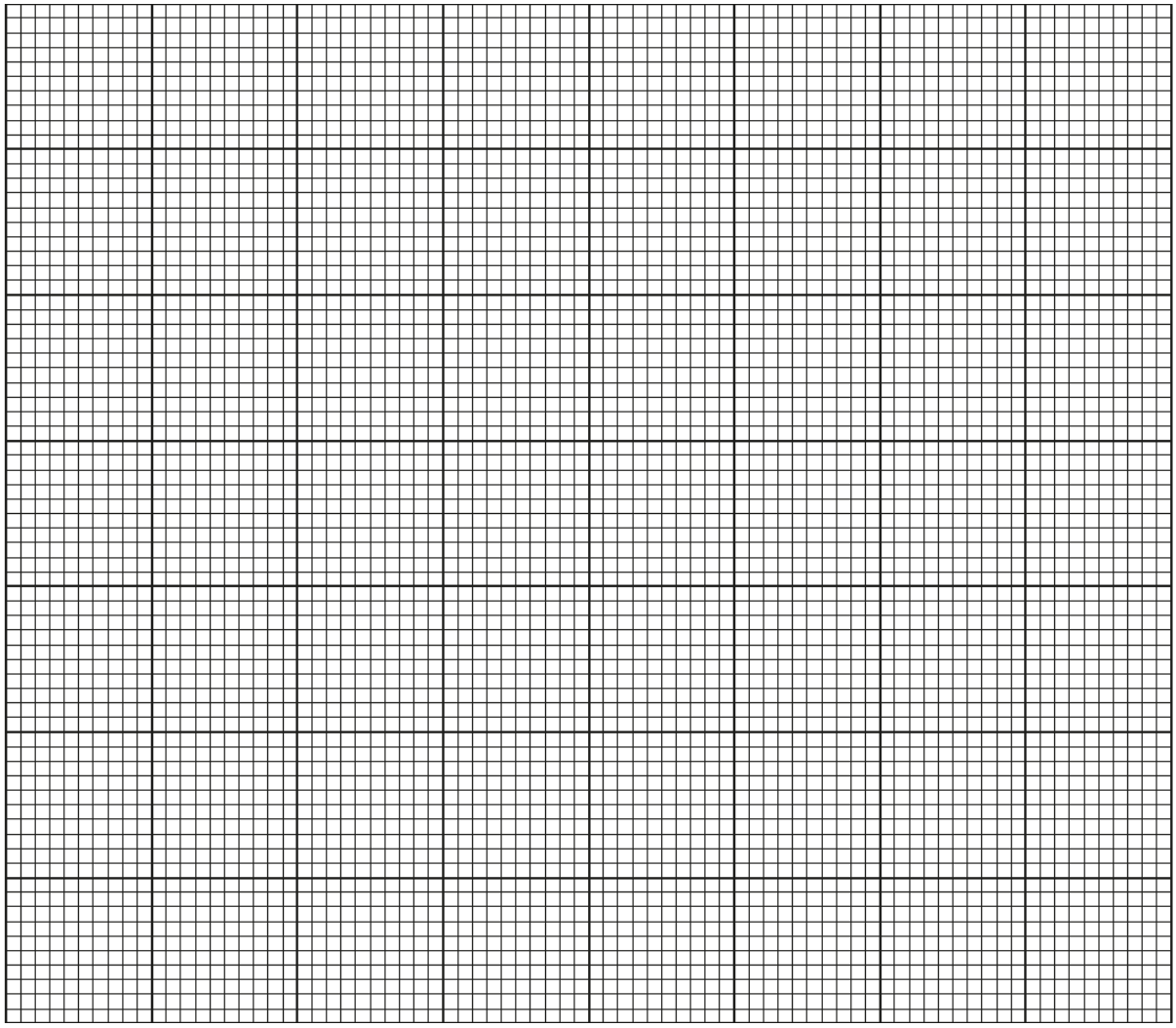
The results obtained by the student are shown in the table.

total volume of **B** added / cm^3	0	10	20	30	40
highest temperature reached / °C	28.0	39.5	51.0	47.5	29.5

(a) Plot a graph of highest temperature reached against total volume of **B** added on the grid below.

Draw two straight lines of best fit. One line should be drawn using data from 0 to 20 cm^3 and the other line should be drawn using data from 30 to 40 cm^3.

Extrapolate the two lines so that they intersect.



[4]

(b) Use your graph to determine the total volume of **B** required to neutralise 25.0 cm^3 of **A**. Show clearly **on the graph** how you obtained your answer.

total volume of **B** = ……. cm^3 [1]

(c) Describe and explain the trend shown by your graph in **(a)**.

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…… [2]

[Total: 7]

4 Many fizzy drinks contain phosphoric acid. Phosphoric acid reacts with sodium hydrogencarbonate to produce a salt, carbon dioxide and water.

Value Coke and ***Kola Koola*** are two fizzy drinks which contain phosphoric acid as the only acid.

A student decides to investigate which of these two fizzy drinks contains a higher concentration of phosphoric acid. The student will determine **graphically** the rate of reaction of phosphoric acid with **solid** sodium hydrogencarbonate **without** collecting the gas produced.

Describe the method the student should use. The method should include suitable apparatus and the measurements that need to be taken.

Include in your answer an explanation of how his results will tell him which drink contains a higher concentration of phosphoric acid.

You are provided with samples of both fizzy drinks, solid sodium hydrogencarbonate and the apparatus normally found in a school laboratory.

You may wish to use a labelled diagram to illustrate your answer.

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[Total: 4]

- End of Paper -

QUALITATIVE ANALYSIS NOTES

Tests for anions

anion	*test*	*test result*
carbonate (CO_3^{2-})	add dilute acid	effervescence, carbon dioxide produced
chloride (Cl^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt.
iodide (I^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	yellow ppt.
nitrate (NO_3^-) [in solution]	add aqueous sodium hydroxide, then aluminium foil; warm carefully	ammonia produced
sulfate (SO_4^{2-}) [in solution]	acidify with dilute nitric acid, then add aqueous barium nitrate	white ppt.

Tests for aqueous cations

cation	*effect of aqueous sodium hydroxide*	*effect of aqueous ammonia*
aluminium (Al^{3+})	white ppt., soluble in excess, giving a colourless solution	white ppt., insoluble in excess
ammonium (NH_4^+)	ammonia produced on warming	–
calcium (Ca^{2+})	white ppt., insoluble in excess	no ppt.
copper(II) (Cu^{2+})	light blue ppt., insoluble in excess	light blue ppt., soluble in excess, giving a dark blue solution
iron(II) (Fe^{2+})	green ppt., insoluble in excess	green ppt., insoluble in excess
iron(III) (Fe^{3+})	red-brown ppt., insoluble in excess	red-brown ppt., insoluble in excess
zinc (Zn^{2+})	white ppt., soluble in excess, giving a colourless solution	white ppt., soluble in excess, giving a colourless solution

Tests for gases

gas	*test and test result*
ammonia (NH_3)	turns damp red litmus paper blue
carbon dioxide (CO_2)	gives white ppt. with limewater (ppt. dissolves in excess CO_2)
chlorine (Cl_2)	bleaches damp litmus paper
hydrogen (H_2)	‘pops’ with lighted splint
oxygen (O_2)	relights a glowing splint
sulfur dioxide (SO_2)	turns aqueous acidified potassium manganate(VII) from purple to colourless