WAKATA PUBLISHERS

UCE CHEMISTRY 545/2 & 545/3 PRACTICAL WORK BOOK 2026 EDITION

UCE
Chemistry
545/2 & 545/3

Practical Workbook

2026 Edition by WAKATA

UCE

Chemistry

545/2 & 545/3

Practical Workbook

BY

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Edition 2026

Contents page

Paper Format (545/2 or 545/3)

A Chemistry practical paper typically contains **one experimental item**, which may be selected from any of the following areas:

- Thermochemistry (Heat of solution, Heat of neutralization, Heat of displacement)
- Rates of chemical reactions
- The reactivity series
- Hard water and soapy detergents
- Solubilty of salts
- Acid – base reactions

Candidates are required to attempt **only one item** within a duration of **two hours**.

Nature of Practical Item

The practical item in the paper may include:

- A scenario or real-life situation
- A clearly defined task
- Helpful hints or guidelines

Expected Candidate's Report / Responses

- Aim of the investigation / experiment
- Variables
- Hypothesis
- Procedure which includes list of apparatus
- Risks / Sources of errors and Mitigations
- Data presentation in table
- Data analysis and interpretation using graph and calculation
- Conclusion and advice

Aim of the investigation / experiment

A candidate is expected to clearly state the aim and purpose of the chemical investigation.

The aim should:

- Indicate what is being investigated or determined
- Mention the substance, process, or relationship involved
- Indicate the intended application or decision, where applicable

Examples:

- *An experiment to determine the rate of reaction between dilute hydrochloric acid and calcium carbonate at different temperatures.*
- *An experiment to determine the solubility of potassium nitrate in water at various temperatures.*
- *An experiment to determine the heat of neutralisation between hydrochloric acid and sodium hydroxide.*

The aim should be **precise, specific,** and **measurable**.

Variables

A candidate should state the variables to be dealt with during the experiment.
The candidate should identify the **dependent variables**, **independent variables** and **control variables**.

Independent variable:

This is the variable that the candidate intentionally changes during the experiment in order to observe its effect.

Examples:

- Temperature of reactants
- Concentration of an acid or alkali
- Mass of a solid reactant
- Volume of a reactant
- Surface area of a solid
- Time of heating
- Etc.

Dependent variable:

This is the variable that changes as a result of altering the independent variable **and is usually** measured or observed.

Examples:

- Time taken for a reaction to complete
- Volume of gas produced
- Change in temperature
- Mass of precipitate formed
- Rate of reaction
- Solubility of a salt
- Etc.

Controlled variables:

These are variables that must be kept constant throughout the experiment to ensure a fair test.

Examples:

- Volume of reactants
- Type of reactants used
- Pressure (especially in gas experiments)
- Same apparatus and method
- Same catalyst (if used)

Some variables may not be easily measurable but must still be controlled, such as:

- Heat loss to the surroundings
- Atmospheric conditions
- Human reaction time
- Etc.

Hypothesis

A hypothesis is a brief prediction **or** expected outcome of the experiment, based on known chemical principles.

It should:

- Be short and precise
- Be testable
- Indicate the expected relationship between variables

Examples:

- *Increasing the temperature increases the rate of reaction.*
- *The solubility of potassium nitrate increases with increase in temperature.*

- Consistent decimal places

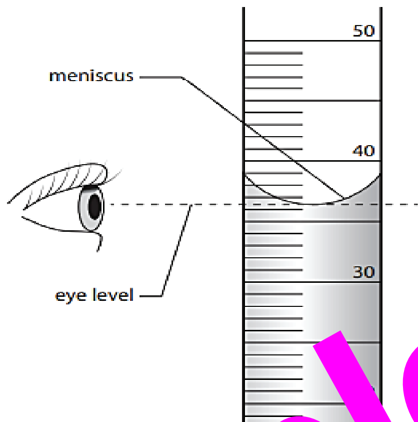
Example structure:

- Independent variable
- Dependent variable
- Repeated readings (if required)

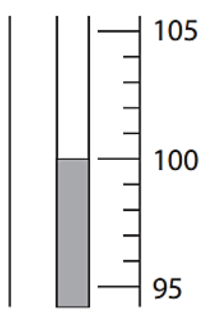
Mean values (where applicable)

Measuring

Being able to take accurate measurements is an essential skill for all chemistry students. As part of the UCE course you will be expected to be able to take accurate measurements using a variety of different apparatus. When using measuring cylinders you will need to look for the meniscus, which is the bottom of the curve formed by the liquid.



Thermometers are a very common tool for measuring temperature in chemistry experiments so you will need to be able to take readings reliably. Not all of the points of the scale on a thermometer will be marked but you will still need to be able to determine the temperature. To do this you will need to work out the value of each graduation. In the diagram below there are four marks between 95 and 100. Each of these marks indicates 1°C.



Students' micro - projects

Chemistry teachers are advised to organize science visits for application of chemistry knowledge. Such sites to visit can be:

- Sugar factory
- Water / sewerage plants
- Salt works
- Beer / distiller / soft drinks
- Oil processing plant
- Plastics factory e.g. foam Mattress, plastic containers, plastic sheeting / tubing
- Battery works / manufacturing
- School audit (atmospheric pollution) / Environmental audits of the nearest water catchment for mineral resources, environment pollutants, community enterprises that reflect chemical at work
- Detergents factory / Producer of personal care (beauty) products
- Leather tannery

Chemistry Practical Investigation areas and guidelines

1. Thermochemistry

Thermochemistry deals with heat energy changes that occur during chemical reactions.

(a) Heat of solution

Heat of solution is the heat change when one mole of a substance dissolves in a solvent, usually water, at constant pressure.

Nature of the process

- It can be exothermic (temperature increases)
- Or endothermic (temperature decreases)

Aim

To determine the heat change when a known mass of a solid dissolves in water.

Independent variable

- Mass of solute (or type of solute)

Dependent variable

- Change in temperature (ΔT)

Controlled variables

- Volume of water
- Initial temperature of water

Neutralisation

Acid + base → salt + water

Practical applications

- Titration
- Soil treatment
- Industrial processes

Conclusion

Acid–base reactions result in neutralisation and heat release.

Worked out examples

Worked Example l

A petroleum industry organized a work shop to train its members on how to make laundry detergents which they can use to clean their wash stained clothes, toilets, offices, and other items. This involved reacting sulphuric acid with potassium hydroxide. In this workshop, participants conducted an experiment as instructed by the trainer. They mixed a solution of sulphuric acid and potassium hydroxide. On observation, the temperature of the solutions raised. One of them asked why the mixture became warmer during the process whenever an acid is added to potassium hydroxide.

The heat produced varies with the volume of the sulphuric acid added to the potassium hydroxide.

The sulphuric acid provided was **BA2** and the potassium hydroxide was **BA1**.

Potassium hydroxide reacts with sulphuric acid according to the following equation.

$$2KOH(aq) + H_2SO_4\,(aq) \rightarrow K_2SO_4\,(aq) + H_2O\,(l) + Heat$$

Task:

(a) Design an experiment to measure the amount of heat given out during the manufacture of the laundry detergent.

(Your design should include the aim, hypothesis, variables, apparatus and materials, procedure, risks and their mitigations)

(b) Carry out the experiment and record your findings *(A minimum of* **five** *readings is required.)*

(c) Which conclusion can the participants draw from their experimental findings?

Student X's Expected Response

(a) Aim: An experiment to determine the maximum heat produced during the reaction of potassium hydroxide (BA1) and sulphuric acid (BA2).

Variables of the Experiment

- Independent variable: Volume of sulphuric acid (BA2) added (e.g., 5, 10, 15 cm^3, etc.), labeled on the x-axis of the graph.
- Dependent variable: Maximum temperature of the mixture (ΔT), labeled on the y-axis.
- Controlled variables:
  - Volume of potassium hydroxide (BA1) fixed (e.g., 25 cm^3)
  - Initial temperature of solutions
  - Concentration of acid and base
  - Same container and stirring method

Hypothesis

The reaction between potassium hydroxide and sulphuric acid produces heat (exothermic reaction).

Materials

- Pipette (25 cm^3)
- Burette (50 cm^3)
- Thermometer
- Plastic beakers/cups
- Retort stand
- BA1 (KOH solution)
- BA2 (H_2SO_4 solution)
- Stirring rod

Procedure of Experiment

(i) 25 cm^3 of BA1 was pipetted into a plastic beaker and its initial temperature was recorded.

(ii) The initial temperature of BA2 was noted.

(iii) BA2 was poured into a burette and the burette was adjusted to the zero mark.

(iv) BA2 was added to BA1 in uniform intervals of 5 cm^3 (or 10 cm^3), with gentle stirring after each addition.

(v) The highest temperature after each addition was recorded.

(vi) The procedure was repeated until 7–8 readings were obtained (up to 35–40 cm^3).

(vii) The results were tabulated and the temperature changes were calculated.

Risks and Mitigations

- Risk: Swallowing the base while pipetting
  Mitigation: Used a pipette filler.

- Risk: Acid spills on skin
  Mitigation: Wore lab coat, gloves, and closed shoes.

- Risk: Breakage of thermometer
  Mitigation: Returned to case after use.

(b) **Table of Results**

Initial temperature of BA1: 27.5 °C;
Initial temperature of BA2: 25.0 °C;
Average initial temperature: 26.25 °C.

Volume of Pipette = 25.0cm^3

Volume of BA2 added (cm^3)	0	5	10	[illegible]	[illegible]	[illegible]	30	35	40
Highest temp. of mixture(^{o}C)	28.0	29.5	31.0	[illegible]	[illegible]	34.0	34.5	33.5	33.0

See next page for graph

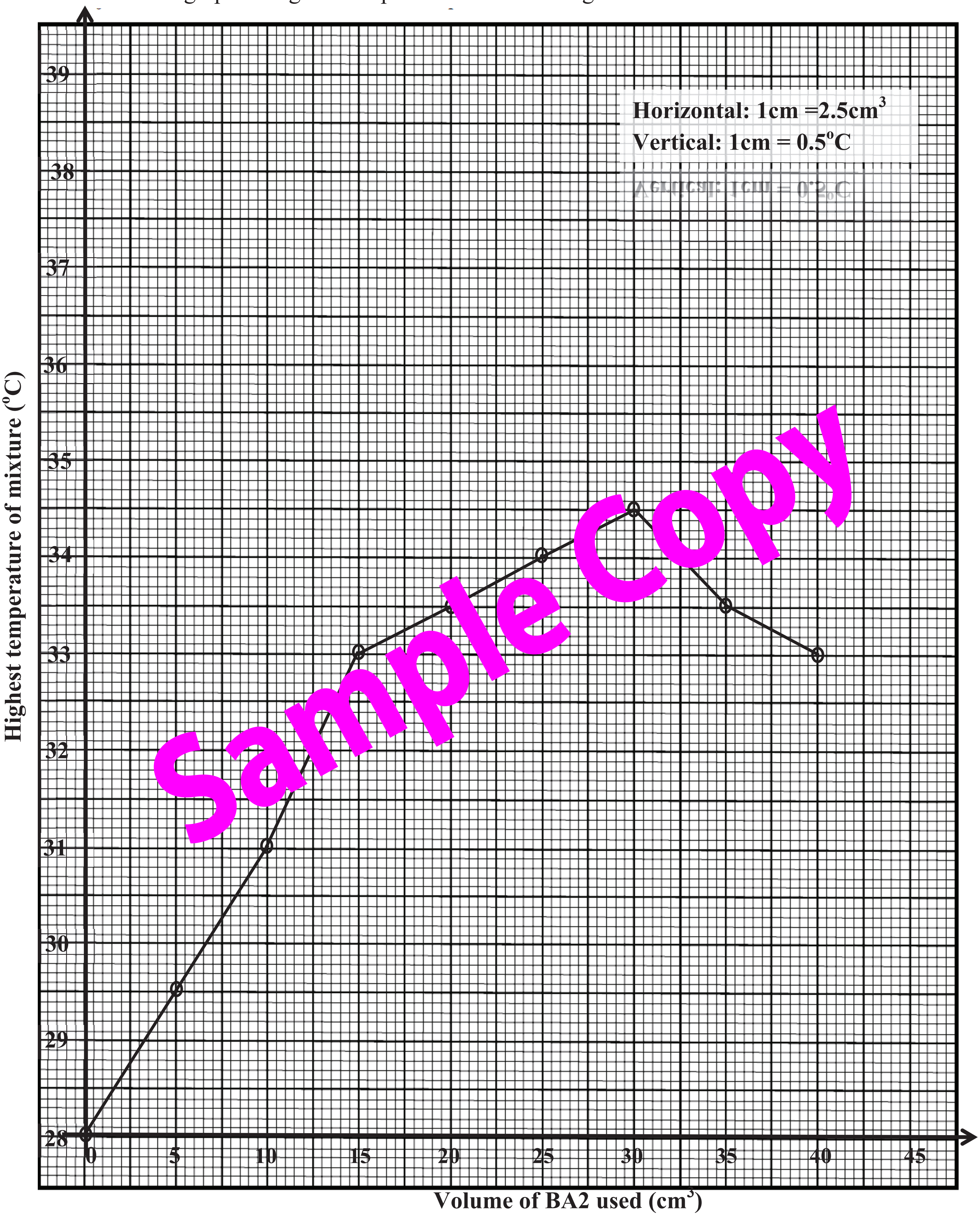
(c) **Data Analysis and Interpretation**

Heat evolved by reaction = Heat gained by mixture.
= mC[illegible]
Highest temperature [illegible] = 6.5 ^{0}C
Volume of the BA2 used = 30cm^3
Heat evolved = (25 +30) × 4.2 × (35.5 – 28.0)
= –1,501.5 J mol^{-1}

Conclusion

- The reaction between potassium hydroxide and sulphuric acid is **exothermic**.
- Maximum heat evolved occurs when 25 cm^3 of BA1 reacts with 30 cm^3 of BA2.
- The heat produced explains why the mixture becomes warmer during the detergent preparation.

A graph of highest temperature of mixture against volume of BA2 added



Worked Example 2

A soap-making factory releases alkaline waste water containing sodium hydroxide during the cleaning of its production tanks. Before this waste water can be safely discharged into the environment, it must be neutralised using sulphuric acid to prevent harm to aquatic life and damage to drainage systems. The factory technician needs to know the exact volume of sulphuric acid required to completely neutralise a known volume of the alkaline waste.

You are provided with:

- **BA1** which is a 1.0 M sulphuric acid solution
- **BA2** which is a Sodium hydroxide solution (representing the alkaline waste water)
- Common laboratory apparatus

Task:

(a) Design an investigation to determine the volume of sulphuric acid required to completely neutralise 25 cm^3 of sodium hydroxide solution.
(Your design should include the aim, hypothesis, variables, apparatus and materials, procedure, risks and their mitigations)

(b) Carry out the experiment and record your findings *(A minimum of* ***five*** *readings is required.)*

(c) Analyse your results and advise the factory technician accordingly.

Student X's Expected Response

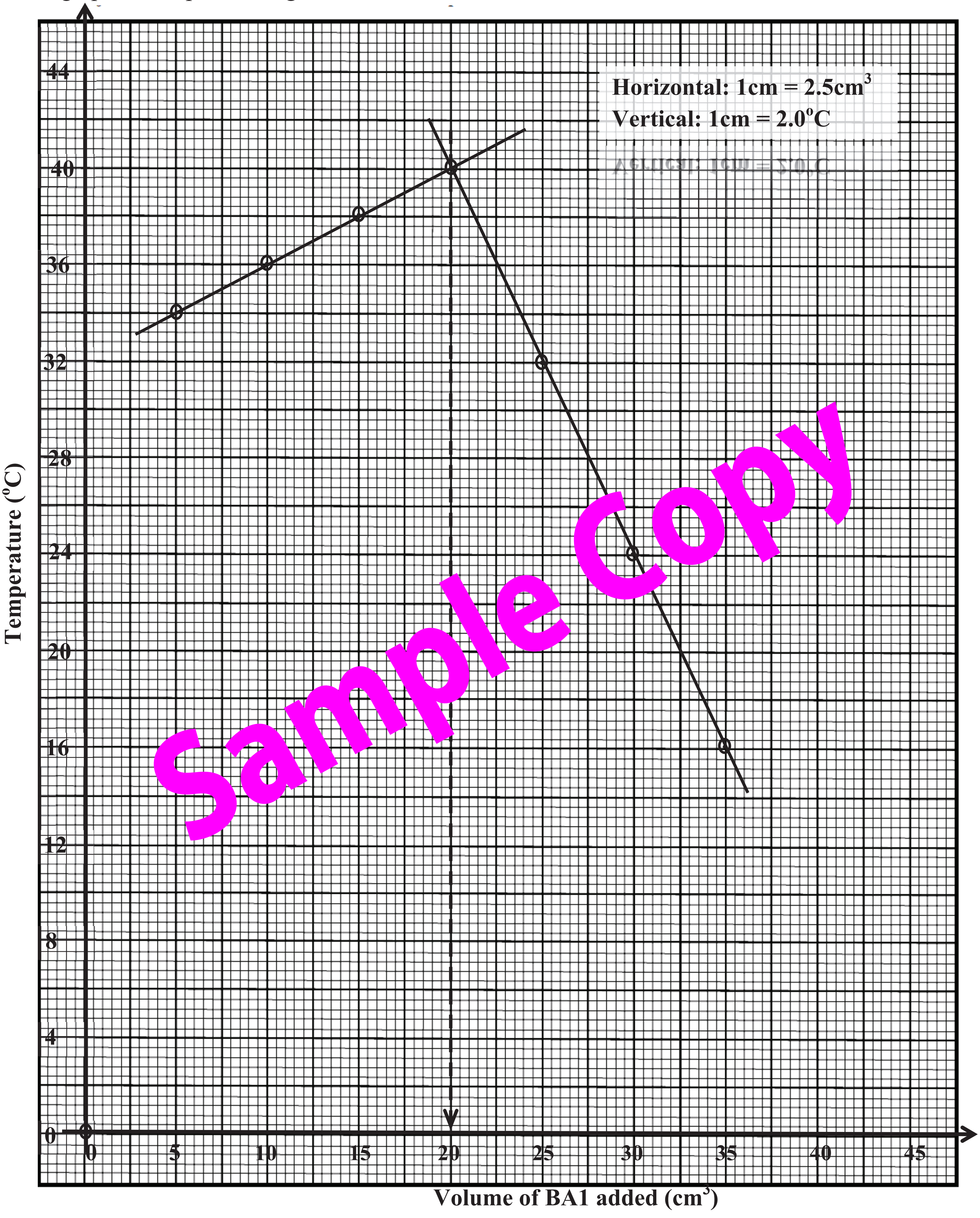
(a) **Aim of the experiment:**
To determine the Volume of sulphuric acid required for complete neutralization of $25cm^3$ of sodium hydroxide solution.

Variables of the experiment
Independent Variable: Volume of BA1 (1M sulphuric acid).
Dependent Variable: Maximum Temperature during the neutralization reaction.
Controlled Variable: Initial concentration and volume of BA2 (sodium hydroxide solution)

Hypothesis

Complete neutralisation of sodium hydroxide occurs when a definite volume of sulphuric acid is added.

A graph of temperature against volume of **BA1**



(c) **Data Analysis and Interpretation**

Volume of **BA1** required for complete neutralization of 25cm^3 of **BA2** is obtained from the graph and it is approximately equal to 20.0cm^3

The experiment confirms the hypothesis regarding the neutralizing capacity of **BA2**.

Worked Example 3

Sulphur is widely distributed as a free element and in combined forms. It is commonly found near volcanoes and occurs in many metal ores such as galena and zinc blende. Extracted sulphur is used in the manufacture of sulphur-containing drugs, such as antifungal medicine. There is currently an outcry over the shortage of antifungal medicine because the supply of sulphur has decreased.

Students in a certain school were tasked with preparing sulphur to support the manufacture of medicine. They chose to prepare colloidal sulphur from the reaction between sodium thiosulphate solution and dilute hydrochloric acid, according to the equation below:

$$Na_2S_2O_3(aq) + 2HCl\,(aq) \rightarrow 2NaCl\,(aq) + S(s) + SO_2(aq) + H_2O\,(l)$$

Their teacher asked them to prepare the sulphur as quickly as possible and advised them to vary the concentration of the reactants to increase the rate at which sulphur is formed. He provided them with:

BA1 which is a solution containing sodium thiosulphate

BA2 which is a solution containing hydrochloric acid

BA3 distilled water

All other apparatus required for the investigation

Task:

(a) As one of the educate club students, design an experiment to investigate the effect of concentration on the reaction between **BA1** and **BA2**, make a report about your findings. *(Your design should include the aim, hypothesis, variables, apparatus and materials, procedure, risks and their mitigations)*

(b) Carry out the experiment and record your findings *(A minimum of* **five** *readings is required.)*

(c) Analyse your results and advise the students accordingly.

NB:

BA1 *is prepared by dissolving* **24.8g** *of Sodium thiosulphate-5-hydrate to make one litre of solution*

BA2 *is prepared by diluting* **129cm^3** *of concentrated hydrochloric acid* (**1.18g/cm^3, 36%)** *acid with distilled water to make* **one litre** *of solution.*

Student X's Expected Response

(a) Aim:

To investigate the effect of concentration on the rate of formation of sulphur when sodium thiosulphate solution (BA1) reacts with hydrochloric acid (BA2).

Hypothesis

Increasing the concentration of sodium thiosulphate solution increases the rate at which sulphur is formed when it reacts with hydrochloric acid.

Variables

Independent variable

- Concentration of sodium thiosulphate solution (BA1), obtained by dilution with distilled water (BA3).

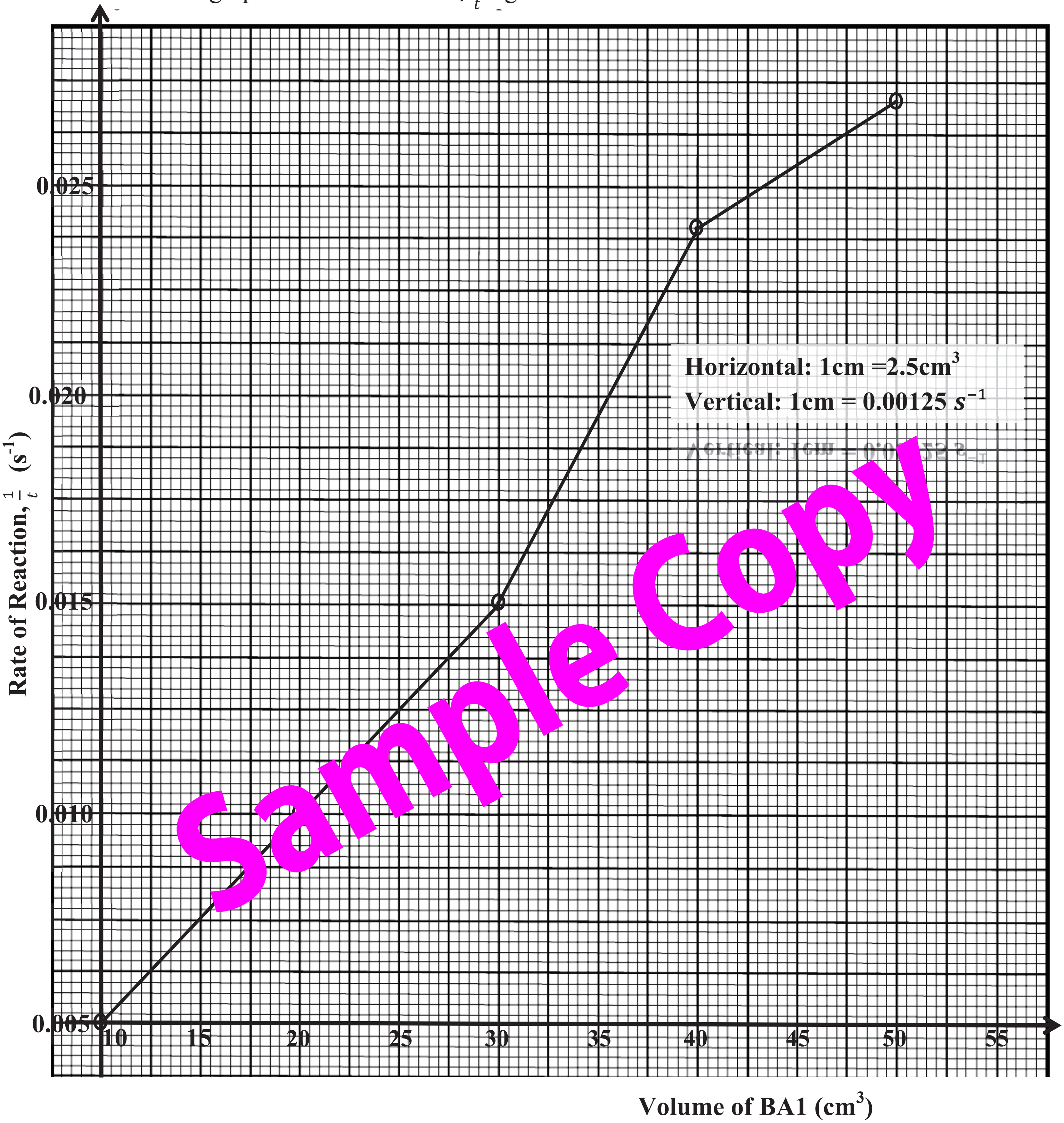
Dependent variable

- Time taken for sulphur to form (measured as the time taken for a cross to disappear).

Controlled variables

- Volume of hydrochloric acid (BA2)
- Concentration of hydrochloric acid
- Total volume of the reaction mixture
- Temperature of the reaction
- Same apparatus and observation method

A graph of rate of reaction, $\frac{1}{t}$ against Volume of **BA1**



Worked Example 4

A local soap-making cooperative in Kibuku Town uses **solid Y** as a raw material in some of its products. Recently, some batches of soap were not consistent, and the cooperative suspects that **solid Y** may be impure. They know that pure **solid Y** melts sharply at 80–82 °C. They also heard that a cooling curve experiment can help determine the purity of solid substances but do not know how to perform it.

You are provided with **solid Y (naphthalene, $C_{10}H_8$)**, a sample from the batch, and common laboratory apparatus.

Task:

(a) As a chemistry learner, design an experiment you would carry out using the cooling curve method to determine whether **solid Y** is pure.
(Your design should include the aim, hypothesis, variables, apparatus and materials, procedure, risks, and their mitigations.)

(b) Carry out the experiment and record your results.
(A minimum of **six readings** *is required.)*

(c) Analyse your results and advise the cooperative on whether the **solid Y** is suitable for use.

Student X's Expected Response

(a) Aim:

To determine the purity of solid **Y** (naphthalene) using a cooling curve.

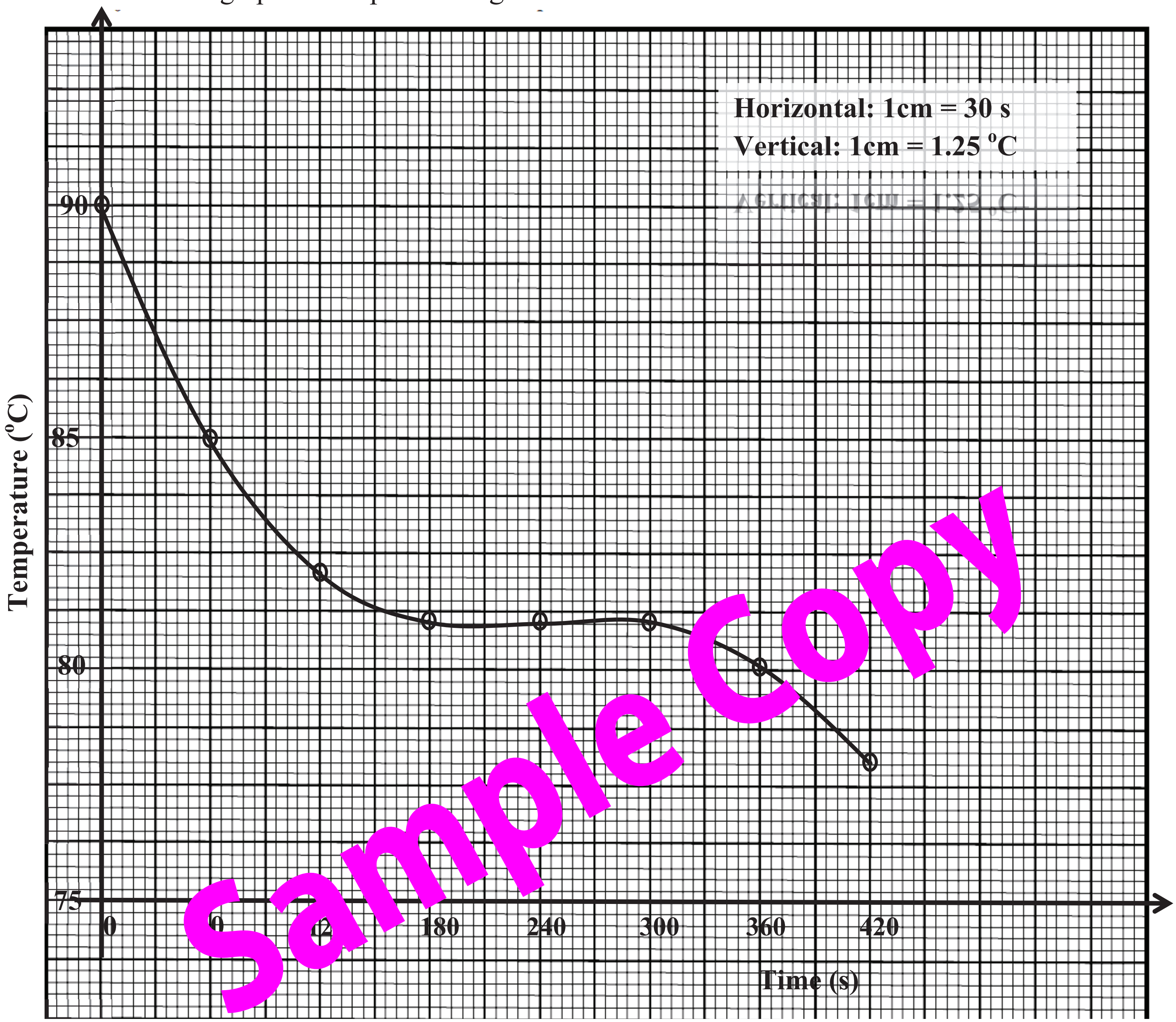
Hypothesis

If solid **Y** (naphthalene) is pure, it will solidify at a constant temperature of 80–82 °C.
If it is impure, the solidification will occur over a range of temperatures.

Variables

- **Independent variable:** Time (minutes or seconds)
- **Dependent variable:** Temperature of solid **Y** (°C)
- **Controlled variables:**
  - Mass of naphthalene

A graph of temperature against time for solid **Y**



Worked Example 5

A small electronics company in Jinja wants to design a heat-generating safety device that uses metals to trigger chemical reactions. The engineers need to choose between Metal **X** and Metal **Y** to produce the most heat when reacting with copper (II) sulphate.

The company wants to know which metal is most suitable for the device. To do this, they plan to measure the heat produced when each metal reacts with copper (II) ions over time. The metal that generates the highest amount of heat will be selected for production.

You, as a chemistry learner, have been consulted to design a clear experiment and report to help the company make the best decision.

You are provided with:

- Powdered zinc (Metal **X**) – 2.0 g
- Powdered iron (Metal **Y**) – 2.0 g
- 120 cm^3 of 0.5 M copper (II) sulphate solution (**BA1**)
- Two plastic beakers
- Thermometer
- Measuring cylinder (50/100 cm^3)
- Stopwatch or clock
- Cotton wool

Task:

(a) Design an experiment to determine the amount of heat evolved when each metal reacts with copper (II) sulphate. *(Your design should include the aim, hypothesis, variables, apparatus and materials, procedure, risks, and their mitigations*.)

(b) Carry out the experiment and record your results. *(A minimum of* **six readings** *is required.)*

(c) Analyze the results and advise the company on which metal is most suitable for their device.

Student X's Expected Response

(a) **Aim:**

To determine which metal, Metal **X** or Metal **Y**, produces the most heat when reacting with copper (II) sulphate **(BA1)** solution.

Hypothesis:
The reaction between Metal **X** and copper (II) sulphate will produce more heat than the reaction between Metal **Y** and copper (II) sulphate.

Variables:

- Independent variable**:** Type of metal used
- Dependent variable: Temperature of the mixture (maximum temperature reached)
- Controlled variables:
  - Mass of metal
  - Volume and concentration of copper (II) sulphate
  - Type of container (plastic beaker)
  - Ambient temperature
  - Stirring method

Apparatus and Materials:

- Metal **X**
- Metal **Y**
- Copper (II) sulphate solution (120 cm³)
- Two plastic beakers
- Thermometer
- Measuring cylinder (50/100 cm³)
- Stopwatch
- Cotton wool (to insulate beaker if necessary)

Procedure of the experiment

(a) 50 cm³ of copper (II) sulphate solution was measured using a measuring cylinder and poured into a plastic beaker.

(b) 2.0 g of Metal **X** was measured and added to the beaker containing the copper (II) sulphate solution.

(c) A thermometer was immediately inserted into the mixture and a stopwatch was started.

(d) The temperature of the mixture was recorded at 30-second intervals for 4 minutes.

(e) The procedure was repeated using 2.0 g of Metal **Y** in a separate plastic beaker containing 50 cm^3 of copper (II) sulphate solution.

(f) The temperature readings were then tabulated against time for each metal.

Risks and Mitigations:

- **Risk:** Spillage of copper (II) sulphate solution.
  Mitigation: Used a funnel and careful pouring.
- **Risk:** Metal powders may irritate skin or eyes.
  Mitigation: Wore gloves and safety goggles.
- **Risk:** Thermometer breakage.
  Mitigation: Handled with care and placed on flat surface.

(b) Results

Table of results

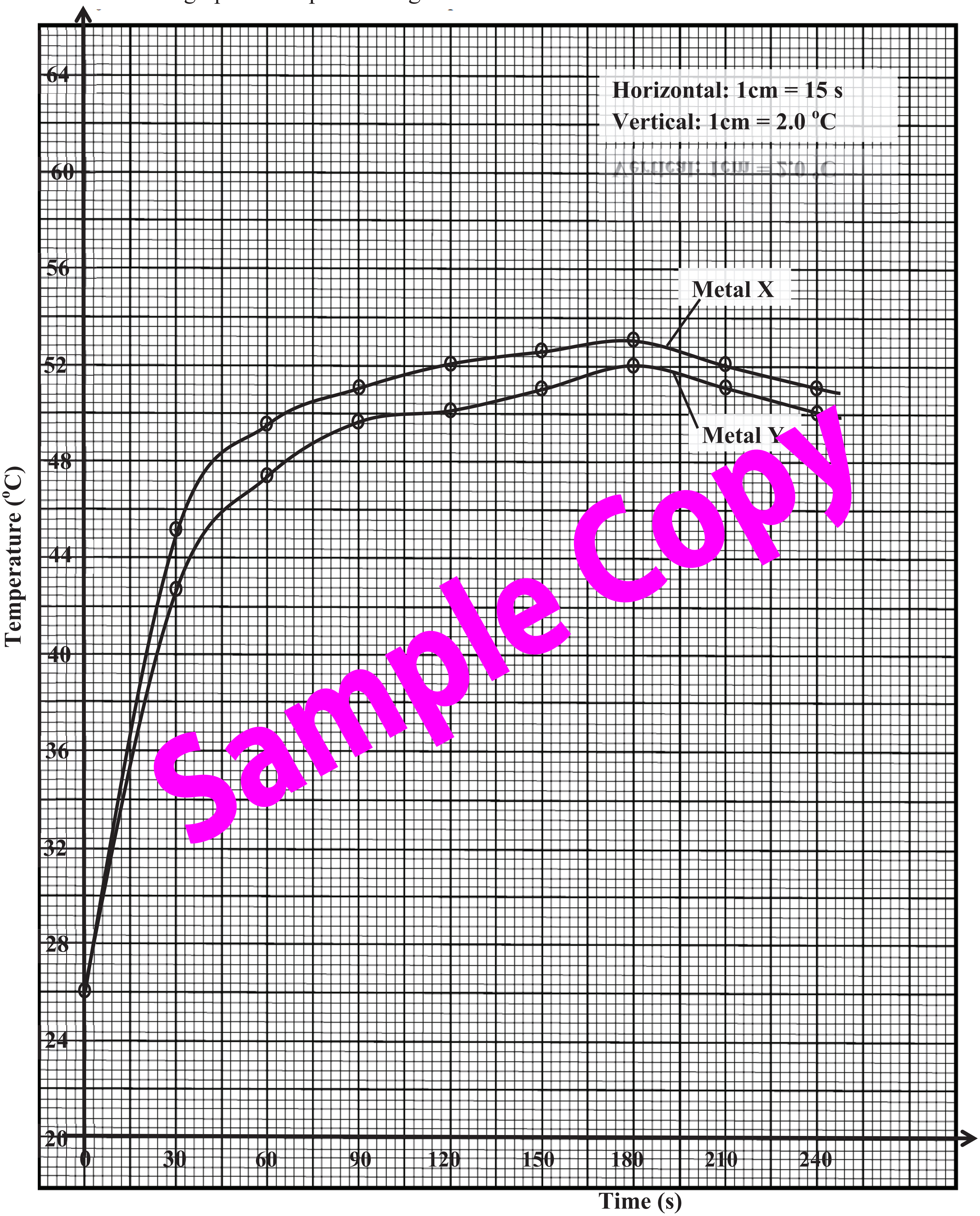
Time (s)	0.0	30.0	60.0	90.0	120.0	150.0	180.0	210	240.0
Temperature of X (°C)	26.0	45.0	4[illegible].5	51.0	52.0	52.5	53.0	52.0	51.5
Temperature of Y (°C)	26.0	4[illegible].5	47.5	49.5	50.0	51.5	52.0	51.0	50.0

See graph on next page

(c) Analysis and Conclusion

- Metal **X** reacts faster and produces a higher maximum temperature than metal **Y**.
- The value / amount of temperature produced is directly proportional to the amount of heat produced
- **Advice to Company:** Metal **X** is more suitable for the heat-generating safety device because it releases more heat during the reaction with copper (II) sulphate.

A graph of temperature against time



Worked Example 6

A community laundry centre in Budama Sub-county provides washing services to schools and nearby households. Recently, many clients complained that their clothes develop white patches and feel rough after washing, especially when soap is used in large amounts.

The manager suspects that the water contains dissolved mineral salts (hard water)**,** which interfere with washing.

The laundry centre uses tap water stored in containers, and approximately 100 litres of water are used each day.

You are provided with:

- BA1: Soap solution
- Hard water sample
- Measuring cylinders, beakers, test tubes
- Filter paper and funnel
- Balance, stirring rod
- Common laboratory apparatus

The reaction representing the interaction of soap with hardness ions is:

Hard water + Soap → Scum (insoluble precipitate)

Task:

(a) Plan and design an investigation to determine the minimum volume of soap solution required to completely react with a given volume of hard water**.** *(Include aim, hypothesis, variables, apparatus, procedure, risks, and precautions)***.**

(b) Carry out the investigation and record your results. *(Use at least six readings)*.

(c) Analyse your results and advise the laundry centre on the correct quantity of soap solution to use.

Student X's Expected Response

(a) Aim:

To determine the volume of soap solution (BA1) required to soften different volumes of hard water used for washing clothes.

Hypothesis:

If soap solution is added to hard water, then a white precipitate will form as hardness ions are removed. The amount of soap needed increases proportionally with the volume of hard water.

Variables:

- **Independent variable:** Volume of hard water
- **Dependent variable:** Volume of soap solution (BA1) required to remove hardness / formation of white precipitate
- **Controlled variable:** Concentration of soap solution, temperature, shaking time

Apparatus and Materials:

- 100 cm³ / 50 cm³ measuring cylinder
- 250 cm³ conical flask
- 50 cm³ burette
- Retort stand and clamp
- Soap solution (BA1)
- Hard water sample

(b) Conducting the investigation

Procedure:

(a) 10 cm³ of hard water was measured using a 100 cm³ measuring cylinder and transferred into a clean 250 cm³ conical flask.

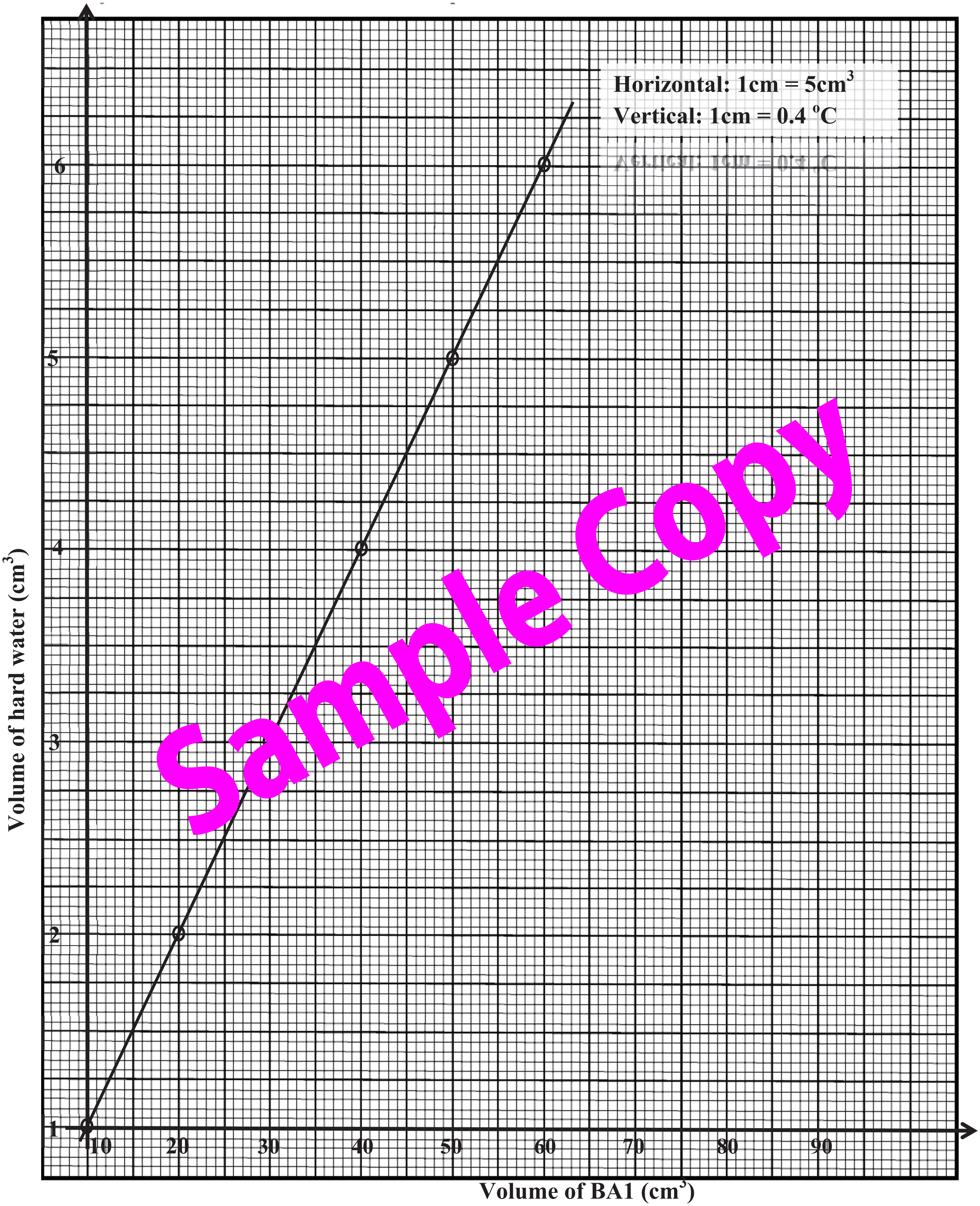
(b) A 50 cm³ burette was filled with soap solution (BA1) and adjusted to the zero mark.

(c) BA1 was slowly added into the hard water while the mixture was gently shaken until a permanent white precipitate formed.

(d) The volume of BA1 used was recorded.

(e) The contents of the flask were poured away, the flask was washed thoroughly, and the procedure was repeated using 20, 30, 40, 50, and 60 cm³ of hard water.

A graph of volume of hard water against volume of **BA1**



Worked Example 7

A small-scale pharmaceutical company located in eastern Uganda produces oral rehydration salts (ORS) in powder form. During quality checks, the technicians noticed that some batches of the salt did not dissolve completely in water at room temperature, leaving undissolved solid particles at the bottom of the container. This raised concerns about the effectiveness and safety of the product.

The production manager explained that the problem could be due to differences in the solubility of the salt at different temperatures**.** According to the company's guidelines, a fixed mass of the salt should dissolve completely in a given volume of water at higher temperatures but may crystallise out as the solution cools. To ensure product quality, the company needs accurate information on how the solubility of the salt changes with temperature.
Since the laboratory technician was unavailable, a group of Senior Four Chemistry students was invited to investigate the solubility behaviour of the salt using simple laboratory apparatus. The students were provided with a sample of the salt labelled **Solid Y** (*12g of potassium nitrate crystals in a stoppered boiling tube)*, which is known to be soluble in hot water but less soluble in cold water.

The students were asked to heat water, dissolve measured amounts of **Solid Y**, allow the solution to cool gradually, and record the temperature at which crystals first appeared. This information would help the company decide the correct preparation and storage conditions for the product.

Task:

As one of the students:

(a) Design and carry out a scientific investigation to determine how the solubility of **Solid Y** varies with temperature. *(Your design should include the aim, hypothesis, variables, apparatus and materials, procedure, risks, and their mitigations*.)

(b) Record your results clearly. *(A minimum of six temperature readings is required.)*

(c) Analyse your results using an appropriate graph and determine the solubility of **Solid Y** at different temperatures.

(d) Hence, advise the pharmaceutical company on the most suitable temperature conditions for dissolving and storing the salt to avoid crystallisation.

Student X's Expected Response

(a) Aim:

To investigate how the solubility of solid **Y** varies with temperature.

Hypothesis

If the temperature of water increases, then the solubility of solid **Y** increases.

Variables

- **Independent variable:** Temperature of the solution (°C)
- **Dependent variable:** Solubility of solid **Y** (mass dissolved per given volume of water)
- **Controlled variables:**
  - Volume of water used
  - Nature of the solvent (distilled water)
  - Rate of cooling
  - Stirring conditions

Apparatus and Materials

- Solid **Y**
- Distilled water
- 250 cm^3 beaker
- Bunsen burner and matches
- Thermometer (0–100 °C)
- Stirring rod
- Measuring cylinder (50 cm^3)
- Balance (or pre-measured solid **Y**)

(b) Procedure

(a) Fifty (50) cm^3 of distilled water was measured using a measuring cylinder and poured into a clean 250 cm^3 beaker.

(b) The water was heated gently using a Bunsen burner until it was near boiling.

(c) Solid **Y** was added gradually to the hot water while stirring until no more solid dissolved, forming a saturated solution.

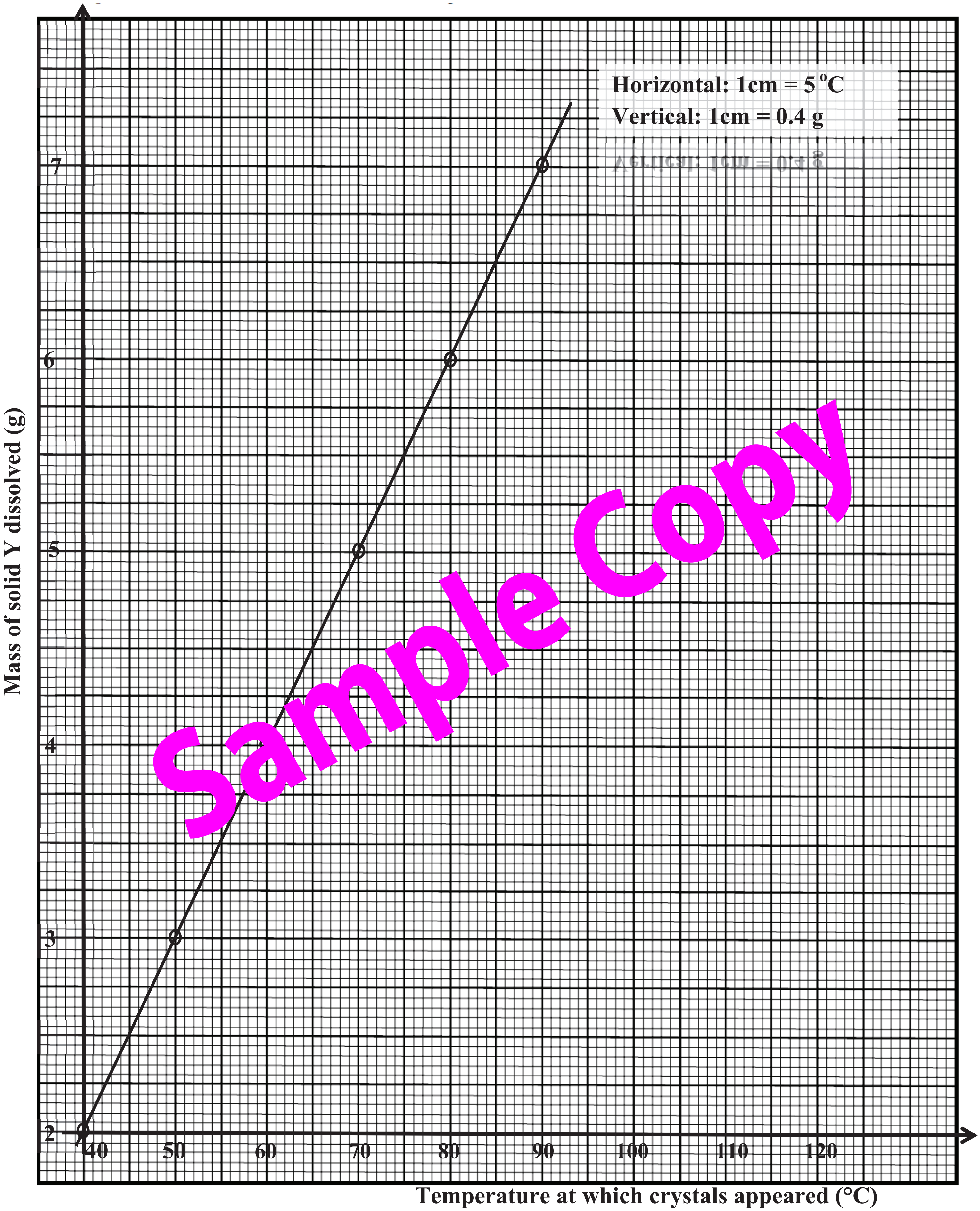
(d) The beaker was removed from the heat and allowed to cool slowly.

(e) The thermometer was inserted into the solution, and the temperature at which crystals of solid **Y** first appeared was noted and recorded.

(f) The experiment was repeated by dissolving different known masses of solid **Y** in the same volume of water.

(g) At least six readings of temperature and corresponding solubility were obtained and recorded.

A graph of mass of solid **Y** dissolved against Temperature at which crystals appeared



Self-trial Experiments

Experiment 1

A first-aid training centre in Lira District prepares simple saline solution for cleaning minor wounds during community outreach programmes. During one of the practical sessions, a trainee was asked to slowly add a prepared solution of hydrochloric acid to a solution of sodium hydroxide contained in a polystyrene cup. As the acid was added, the trainee observed that the cup became warmer.

The instructor explained that the warming effect was due to the neutralisation reaction taking place between the acid and the base, but the trainee wanted to investigate how the volume of acid added affects the amount of heat produced.

The acid provided was labelled **BA1**, while the base was labelled **BA2**. A thermometer was used to measure the temperature change during the reaction.

The reaction between **BA2** and **BA1** is represented by the equation:

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) + Heat$$

Task:

(a) Plan and design an investigation to determine the amount of heat produced when different volumes of **BA1** are added to a fixed volume of **BA2.**
(Your design should include the aim, hypothesis, variables, apparatus and materials, procedure, risks and their mitigations.)

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(b) Carry out the investigation and record your results. *(A minimum of six readings required)*.

(c) Analyse your results and advise the training centre on how the volume of acid affects heat production during neutralisation.

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Experiment 30

A government secondary school in Iganga District prepares standard solutions for Chemistry practical lessons. During revision experiments, the laboratory technician noticed that **Solid Y** sometimes dissolve completely in hot water but reappear as crystals when the solution cools, especially when lessons are delayed.

This causes confusion among students, who think the chemical is impure. The technician suspects that the problem is related to the change in solubility of **Solid Y** with temperature, rather than impurity.

To confirm this, a group of Senior Four Chemistry students is asked to investigate how the solubility of **Solid Y** varies with temperature using a simple laboratory method. The students are given **Solid Y** and instructed to dissolve measured masses in water, heat the solution, and then allow it to cool slowly while observing the temperature at which crystals first appear.

Task:

As one of the students:

(a) Design and carry out an experiment to determine how the solubility of **Solid Y** varies with temperature. *(Your design should include the aim, hypothesis, variables, apparatus and materials, procedure, risks, and mitigation)*

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(b) Carry out the investigation and record your results. *(A minimum of six readings required)*.

(c) Analyse your results and advise the laboratory technician on suitable temperature conditions for preparing and storing potassium nitrate solutions to prevent crystallisation.

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Experiment Requirements (Practical Instructions)

In addition to the apparatus ordinarily contained in Chemistry laboratory, each candidate will require:

Experiment 1

2 plastic beakers.
1 thermometer.
1 measuring cylinder of $50cm^3$ or $100\ cm^3$.
1 burette.
2 conical flasks.
6 test tubes.
1 pipette of $25.0cm^3$ or $20.0cm^3$.
1 stop clock.
5 labels.
$100\ cm^3$ of distilled water.
$50\ cm^3$ of **BA1**.
$250\ cm^3$ of **BA2**. Easy access to:

- Heat source.
- Phenolphthalein and methyl orange indicators.

BA1 is prepared by diluting $112cm^3$ of concentrated hydrochloric acid ($1.18g/cm^3$, 36%) acid with distilled water to make one litre of solution.

BA2 is prepared by dissolving **80g** of **Sodium hydroxide pallets**, to make one litre with distilled water.

Experiment 2

2 plastic beakers.
1 conical flask
1 thermometer.
1 measuring cylinder of $50cm^3$ or $100\ cm^3$.
1 measuring cylinder of $10\ cm^3$
1 stop clock or stop watch
White sheet of paper
$200\ cm^3$ of **BA1**
$100\ cm^3$ of **BA2**
$150\ cm^3$ of **BA3**

BA1 is prepared by dissolving **24.8g** of Sodium thiosulphate-5-hydrate to make one litre of solution

BA2 is prepared by diluting $\mathbf{129cm^3}$ of concentrated hydrochloric acid (**$1.18g/cm^3$, 36%)** acid with distilled water to make **one litre** of solution.
BA3 is distilled water.

Experiment 3

1 boiling tube.
1 thermometer (0 °C – 100 °C).
1 retort stand and clamp.
1 beaker ($250\ cm^3$).
1 measuring cylinder of $50\ cm^3$ or $100\ cm^3$.
1 stop clock.
1 glass rod (stirring rod).
1 tripod stand.
1 wire gauze.
1 test-tube holder or tongs.
5 labels.
10–20 g of solid Z (Solid Z is **Naphthalene ($C_{10}H_8$)**).
$100\ cm^3$ of distilled water.

Easy access to:

• Heat source.
• Cold water (for controlled cooling).

Experiment 4

1 transparent beaker ($250\ cm^3$ or $400\ cm^3$).
1 measuring cylinder ($100\ cm^3$ or $50\ cm^3$).
1 thermometer (0–100 °C).
1 stopwatch or stop clock.
1 dropper or pipette.
1 glass rod (for gentle mixing if required).

