Name and Index Number: ( )	Class:

SENG KANG SECONDARY SCHOOL
2024 PRELIMINARY EXAMINATION

CHEMISTRY **6092/03**

Secondary 4 Express **1 August 2024**

Paper 3 Practical **1 hour 50 minutes**

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your index number and name on all the work you hand in.
Give the details of the practical shift and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, 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 10.

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	/ 18
3	/ 4
Total	**/ 40**
% / Grade	

Parent's / Guardian's Signature: ……………………………………..

This document consists of **10** printed pages.

Do not turn over the page until you are told to do so.

1 A student suggests that the concentration of sulfuric acid can be determined by measuring the temperature of the solution as the acid is added in small amounts to a known volume of sodium hydroxide solution in a styrofoam cup.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

The student proposes the following hypothesis.

‘As the acid is added to the alkali, the temperature rise will be directly proportional to the volume of acid added until the end-point of the reaction is reached. Upon further addition of acid there will be a reduction in the temperature of the solution in the cup as the acid added is not reacting and is at a lower temperature than the solution in the styrofoam cup.’

The following reagents are provided.

A is **approximately** 0.75 mol/dm^3 sulfuric acid, H_2SO_4.
B is 2.00 mol/dm^3 sodium hydroxide, NaOH.

(a) Use the equation to estimate the volume of A that will neutralise 25.0 cm^3 of **B**.

volume of **A** = ………………………………… [1]

(b) In this experiment, you will be adding **A** from a burette to 25.0 cm^3 of **B** in a styrofoam cup and measuring the temperature of the solution after each addition of a certain volume of **A**.

In order to obtain precise information about the end-point of the reaction, you will need to decide on the:

- volume of **A** to be added each time (do **not** use a volume which is less than 2.00 cm^3),
- total volume of **A** to be added.

volume of **A** to be added each time = …………………………

total volume of **A** to be added = …………………………
[2]

(c) Read all the instructions below carefully before starting the experiments in this part of the question.

Instructions

Place a styrofoam cup into a 250 cm^3 glass beaker.

Put **A** into a burette.

Pipette 25.0 cm^3 of **B** into the styrofoam cup. Measure and record the temperature of **B** in the styrofoam cup in Table 1.1.

Add the first volume of **A** from the burette into the styrofoam cup. Stir, using the thermometer, and measure the highest temperature reached. Record this temperature in Table 1.1.

Using your answers in **(b)**, continue to add volume of **A** and for each addition, record the highest temperature in Table 1.1.

Complete your results in Table 1.1.

Table 1.1

experiment	total volume of **A** added / cm^3	initial temperature of **B** / °C	highest temperature of mixture / °C	temperature rise / °C
1	0.00			
2				
3				
4				
5				
6				
7				
8				

[4]

(d) Using your results in Table 1.1, plot a graph of temperature rise against the volume of **A** added on the grid.

Use these points to draw **two** intersecting straight lines of best fit.

[4]

(e) **(i)** Use your graph to obtain a value for the volume of **A** added at the end-point of the titration.

Show clearly **on the graph** how you obtained your answer.

volume of **A** at the end-point = ………………………… [1]

(ii) Use your answer to **(e)(i)** to calculate the concentration, in mol/dm^3, of H_2SO_4 in **A**.

Show your working clearly.

concentration of **A** = ………………………… [1]

(f) Explain how the results in Table 1.1 and/or graph support or do not support each part of the hypothesis proposed by the student.

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…………………………………………………………………………………………….. [2]

(g) The student, carrying out the experiment, noticed that each subsequent temperature rise became less as the reaction was approaching the end-point.

Give **one** reason why this was the case.

……………………………………………………………………………………………..

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

(h) Another student put forward the hypothesis that the heat energy produced in the reaction, rather than the temperature rise, is proportional to the volume of acid added.

Calculate the total heat produced by the addition of **A** at the end-point.

Assume that it takes 4.2 J to raise the temperature of 1.0 cm^3 of solution by 1.0 °C.

heat produced = ………………………… J [2]

[Total: 18]

2 Copper(II) sulfate, $CuSO_4$, is used as a drying agent in the anhydrous form.

(a) Hydrated copper(II) sulfate has the chemical formula $CuSO_4 \bullet xH_2O$, where x can range from 0 to 5. When x is 0, the compound exists as the anhydrous form of copper(II) sulfate, and when x is a whole number ranging between 1 to 5, it exists as the hydrated form of copper(II) sulfate.

When hydrated copper(II) sulfate is heated, it loses its water of crystallisation to form anhydrous copper(II) sulfate as shown in the equation.

$$CuSO_4 \bullet xH_2O(s) \rightarrow CuSO_4(s) + xH_2O(g)$$

You are going to determine the value of x in the sample of hydrated copper(II) sulfate provided.

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

$\mathbf{R_1}$ is hydrated copper(II) sulfate, $CuSO_4 \bullet xH_2O$.

1. Use the electronic balance to measure and record the mass of an empty boiling tube.
2. Transfer all solid $\mathbf{R_1}$ to the boiling tube. Measure and record the mass of the boiling tube and its contents.
3. **Gently** heat the boiling tube and its contents for 3 minutes. It is important that $\mathbf{R_1}$ is heated gently to achieve accurate results. Record your observations in **(a)(i)**.
4. Leave the boiling tube and its contents to cool to room temperature.

You may start working on Question 2(e) whilst you are waiting for the boiling tube to cool.

5. Reweigh the boiling tube and its contents and record the mass.
6. Record all your results in an appropriate format in **(a)(ii)**.

(i) **observations**

…………………………………………………………………………………………..

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

(ii) **results**

[3]

(iii) From your results in **(a)(ii)**, determine

the mass of $\mathbf{R_1}$ before heating ....

the mass of anhydrous $CuSO_4$ after heating ....

[2]

(b) **(i)** Calculate the amount, in moles, of anhydrous copper(II) sulfate, $CuSO_4$, remaining after heating.

[A_r: Cu, 64; S, 32; O, 16]

amount of $CuSO_4$ = ... [1]

(ii) Calculate the **total** mass, in g, of water lost from the original sample of $\mathbf{R_1}$ after heating.

total mass of water lost = ... [1]

(iii) Calculate the total amount, in moles, of water lost during heating.

[A_r: H, 1; O, 16]

amount of water lost = ... [1]

(iv) Use the equation for the loss of water of crystallisation of hydrated copper(II) sulfate, your answers to **(b)(i)** and **(b)(iii)** to calculate the value of x in the given sample of $\mathbf{R_1}$.

Give your answer to the nearest **whole number**.

value of x = ...…......... [1]

(c) Use the information in **(a)** to state **two** assumptions that must be made in order for the experiment to be valid.

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

(d) Upon strong heating, anhydrous copper(II) sulfate decomposes to give a black residue, CuO, as shown in the equation.

$$2CuSO_4(s) \rightarrow 2CuO(s) + 2SO_2(g) + O_2(g)$$

(i) State a reason, other than the formation of CuO, why it is important that $\mathbf{R_1}$ is heated **gently** in **(a)**.

……………………………………………………………………………………..

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

(ii) A student carried out the experiment in **(a)**.

The student heated the sample of $\mathbf{R_1}$ strongly causing it to decompose.

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

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…………………………………………………………………………………….. [3]

(e) $\mathbf{R_2}$ contains hydrated copper(II) sulfate, $CuSO_4 \cdot xH_2O$ in a test-tube.

Add about 5 cm depth of deionised water into the test-tube containing $\mathbf{R_2}$, making sure all of $\mathbf{R_2}$ dissolves.

(i) To about 2 cm depth of the resulting solution in a clean test-tube, add an equal volume of aqueous potassium iodide. Leave the resulting mixture to stand for about 5 minutes.

Record your observations in the space provided.

……………………………………………………………………………………..

…………………………………………………………………………………….. [2]

(ii) Hence, suggest the identity of **one** product of the reaction in **(e)(i)**.

Explain your answer.

……………………………………………………………………………………………..

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

[Total: 18]

3 **M** is a metal that is more reactive than copper. It forms a white compound **M**CO_3 which decomposes on heating according to the equation:

$$MCO_3 \rightarrow MO + CO_2$$

MO produced is a yellow solid which turns white when cooled.

Outline a method you could use to determine the relative atomic mass of **M**.

You are given a solid sample of **M**CO_3. You can assume all the apparatus and reagents normally found in the school laboratory are available.

You should include in your answer the measurements you would take, and show how you would use your results to obtain a value for the relative atomic mass of **M**.

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……………………………………………………………………………………………… [4]

[Total: 4]

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.

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

[Lead(II) ions can be distinguished from aluminium ions by the insolubility of lead(II) chloride.]

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 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

2024 Secondary Four Express Chemistry Prelim Exam Paper 3 Confidential Instructions

Safety

Attention is drawn, in particular, to certain materials used in the examination. The following codes are used where relevant.

C	corrosive	**MH**	moderate hazard
HH	health hazard	**T**	acutely toxic
F	flammable	**O**	oxidising
N	hazardous to the aquatic environment		

The attention of Supervisors is drawn to any local regulations relating to safety and first aid.

'Hazard Data Sheets', relating to materials used in this examination, should be available from your chemical supplier.

Apparatus

1 In addition to the fittings ordinarily contained in a chemical laboratory, the apparatus and materials specified below will be necessary.

2 For *each candidate* (Note: Labels do **not** need to include concentrations.)

1 × 50cm^3 burette
1 × burette stand
1 × burette clamp
1 x pipette
1 x pipette filler
1 × filter funnel for filling burette
1 × boiling tube
1 × small beaker
1 x thermometer
1 x styroform cup
1 × bunsen burner
1 × lighter
2 × teat pipettes
1 × wooden splint
2 × test-tubes
1 × glass rod
1 × waste container
1 × red and blue litmus paper
access to electronic balance
access to test-tube rack
access to test-tube holder
access to deionised water
access to cloth
access to paper towels
access to safety googles
access to bench reagents

Chemicals Required

1 It is especially important that great care is taken that the confidential information given below does not reach the candidates either directly or indirectly.

2 Particular requirements

hazard	Label	per candidate	identity	notes (hazard symbols given in this column refer to the raw materials)
[C]	**A**	100 cm^3	0.750 mol/dm^3 of sulfuric acid	
	B	50 cm^3	2.00 mol/dm^3 of aqueous sodium hydroxide	
Supervisors are asked to carry out a standard acid/base titration between solutions A and B to ensure the volume of				
	R_1	3.0 g	Hydrated copper(II) sulfate	
	R_2	2.0 g	Hydrated copper(II) sulfate	-
	Potassium iodide			

2023 Secondary 4E Chemistry Prelim Exam Paper 3 Marking Guide

Question	Skill	Indicative material	Mark	Total
1(a)	ACE	No. of moles of NaOH = $2.00 \times \frac{25}{1000}$ = 0.05 mol.		**[1]**
		Mole ratio = NaOH : H_2SO_4 = 1 : 2 = 0.05 : 0.025		
		Volume of H_2SO_4 needed = $\frac{0.025}{0.75}$ = 0.0333dm^3 ***OR*** 33.3cm^3 ***OR*** 33.33cm^3 **[accept final answer to 3 s.f. or 2 d.p.]**	[1]	
1(b)	P	5.00 [2 d.p.]; 35.00 [must record to nearest 0.05cm^3]	[1]	**[2]**
	PDO	Correct units of dm^3/cm^3 in **(a)** and cm^3 in **(b)**	[1]	
1(c)	PDO	All data collected	[1]	**[4]**
		Record volume of **A** to nearest 0.05cm^3 **AND** all temperatures to nearest 0.5cm^3	[1]	
		Trend of temperature increases from 0.00 to 30.00cm^3 **AND** then decreases from 30.00 to 35.00cm^3 **[reject if** **- volume of A recorded overshot 50.00cm^3** **- initial temp. of B is not constant throughout]**	[1]	
		Correct subtractions of **ALL** values for temperature rise	[1]	
1(d)	PDO	Correct axes **AND** units	[1]	**[4]**
		Appropriate scale	[1]	
		All points plotted correctly	[1]	
		Best-fit straight lines passing through the origin with intersection	[1]	
1(e)(i)	MMO	Correct reading of the maximum temperature rise at the intersection **WITH** dotted lines drawn in the graph **AND** units	[1]	**[1]**
1(e)(ii)	MMO	Concentration of H_2SO_4 = $\frac{0.025}{\frac{(e)(i)}{1000}}$ **WITH** correct unit	[1]	**[1]**
1(f)	MMO	First part of the hypothesis is supported because the graph is a straight line passing through the origin (0,0).	[1]	**[2]**
		Second part of the hypothesis is supported because the temperature fall after the end-point when volume is at … [quote the value from (e)(i)]	[1]	
1(g)	MMO	Lesser number of particles/moles in **B/NaOH** ***OR*** concentration of **B/NaOH** decreases, hence rate of reaction is lowered. **[reject: Lesser reacting particles with no mention of B/NaOH being used up. / Heat loss to the surrounding.]**	[1]	**[1]**
1(h)	ACE	Temp. rise at intersection point × 4.2 × answer in **(e)(i)**	[1]	**[1]**
	PDO	Final answers in **(e)(ii)** and **(h)** are rounded off to 3 s.f. correctly	[1]	
				Total: 18

Question	Skill	Indicative material	Mark	Total
2(a)(i)	MMO	Some blue crystals turn to white powder, while some crystals remained as blue.	[1]	**[1]**
		AND		
		Condensation of water observed in the inner boiling tube.		
2(a)(ii)	MMO	Headers WITH units (1) mass of boiling tube / g (2) mass of boiling tube + **R_1** / g (3) mass of boiling tube + **contents** after heating / g **[reject if the last row of the header state R_1]**	[1]	**[3]**
		Mass to nearest 0.05g for all data	[1]	
		Trend of (1) having the smallest mass and mass in (2) > mass in (3)	[1]	
2(a)(iii)	PDO	(4) Mass of **R_1** before heating = (2) – (1)	[1]	**[2]**
		AND		
		(5) Mass of anhydrous $CuSO_4$ after heating = (3) – (1)		
		Correct units of g	[1]	
2(b)(i)	PDO	$\frac{(5)}{160}$	[1]	**[1]**
2(b)(ii)	PDO	(4) – (5)	[1]	**[1]**
2(b)(iii)	PDO	$\frac{\text{Ans in (b)(ii)}}{18}$	[1]	**[1]**
2(b)(iv)	PDO	$\frac{\text{Ans in (b)(iii)}}{\text{Ans in (b)(i)}}$ **[reject if value of *x* is not within 1 to 5, regardless if the working is correct or not]**	[1]	**[1]**
2(c)	ACE	Heating the sample once for 3 minutes is sufficient for the complete decomposition of **R_1** to anhydrous copper(II) sulfate.	[1]	**[2]**
		Water is completed evaporated from the boiling tube ***OR*** condensed water did not drip back to form hydrated $CuSO_4$.	[1]	
		[reject: - **No decomposition of solid / R1 / $CuSO_4$** - **R_1 did not contain impurities** - **R_1 is a pure substance given** - **(anhydrous) $CuSO_4$ did not further decomposed to form other products {because the blue crystals did not fully decompose based on observations in (a)(i), hence no opportunity for anhydrous $CuSO_4$ to decompose to CuO}** - **No human error** - **Any discussion of the value of x.**		
2(d)(i)	ACE	To prevent the formation of sulfur dioxide, an acidic gas, that can cause irritation to the eyes or respiratory system. ***OR*** Formation of too much oxygen gas can cause other substances to ignite/combust/burn easily.	[1]	**[1]**
		[reject: Sulfur dioxide forms acid rain. / Sulfur dioxide is a toxic gas (NOTE: CO is the only toxic gas in the syllabus). / Sulfur dioxide is a harmful gas. Oxygen is a		

Question	Skill	Indicative material	Mark	Total
		flammable gas.]		
		Common issue: Students did not relate their answers to the sulfur dioxide and oxygen in the equation.		
2(d)(ii)	ACE	Total mass and the number of moles of 'water lost' would be higher than expected because this mass will include the mass of water of crystallisation, sulfur dioxide and oxygen.	[1]	**[3]**
		Mass and the number of moles of $CuSO_4$ calculated would be less than expected.	[1]	
		Calculated value of x would be higher than expected.	[1]	
2(e)		***Equation for understanding:*** $2CuSO_4(aq) + 4KI(aq) \rightarrow 2CuI(s) + I_2(aq) + 2K_2SO_4(aq)$		
2(e)(i)	MMO	Blue solution turns brown/yellowish-brown/orange-brown/orange/reddish-brown [due to formation of aqueous iodine], (which eventually turns to green solution after 5 minutes). ***OR*** White/off-white/ ppt. [due to formation of copper(I) iodide] **[reject: Blue solution turns yellow / Pale yellow ppt. / Brown ppt. / Green ppt.]**	[1]	**[1]**
2(e)(ii)	ACE	(Aqueous) iodine because potassium iodide, a (strong) reducing agent, is oxidised from I^- to I_2. ***OR*** Copper(I) iodide because potassium iodide, a (strong) reducing agent, reduces copper in copper(II) sulfate from Cu^{2+} to Cu^+ in copper(I) iodide. **[reject: Fe^{2+} / Fe^{3+} / Copper(II) iodide / Potassium sulfate because the colourless solution of potassium sulfate could NOT be observed.]** ***Common issue: Students wrote about K being more reactive than Cu, hence displaces Cu from $CuSO_4$.***	[1]	**[1]**
				Total: 18

Question	Skill	Indicative material	Mark	Total
3	P	Detailed description of the Procedure: 1. Heat 1 g of MCO_3 in a dry (hard glass) test-tube until no further change is observed / mass remains constant / volume of gas collected remains constant. 2. Measure the mass of MO using electronic balance after it has cooled. ***OR*** Record the volume of CO_2 collected with a gas syringe. 3. To calculate the mass of CO_2, use mass of MCO_3 – mass of MO. Hence, no. of moles of CO_2 = $\frac{mass\ of\ MCO_3 - mass\ of\ MO}{44}$ ***OR*** no. of moles of CO_2 = $\frac{\text{volume of gas collected}}{24\,000\ \text{cm}^3}$ 4. Based on mole ratio, no. of moles of MO = no. of moles of CO_2 OR no. of moles of MCO_3 = number of moles of CO_2 5. To calculate M_r of MO, use mass of MO ÷ no. of moles of MO. Hence, A_r of M = M_r of MO – 16 ***OR*** To calculate Mr of MCO_3, use mass of MCO_3 ÷ number of moles of MCO3. Hence, A_r of M = M_r of MCO_3 – 60		
		Marking point:		
		(1) Approach with the idea of heating till constant mass is reached / volume of (CO_2) gas remains constant	[1]	**[4]**
		(2) Measurement of mass of MO / volume of (CO_2) gas collected.	[1]	
		(3) Calculation of no. of moles of MO/MCO_3 using the mole ratio	[1]	
		(4) Calculation to determine A_r of M from the number of mole of MO/MCO_3	[1]	
				[Total: 4]