NAME:	NO:	CLASS:

ADMIRALTY SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2024

SUBJECT	:	Chemistry
CODE/PAPER	:	6092/3
LEVEL/STREAM	:	Secondary 4 Express
DATE	:	19 August 2024
TIME	:	0800h – 0950h
DURATION	:	1 hour 50 minutes

Instructions to candidates:
Write your name, index number and class on the cover page.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs, tables or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer all questions in the space provided.
Candidates are reminded that all quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, where appropriate.
The number of marks is given in brackets [ ] at the end of each question or part question.

If the degree of accuracy is not specified in the question and if the answer is not exact, give the answer to three significant figures. Give answers in degrees to one decimal place.
At the end of the examination, fasten all your work securely together.

Chemistry practical notes for this paper are printed on Page 13.

For Examiner's Use	
Paper 3	/ 40

DO NOT TURN OVER THIS PAPER UNTIL YOU ARE TOLD TO DO SO.

This question paper consists of **13** printed pages including this cover page.

1 The reaction of aqueous solutions of alkalis and strong acids is exothermic.

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$$

You are going to investigate how the temperature changes when different volumes of sulfuric acid and sodium hydroxide are mixed together.

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

Instructions

You are going to carry out seven experiments.

P is sulfuric acid of unknown concentration.
Q is a 1.20 mol/dm^3 of sodium hydroxide.

(a) Experiment 1

- Place a polystyrene (Styrofoam) cup into a 250 cm^3 glass beaker.
- Put **P** into a burette and measure 40.00 cm^3 of **P** into the Styrofoam cup. Measure the temperature of **P** and record the value in the results table provided **on page 4**.
- Use a measuring cylinder to measure 10 cm^3 of **Q**. Pour this volume of **Q** into the Styrofoam cup containing **P**. Stir, using the thermometer, and measure the highest temperature reached. Record this temperature in the results table provided **on page 4**.
- Empty the polystyrene cup and rinse it with water.

Experiment 2

- Place a polystyrene cup into a 250 cm^3 glass beaker.
- Put **P** into a burette and measure 35.00 cm^3 of **P** into the Styrofoam cup. Measure the temperature of **P** and record the value in the results table provided **on page 4**.
- Use a measuring cylinder to measure 15 cm^3 of **Q**. Pour this volume of **Q** into the Styrofoam cup containing **P** to make the total volume of the mixture 50 cm^3. Stir, using the thermometer, and measure the highest temperature reached. Record this temperature in the results table provided **on page 4**.
- Empty the polystyrene cup and rinse it with water.

Experiments 3 to 7

- Choose 5 further volumes of **P** between 10.00 cm^3 and 40.00 cm^3. Record the volumes you have chosen in the results table provided **on page 4**.

- Follow the instructions for **Experiment 2** for each pair of volumes you have chosen.
- Complete the results table provided **on page 4** by calculating the temperature rise for each experiment.

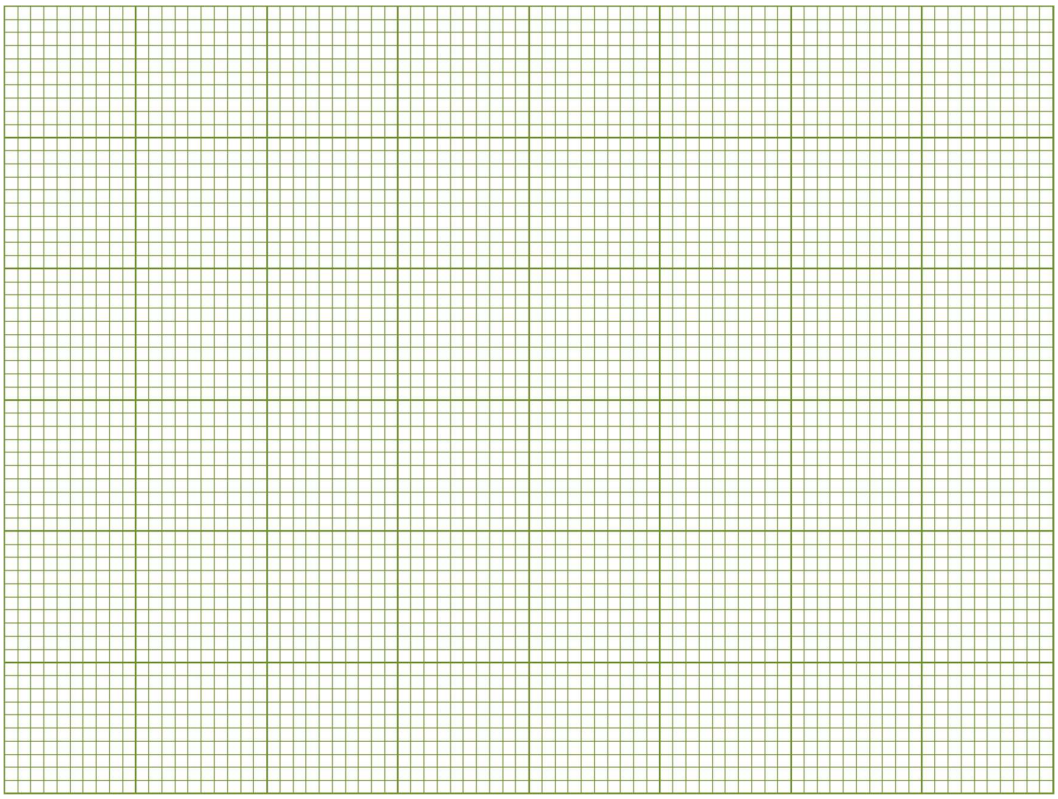
(Continued on the next page)

Results

experiment	volume of **P** /cm^3	volume of **Q** /cm^3	initial temperature of **P** /°C	highest temperature of mixture /°C	temperature rise /°C
1	40.00	10			
2	35.00	15			
3					
4					
5					
6					
7					

[5]

(b) Use your results to plot a graph of temperature rise against volume of **Q** on the grid below. Use these points to draw two intersecting straight lines of best fit. You should include the origin (0, 0).



[4]

(c) Use your graph to determine the volume of **Q** used at the maximum rise in temperature.

volume of **Q** used = …….…… cm^3 [1]

(d) Calculate the volume of **P** required to neutralise the volume of **Q** in **(c)**.

volume **P** used = …….…… cm^3 [1]

(e) Hence or otherwise, calculate the concentration of **P**.

concentration of **P** = …….…… mol/dm^3 [3]

(f) Explain why the mixture was conducted in a polystyrene cup instead of a glass beaker.

……..

…….. [1]

(g) The experiment was repeated using 20 cm^3 of **P** with concentration of 2 mol/dm^3. It was discovered that only 15 cm^3 of **Q** was required to reach the maximum temperature.

Predict whether the maximum temperature reached will be higher, lower or equal to the maximum temperature obtained in the experiment that you conducted. Explain your answer.

……..

……..

…….. [2]

2 Copper(II) carbonate decomposes on heating.

$$CuCO_3(s) \rightarrow CuO(s) + CO_2(g)$$

You are supplied with an impure sample of copper(II) carbonate. You are to determine the percentage by mass of copper(II) carbonate present in the sample.

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

Instructions

C is impure copper(II) carbonate.

(a)
- Weigh the empty boiling tube and record the mass.
- Carefully add 2.0 g of **C** to the boiling tube.
- Weigh the boiling tube and its contents and record the mass.
- Gently heat the boiling tube and its contents for 1 minute so that the copper(II) carbonate decomposes.
- Leave the boiling tube and its contents to cool to room temperature.
- Reweigh the boiling tube and its contents and record the mass.
- Record all your results in an appropriate format.

Results

[2]

(b) From your results, deduce the change in mass of **C** after thermal decomposition has taken place.

change in mass of **C** = ……..…… g [1]

(c) Calculate the mass of copper(II) carbonate that has reacted.
[A_r: C, 12; Cu, 64; O, 16]

mass of copper(II) carbonate = ……..……. g [2]

(d) Calculate the percentage by mass of copper(II) carbonate in **C**.

percentage by mass of copper(II) carbonate in **C** = ……..……. % [1]

(e) Suggest one way to improve the accuracy of the experiment.

……..

……..

…….. [1]

3 Hard water is water that has a high concentration of dissolved minerals. It contains **one** cation and **one** anion from those listed in the Qualitative Analysis notes. Hard water can be softened by adding a certain compound to remove the dissolved cations from the hard water.

X is a sample of hard water.
Y contains a compound that can soften hard water.

You will carry out tests on **X** and **Y** to identify the ions present.

Instructions

(a) (i) Carry out the following tests. Test and identify any gases evolved. Record your observations in the table.

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

test	*instructions*	*observations*
1	Put about 1 cm depth of solution **X** into a test-tube. Add aqueous sodium hydroxide slowly with shaking until no further change is seen. **Keep this mixture for Test 4.**	
2	Put about 1 cm depth of solution **X** into a test-tube. Add aqueous ammonia slowly with shaking until no further change is seen.	
3	Put about 1 cm depth of solution **X** into a test-tube. Add an equal depth of dilute nitric acid and then add a few drops of aqueous silver nitrate.	
4	To the mixture from test 1, add a piece of aluminium foil and warm the mixture gently.	

5	Put about 5 cm depth of solution **X** into a test-tube. Add an equal depth of solution **Y**. Keep for Test 6.	
6	Filter the contents of the test-tube from Test 5 into a boiling tube. Add an equal depth of dilute nitric acid to the residue.	

[8]

(ii) Deduce the formulae of the cation and anion present in **X**.

cation ……

anion …… [2]

(iii) Using your observations from Test 5, explain how hard water can be softened.

……

……

…… [1]

(b) **A** is a 100 cm^3 solution that contains 50 cm^3 of a sample of hard water that has a high concentration of iron(II) ions, and 50 cm^3 of sulfuric acid.

B is a 0.500 mol/dm^3 solution of potassium manganate(VII).

When **B** is added very slowly to **A**, the purple colour disappears quickly but as more **B** is added the colour disappears less quickly. At the end-point, one drop of **B** produces a pale pink colour that does not disappear on swirling. In this reaction, five moles of iron(II) ions reacts with one mole of **B**.

Use this information to outline a method to determine the concentration of iron(II) in the 50 cm^3 sample of hard water.

In your method you should include:

- A labelled diagram of the apparatus required
- The measurements you would take
- An explanation of how you would use your results to determine the concentration of iron(II) ions present in the sample of hard water.

You may assume that the apparatus and reagents normally found in a school laboratory are available.

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……..

…….. [5]

QUALITATIVE ANALYSIS NOTES

Test 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.

Test 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

Test 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 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.