SINGAPORE CHINESE GIRLS' SCHOOL
PRELIMINARY EXAMINATION
SECONDARY FOUR

CANDIDATE NAME	ANSWERS		
CLASS	4	REGISTER NUMBER	

CHEMISTRY

6092/03

Paper 3 Practical Friday

02 Aug 2024

1 hour 50 min

Candidates answer on the Question Paper

READ THESE INSTRUCTIONS FIRST

Write your name, class and register 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 an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction tape.

Answer **all** questions in the spaces provided in 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 9.

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	**/ 15**
2	**/ 16**
3	**/ 9**
Total	**/ 40**

1 The aim of this experiment is to determine the relative formula mass of barium peroxide, BaO_2.

Solution **R**, which contains hydrogen peroxide, was prepared by adding dilute sulfuric acid to 8.50 g of barium peroxide, filtering off the insoluble barium sulfate and diluting the resulting solution to 1.00 dm^3. The equation for the reaction is shown below:

$$BaO_2(s) + H_2SO_4(aq) \rightarrow BaSO_4(s) + H_2O_2(aq)$$ ----- **equation 1**

The concentration of hydrogen peroxide in **R** can be determined by adding acidified aqueous potassium iodide and titrating the liberated iodine with aqueous sodium thiosulfate. The equations for the reactions are shown below:

$$H_2O_2 + 2KI + 2H^+ \rightarrow I_2 + 2H_2O + 2K^+$$ ----- **equation 2**

$$I_2 + 2Na_2S_2O_3 \rightarrow 2NaI + Na_2S_4O_6$$ ----- **equation 3**

You are to determine the concentration of hydrogen peroxide in **R** and use this to determine the relative formula mass of barium peroxide.

Q is 0.100 mol/dm^3 sodium thiosulfate.

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

Instructions

(a) Put **Q** into the burette.

Pipette a 25.0 cm^3 portion of **R** into a flask and add one full test-tube of dilute sulfuric acid followed by about one full test-tube of aqueous potassium iodide. The solution should turn red-brown. Do not add the starch indicator at this stage.

Add **Q** from the burette until the red-brown colour fades to pale yellow, then add a few drops of the starch indicator. This will give a dark blue solution. Continue adding **Q** slowly from the burette until one drop of **Q** causes the blue colour to disappear, leaving a colourless solution. This is the end-point of the titration.

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

Presentation (indicate qn number): –1 overall

Results

Titration Number	1	2
Final burette reading / cm^3	25.10	25.10
Initial burette reading / cm^3	0.00	0.00
Volume of Q used / cm^3	25.10	25.10
Best results (✓)	✓	✓

Headers with units (1), 2 d.p. for burette readings and (b) (1), accuracy (2) ±0.20 per reading, concordance (1) rej: vol, amount, final volume of Q

[5]

(b) From your titration results, obtain an average volume of **Q** to be used in your calculations. Show clearly how you obtained this volume.

Average volume = $\frac{25.20 + 25.20}{2}$ = 25.20 cm^3

working + answer

average volume of **Q** ……………25.20…………… cm^3 [1]

(c) **Q** is 0.100 mol/dm^3 sodium thiosulfate.
Use **equation 3** to calculate the number of moles of iodine liberated.

No. of moles of $Na_2S_2O_3$ = $\frac{25.20}{1000}$ x 0.100 = 0.00252 mol (ecf)

No. of moles of I_2 = $\frac{1}{2}$ x 0.00252 = 0.00126 mol

number of moles of iodine ……………0.00126…………… mol [1]

(d) Using your answer from **(c)** and **equation 2**, calculate the concentration in mol/dm^3, of hydrogen peroxide in **R**.

No. of moles of H_2O_2 in 25.0 cm^3 of **P** = 0.00126 mol (ecf)

Concentration of H_2O_2 in **P** = 0.00126 ÷ $\frac{25}{1000}$ = 0.0504 mol/dm^3 (ecf)

No working – 0m

concentration of hydrogen peroxide in **R** ……………0.0504…………… mol/dm^3 [2]

(e) **R** was prepared by adding dilute sulfuric acid to 8.50 g of barium peroxide and diluting the resulting solution to 1.00 dm^3.

Using your answer to **(d)**, calculate the relative formula mass of barium peroxide.

M_r of BaO_2 = 8.50 ÷ 0.0504 = 168.65 ≈ 169 (3 s.f.)

1m for relative formula mass (no units)

1m working

Wrong working, correct answer – 0m

relative formula mass of barium peroxide is ……………169…………… [2]

(f) After rinsing the burette with distilled water, a student did not rinse her burette with **Q**, before performing the titration. State and explain the impact of this error on her titration results.

As the concentration of **Q** is lowered [1] due to dilution, a larger volume of Q is required to deliver the same number of moles. As such, she will get a larger than expected volume of **Q** used. [1] accept: more dilute rej: affect results / amount of Q

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

(g) Using oxidation numbers, show that **equation 2** is a redox reaction.

KI is oxidised as the oxidation number (O.N.) of iodine increases from –1 in KI to 0 in I_2. [1] H_2O_2 is reduced as the O.N. of oxygen decreases from –1 in H_2O_2 to –2 in H_2O. [1] Since both oxidation and reduction occurs together, this is a redox reaction.

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

[Total: 15]

2 (a) You are provided with solid **C**. Carry out the following tests and record your observations in the table. You should test and name any gas evolved. **C** is copper(II) carbonate

test	observations
Test 1 Place 2 spatulas of solid **C** in a clean test-tube. Heat the test tube strongly.	Green solid turns black. [1] CO_2 gas [1] evolved gives a white ppt. in limewater. [1]. (credited once for Test 1 and Test 2)
Test 2 Place half a spatula of solid **C** in a clean test-tube. Carefully add dilute sulfuric acid until the reaction is complete. Use a glass rod to stir the mixture. Keep the final solution for use in **Test 3 – 4**.	Green solid dissolves/forms/reacts/disappears to form a blue solution. [1] Effervescence observed [1].
Test 3 Place 1 cm depth of the solution formed in **Test 2** in a clean test tube. Add aqueous ammonia slowly with shaking, until no further change is seen.	Light blue ppt. formed, soluble in excess to give a dark blue solution. [1]
Test 4 Place 1 cm depth of the solution formed in **Test 2** in a clean boiling tube. Add an equal volume of potassium iodide. Leave the mixture to stand for a few minutes to observe the colour(s) of the product(s) clearly. Keep the mixture for **Test 5**.	(Ignore brown ppt. formed) **White/grey/light-brown/beige/off-white ppt.** [1] settled below the test-tube, with a **brown solution** above. [1] rej: cream/light yellow
Test 5 To the mixture obtained in **Test 4**, add solution **Q** until the boiling tube is half-full.	(BOD/ecf from test 4) **Brown** solution turns **colourless**. [1] Ignore white ppt. Rej: brown solution turns yellow.

[9]

(b)

You are provided with solution **D**. Carry out the following tests and record your observations in the table. You should test and name any gas evolved. D is iron(III) nitrate

test	observations
Test 1 Place 1 cm depth of solution **D** in a boiling tube and add sodium hydroxide slowly, with shaking, until no further change is seen. Add an aluminium strip and warm the mixture.	red-brown ppt. formed, insoluble in excess. [1] rej: brown / red ignore effervescence NH_3 gas evolved turns moist red litmus paper blue. [1]
Test 2 Place 1 cm depth of solution **D** in a test-tube and add hydrochloric acid.	No observable/visible change OR orange solution turns yellow / pale-yellow. [1]

[3]

(c) Deduce the formula of the compound in solid **C**.

$CuCO_3$ ....[2]

(d) Deduce the formula of the compound in solution **D**.

$Fe(NO_3)_3$ ....[2]

Max 2 marks for if names(s) are given

[Total: 16]

3 (a) All chemical reactions would involve the absorption of energy to break bonds and the release of energy when new bonds are formed. In a chemical reaction, a difference between the amounts of energy absorbed and released would result in an energy change. This usually takes the form of heat energy, which could register as a temperature rise or temperature drop of the reacting solution.

When zinc powder is added to aqueous copper(II) sulfate, an exothermic reaction occurs.

$$CuSO_4(aq) + Zn(s) \rightarrow ZnSO_4(aq) + Cu(s) \qquad \Delta H < 0$$

The maximum temperature change, ΔT_{max}, occurring during this reaction may be determined experimentally.

In this question, you are to plan a procedure that would provide sufficient data to allow you to determine a value for ΔT_{max}. You may assume that you are provided with:

- aqueous copper(II) sulfate
- powdered zinc solid
- the equipment normally found in a school laboratory.

In your plan you should include brief details of:

- the apparatus you would use
- the procedure you would follow
- the measurements you would make to allow you to determine a value for ΔT_{max}.
- how you would use your measurements to calculate a value for ΔT_{max}.

1. Using an electronic balance, measure out 0.5 g of powdered Zn solid into a weighing boat.
2. Using a measuring cylinder, measure 50.0 cm^3 of $CuSO_4(aq)$ into a clean and dry styrofoam cup nested in a 250 cm^3 beaker.
3. Using a thermometer, measure and record the initial temperature of the $CuSO_4(aq)$ as T_1.
4. Quantitatively transfer the powdered Zn solid into the Styrofoam cup.
5. Stir gently with a thermometer, and record the highest temperature reached as T_2.
6. ΔT_{max} can be calculated by $T_2 - T_1$.

Quantities of chemicals used are stated – 1m

Use of Styrofoam cup and thermometer and measuring cylinder/electronic balance – 1m

Measurement and recording of initial and highest temperatures – 1m

Calculation of ΔT_{max} – 1m

[4]

(b) Describe and explain the expected observations during the reaction between zinc powder and aqueous copper(II) sulfate.

- Blue $CuSO_4$ solution decolourises as the concentration of Cu^{2+} decreases. [1]
- Reddish brown Cu solid is produced as the more reactive Zn displaces copper from copper(II) sulfate. [1]

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

(c) Jane carried out an experiment by adding 0.5 g of zinc to 100 cm^3 of 0.1 mol/dm^3 aqueous copper(II) sulfate. Show, by calculations, that zinc is the limiting reagent.
[A_r of Zn = 65]

No. of moles of Zn = 0.5 ÷ 65 = 0.007693 mol
No. of moles of $CuSO_4$ = $\frac{100}{1000}$ x 0.1 = 0.01 mol [1m for both no. of moles]

Since the 0.01 mol of $CuSO_4$ requires 0.01 mol of Zn for complete reaction, while only 0.007693 mol of Zn is available, Zn is the limiting reagent. [1]

[2]

(d) Jane found that the ΔT_{max} for her experiment was +6.5 °C.
Calculate the enthalpy change, ΔH, of the reaction using the equation given below:

$$\Delta H = -\frac{V \times c \times \Delta T_{max}}{no.\ of\ moles\ of\ limiting\ reagent}\ \text{J/mol}$$

where V is the volume of copper(II) sulfate in cm^3
c has a value of 4.2

$\Delta H = -\frac{(100)(4.2)(+6.5)}{0.007693}$
= –354 868 J/mol
≈ –355 000 J/mol (3 s.f.)

ΔH = ……… –355 000 ……… J/mol [1]

[Total: 9]

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

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