



**TANJONG KATONG GIRLS' SCHOOL
PRELIMINARY EXAMINATION
SECONDARY FOUR EXPRESS**

CANDIDATE
NAME

ANSWERS

CLASS

4

INDEX

NUMBER

CHEMISTRY

Paper 3 Practical Test

6092/03

5 August 2025

1 hour 50 minutes

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on all the work you hand in.

Write in dark blue or black pen.

You may use a 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 **13**.

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

Total

This document consists of **13** printed pages and **1** blank page.

- 1 You are going to investigate the reaction between aqueous copper(II) nitrate and aqueous sodium carbonate.

- Step 1: Label the test-tubes 1, 2, 3, 4 and 5 and place them in order in the test-tube rack.
- Step 2: Use the measuring cylinder to pour 5.0 cm^3 of the 1 mol/dm^3 of aqueous copper(II) nitrate into each of the five test-tubes.
- Step 3: Using another measuring cylinder, add 1.0 cm^3 of 1 mol/dm^3 of aqueous sodium carbonate to test-tube 1. Using the glass rod, carefully stir the contents of the test-tube. **Repeat for steps 4 to 7.** Rinse the glass rod with distilled water before stirring it in each test-tube.
- Step 4: Add 2.0 cm^3 of 1 mol/dm^3 of aqueous sodium carbonate to test-tube 2.
- Step 5: Add 3.0 cm^3 of 1 mol/dm^3 of aqueous sodium carbonate to test-tube 3.
- Step 6: Add 4.0 cm^3 of 1 mol/dm^3 of aqueous sodium carbonate to test-tube 4.
- Step 7: Add 5.0 cm^3 of 1 mol/dm^3 of aqueous sodium carbonate to test-tube 5.

Leave the contents of the test-tubes to stand for 15 minutes.

You should start Question 2 while you are waiting for the solid formed in the test-tubes to settle.

- (a) After 15 minutes, use a ruler to measure the height of the solid formed in each test-tube. In Table 1, record the volume of 1 mol/dm^3 of aqueous sodium carbonate added, and the height (in cm) of the solid formed in each test-tube. Include appropriate headings in Table 1.

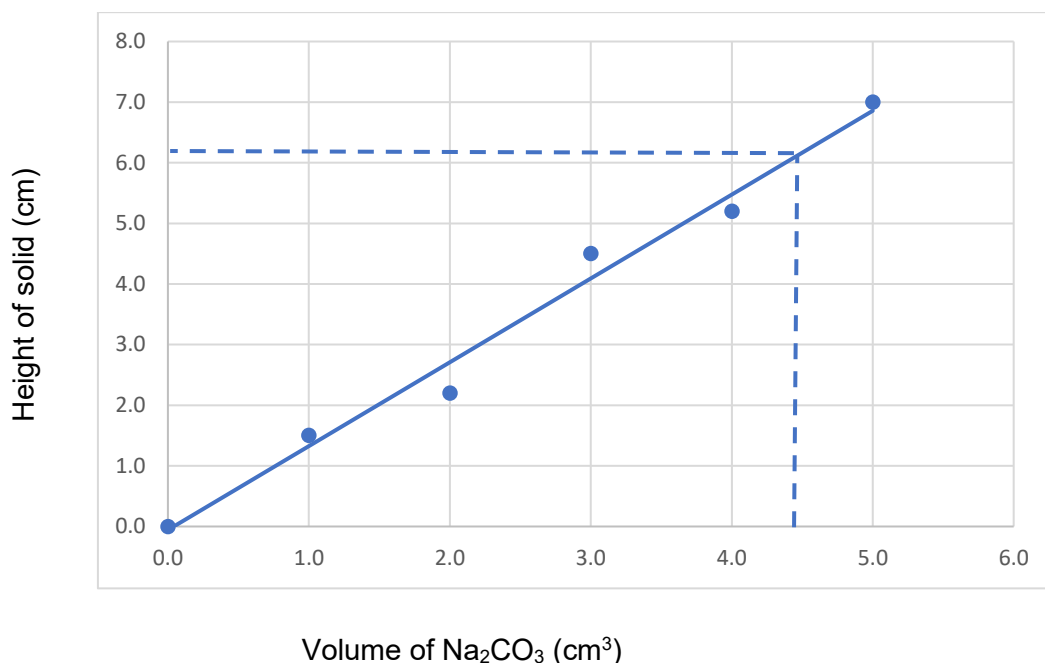
Table 1

test-tube number	Volume of Na_2CO_3 (aq) / cm^3	Height of solid / cm
1	1.0	1.5
2	2.0	2.2
3	3.0	4.5
4	4.0	5.2
5	5.0	7.0

[4]

Volume of Na_2CO_3 (aq) in cm^3 measured to 1 d.p	[1]
Height of solid in cm measured to 1 d.p. (allow mm measurement to nearest whole number)	[1]
Appropriate heading and correct units	[1]
Full set of data shows - correct volumes of Na_2CO_3 (aq), according to question - height increasing with test-tube number	[1]

- (b) On the grid provided, plot a graph of height of solid against volume of aqueous sodium carbonate added.



Axis labels and correct units (based on table of values)	[1]
Appropriate axis and scale must include (0,0) origin (vertical: height of solid / cm; horizontal: volume of aqueous Na_2CO_3 added / cm^3).	[1]
All points plotted correctly from table of values	[1]
Best fit line that uses all/most points and starts from origin Line can be straight or curved, whichever is more suitable (ECF if already penalised for axis not including origin)	[1]

[4]

- (c) Describe the trend in the height of the solids formed in test-tubes 1 to 5.

The height of the precipitate generally increases as the volume of aqueous sodium carbonate added increases [1].

.....[1]

- (d) From the graph, deduce the height of the solid formed when 0.0045 moles of aqueous sodium carbonate is added to 0.005 moles of copper(II) nitrate.

Value from graph with unit (indicated with dotted line) when 4.5 cm³ of aqueous sodium carbonate is added to 5 cm³ of copper(II) nitrate.

.....[1]

- (e) Suggest two improvements that can be made in order to improve the accuracy of the results.

Use a burette to add the copper(II) nitrate to the test tubes.

Repeat experiment twice and calculate average height of precipitate for each test tube.

Allow the precipitate a longer time to settle to the bottom of the test-tube.

[Any two]

.....[2]

[Total: 12]

- 2** Water of crystallisation refers to the water molecules bonded to the lattice structure of ionic compounds.

You are going to investigate the enthalpy change, ΔH_{hyd} , when anhydrous sodium carbonate, Na_2CO_3 , converts to hydrated sodium carbonate, $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$.

One way to determine the enthalpy change is to measure the changes in temperature when samples of anhydrous sodium carbonate and hydrated sodium carbonate are added separately to excess hydrochloric acid.

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

Instructions

You are going to carry out two experiments.

X is 2.2 g of anhydrous sodium carbonate, Na_2CO_3 .

Y is 5.5 g of hydrated sodium carbonate, $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$

Z is 1.50 mol/dm³ hydrochloric acid, HCl.

(a) Experiment 1

Place a Styrofoam cup into a 250 cm³ beaker.

Transfer 25.0 cm³ of **Z** into the cup using the 25 cm³ measuring cylinder. Measure the temperature of **Z** and record the value in the table.

Pour all of **X** into the acid in the cup. Stir, using the thermometer, and measure the highest or lowest temperature reached. Record this temperature in the table.

Experiment 2

Repeat *Experiment 1* using the Styrofoam cup, but use **Y** in place of **X**.

Complete Table 2 and calculate the temperature change for each experiment.

Table 2

experiment	initial temperature of Z /°C	highest or lowest temperature of Z /°C	temperature change /°C
1	30.0	38.5	8.5
2	30.0	21.0	-9.0

All four thermometer readings recorded to .0 °C or .5 °C.

ΔT calculated correctly using $T_{\text{final}} - T_{\text{initial}}$ with negative sign for Experiment 2. Experiment 1 temperature increase AND experiment 2 temperature decrease

Full set of data

2 correct answers= 1mk

[3]

- (b) (i) The amount of heat transferred in the experiments can be calculated using the expression shown.

Heat transferred (J) = mass of solution (g) x maximum temperature change (°C) x 4.2

Use this expression to calculate, in J, the amount of heat transferred in each experiment.

Assume that 1.0 cm³ of solution has a mass of 1.0 g.

Heat transferred in Experiment 1 = $25 \times 4.2 \times 8.5 = \underline{892.5} \text{ J}$ [1]

Heat transferred in Experiment 2 = $25 \times 4.2 \times 9.0 = \underline{945} \text{ J}$ [1]

Allow ECF from incorrect ΔT

Answers to be in 2-3 sf

Experiment 1 with X: heat transferred =J

Experiment 2 with Y: heat transferred =J [2]

- (ii) Calculate the enthalpy change, ΔH , in kJ/mol, when all the solid reacts with hydrochloric acid in each experiment.

[M_r : Na_2CO_3 , 106, $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$, 286]

$\text{Enthalpy change, } \Delta H = \frac{\text{Heat transferred in kJ}}{\text{Number of moles of solid}}$

$$\begin{aligned} \Delta H_1 &= \frac{892.5 \times 106}{2.2 \times 1000} \\ &= -43.0 \text{ kJ/mol} \end{aligned} \quad [1]$$

$$\begin{aligned} \Delta H_2 &= \frac{945 \times 286}{5.5 \times 1000} \\ &= +49.1 \text{ kJ/mol} \end{aligned} \quad [1]$$

H_1 is negative (exothermic) and ΔH_2 is positive (endothermic).

Answers to be in 3 sf

Experiment 1 with X: $\Delta H_1 = \dots\dots\dots$ kJ/mol

Experiment 2 with Y: $\Delta H_2 = \dots\dots\dots$ kJ/mol [2]

- (iii) The enthalpy change of hydration, ΔH_{hyd} , can be calculated using the expression:

$$\Delta H_{\text{hyd}} = \Delta H_1 - \Delta H_2$$

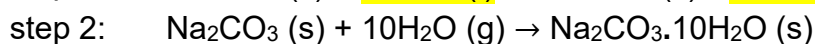
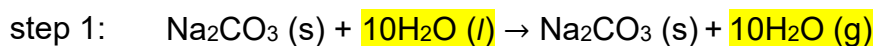
Use your answers from (b)(ii) to calculate the enthalpy change of hydration, ΔH_{hyd} .

$$\begin{aligned} \Delta H_{\text{hyd}} &= \Delta H_1 - \Delta H_2 \quad [1] \\ &= -43.0 - 49.1 \\ &= -92.1 \text{ kJ/mol} \end{aligned}$$

Allow ECF

$$\Delta H_{\text{hyd}} = \dots\dots\dots \text{ kJ/mol} [1]$$

- (iv) Another way to determine the hydration of anhydrous sodium carbonate can be shown in a two-step chemical equation as shown.



Using your knowledge of Kinetic Particle Theory, explain if **step 1** is an endothermic or exothermic process.

Since energy is taken in to weaken the forces of attraction [1]
between the water molecules, the reaction is endothermic [1].

.....[2]

- (v) Explain why it is necessary to stir the mixture in the cup before measuring the highest or lowest temperature reached.

Ensure even distribution of heat in the mixture

.....[1]

- (vi) State one source of error and suggest one improvement that can be made to reduce this error.

Error: Volume of liquids measured is not accurate. [1]

Improvement: Use a burette which is of higher accuracy. [1]

OR

Error: Heat loss from solution to surroundings [1]

Improvement: Use a lid to minimise heat loss to the surroundings.
[1]

- (vii) A student carrying out the experiment with an anhydrous sodium carbonate, **X**, could not find 1.50 mol/dm^3 hydrochloric acid. The student used the same volume of 0.750 mol/dm^3 sulfuric acid instead.

Predict the effect on the change in temperature obtained by the student. Assume the same mass of **X** was used.

There will be no change or no effect on the temperature change [1]

Since sulfuric acid is a dibasic acid, it will have the same mole/concentration of H^+ ions as the 1.50 mol/dm^3 of HCl . [1]

.....[2]

[Total: 15]

3 Read all the instructions carefully before starting the experiments in Question 3.

You are provided with a mixture of two solids, **J** and **K**, which are both salts. **J** is soluble and **K** is insoluble in water.

Carry out the following tests and record your observation. You should test and name any gas evolved. If no change is observed for a test, write 'no observable change'.

Instructions

- (a) Add 3 spatulas of the mixture to a boiling tube. Add a 6 cm depth of distilled water to the mixture. Stopper the boiling tube with a rubber bung and shake the mixture for a minute.

Filter the mixture and keep the residue for tests later.

Tests on filtrate

Divide the solution into two equal portions in two test-tubes.

test	observations
Test 1 To the first portion of the solution, add about 1 cm depth of aqueous sodium hydroxide and shake the contents. Heat the contents carefully and test any gas evolved with damp litmus paper.	No observable change. Pungent gas evolved turns <u>moist red litmus blue</u> . Gas is <u>ammonia / NH₃</u> . [both answers=1 mk]
Test 2 To the second portion of the solution, add a 1cm depth of dilute nitric acid into a test-tube. Add a few drops of aqueous silver nitrate.	White ppt formed. [1]

Test on residue

test	observations
Test 3 Use a spatula to transfer some of the residue into a test-tube. Add dilute hydrochloric acid to a depth of approximately 3 cm. To the solution formed, add about 1 cm depth of dilute sulfuric acid	 Effervescence. Gas forms white ppt in limewater. Gas is CO ₂ [1] White ppt formed [1]

[4]

- (b) Deduce the formulae of the cation and anion present in solid J.

cation: **NH₄⁺**

anion: **Cl⁻**

[2]

- (c) Using your knowledge on solubility rules, suggest the identity of solid K. Use your observations to explain how you reached the conclusion.

solid K **barium / calcium / lead carbonate [1]**

When hydrochloric acid is added to the residue, effervescence is formed indicating the anion is a carbonate. White ppt formed when sulfuric acid is added indicating the cation can be either Ba²⁺, Ca²⁺ or Pb²⁺. **[1]**

..... [2]

- (d) A farmer would like to fertilise his soil with the fertiliser ammonium sulfate, $(\text{NH}_4)_2\text{SO}_4$.
He took a sample of the soil from his farmland and would like to find out the amount of ammonium sulfate fertiliser already present in the soil.

You are **not** to use precipitation method to answer.

With the help of a chemical equation, outline a method to determine the mass of sulfate ions present in the soil.

- **Dissolve** a known mass (e.g 5.0 g) of the soil sample in **water**.
- **Filter** the mixture and **collect ammonium sulfate** solution as **the filtrate**.
- Add **excess NaOH** to the filtrate and warm. **Use a gas syringe** to collect the **volume of ammonia gas** produced.



- Find the **number of moles of ammonia gas and ammonium/sodium sulfate**:

$$\text{Moles of ammonia gas} = \frac{\text{Volume of ammonia gas}}{24000}$$

$$\text{Number of moles of sodium sulfate} = \frac{\text{Number of moles of ammonia gas}}{2}$$

- Number of moles of sodium sulfate = Number of moles of sulfate (SO_4^{2-})
- Calculate mass of sulfate (SO_4^{2-}): **Number of moles X molar mass**

.....[5]

[A] Approach (correct concept) Ammonium salt reacts with alkali to form salt, NH_3 gas and water Reject: Precipitation method	[1]
[P] Procedure • Dissolve a known mass of soil in water and filter • Add excess NaOH and measure NH_3 gas using a gas syringe	[1] [1]
[DP] Data Processing • Chemical equation (correct reactants and products with proper balancing) • Show correctly how the number of moles of ammonia and the mass of sulfate are formed	[1] [1]

[Total: 13]

Common mistakes:

- Did not dissolve soil in water and filter, add NaOH (aq) immediately instead
- React ammonium sulfate with acid (HCl) to form ammonia/hydrogen gas instead of alkali
- Use precipitation method instead (did not read the question carefully)
- Heat the ammonium sulfate solution to get sulfate ions and calculate the mass
- Incorrect or unbalanced chemical equation for the reaction between ammonium sulfate and alkali.

NOTES FOR QUALITATIVE ANALYSIS

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 with 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

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