Class/ Index Number	Centre Number/ 'O' Level Index Number	Name
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新加坡海星中学

MARIS STELLA HIGH SCHOOL

PRELIMINARY EXAMINATION

SECONDARY FOUR

PHYSICS **6091/03**

Paper 3 Practical

20 August 2024

1 hour 50 minutes

Candidates answer on the Question Paper.
No additional materials are required.

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name 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 fluid.

Answer **all** questions.
All of your answers should be written in this Question Paper: scrap paper must **not** be used.
Graph paper is provided in this Question Paper. Additional sheets of graph paper should be used only if it is necessary to do so.

You will be allowed to work with the apparatus for a maximum of 55 minutes for each section.
You are expected to record all your observations as soon as they are made.
An account of the method of carrying out the experiments is **not** required.

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. The total number of marks for this paper is 40.

Shift
Laboratory

Examiner's Use	
1	
2	
3	
Total	**40**

This document consists of **14** printed pages inclusive of this cover page.

Section A

1 *In this experiment you will investigate the indentation made by a glass ball in the surface of some modelling clay.*

You have been provided with:

- a glass ball
- two 100 g masses and one 100 g mass hanger
- a 30 cm plastic ruler
- a set square
- a stand, boss, clamp and brick
- a wooden strip (metre rule)
- a piece of modelling clay
- a wooden stand
- a loop of string
- stopwatch

(a) Ensure that the wooden strip is clamped and the clamp is able to rotate freely in the boss.

Place the glass ball and the modelling clay between the centre of the wooden strip and the wooden stand as shown in Fig. 1.1.

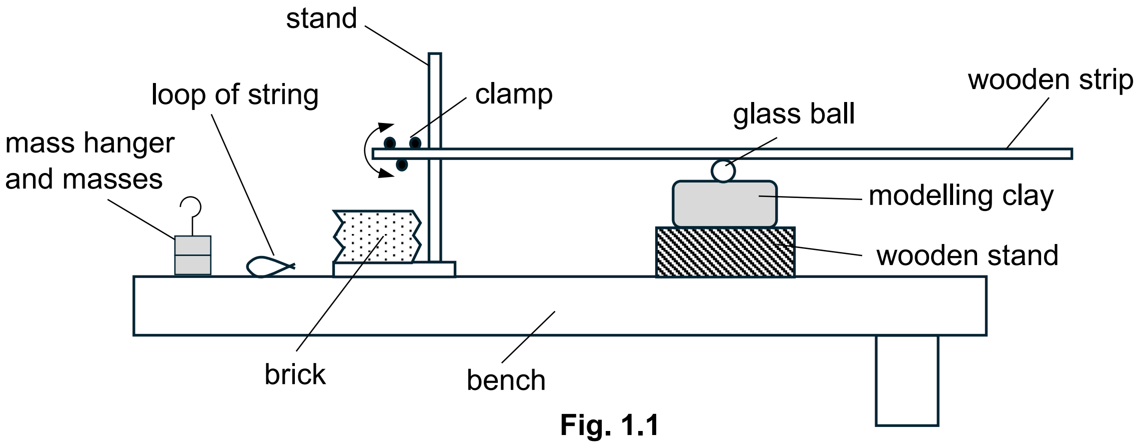


Fig. 1.1

Put the two 100 g masses onto the mass hanger.

The combined weight F_1 of the mass hanger and both 100 g masses is 3.0 N.

Place the mass hanger and masses directly above the glass ball for about one minute.

Remove the mass hanger and masses.

Raise the wooden strip and remove the ball from the modelling clay.

Observe a small circle where the ball has been pressed into the surface of the clay.

This is an indentation.

(i) Measure and record the diameter d_1 of the indentation.

$d_1 = \frac{1.1+1.1}{2}$

$= 1.1$

d_1 = ...1.1 cm.... [1]

(ii) The area of a circle can be calculated using the equation:

$$A = \frac{\pi d^2}{4}$$

where A is the area and d is the diameter of the circle.
Calculate the area A_1 of the indentation with diameter d_1.

$$A_1 = \frac{\pi(1.1)^2}{4}$$

$= 0.95\ \text{cm}^2$

A_1 = 0.95 cm^2 (2sf) .... [1]

(b) (i) Replace the ball on a different part of the modelling clay under the wooden strip.

Lower the strip so that it rests on top of the ball.

Using the loop of string, attach the mass hanger and masses near the end of the wooden strip as shown in Fig. 1.2.

Ensure that the wooden strip does not touch the bench top when mass is loaded.

Measure and record x and y.

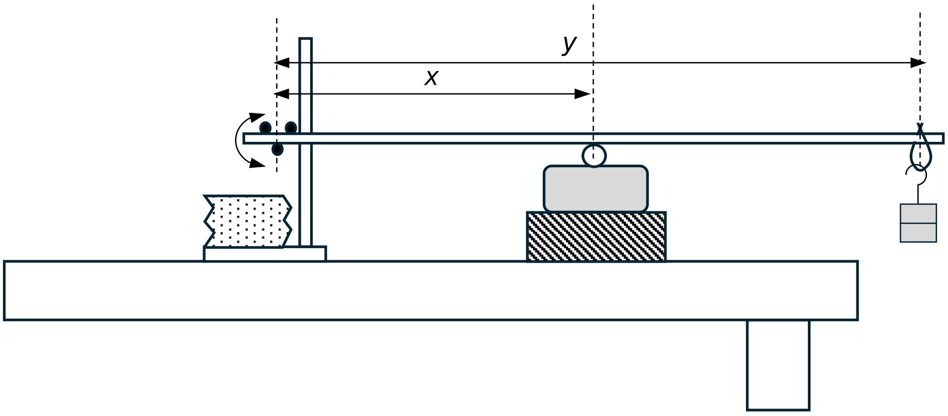


Fig. 1.2

x = 47.0 cm ....

y = 94.0 cm ....

[1]

(ii) Calculate the force F_2 exerted on the modelling clay using the equation:

$$F_2 = \frac{3y}{x}$$

$$F_2 = \frac{3(94.0)}{(47.0)}$$

$F_2 = 6.0$ N

$F_2 =$ 6.0 N .... [1]

(iii) Measure and record the diameter d_2 of the indentation produced by the ball in the clay.

Using the equation in **(a)(ii)**, calculate the area A_2 of the circle with diameter d_2.

$d_2 = \frac{1.5+1.5}{2}$

$= 1.5$ cm

$A_2 = \frac{\pi(1.5)^2}{4}$

$= 1.77\ cm^2$

$d_2 =$ 1.5 cm ....

$A_2 =$ 1.77 cm^2 ....

[1]

(c) Plan

A student claims that *F* is directly proportional to *A*.

Plan an experiment to find out if the student's claim is correct.

In your plan, you should:

- state quantities that you should keep constant
- describe how you will perform the experiment
- explain one precaution that you should take to ensure the accuracy of the experiments
- draw a table, with column headings, to show how to display the range of readings
- sketch the graph that you would obtain if the suggested relationship is correct.

Defining variables

Independent variable: Area of indentation, *A*

Dependent variable: Force exerted on modelling clay, *F*

Control variables: Mass of load and hanger, type of modelling clay used, position the hanger is attached to the wooden strip, dimension of the modelling clay

Procedure

1. Setup as shown in Fig 2.2
2. Position the glass ball such that it is below the 50 cm mark of the wooden strip. Measure and record the distance from the clamp to the centre of glass ball, *x*.
3. Attach the 3.0 N mass hanger and load near to the end of the wooden strip using a loop of string. Keep this position constant throughout the experiment. Measure and record the distance from the clamp to the loop of string, *y*.
4. To ensure that the glass ball will not sink further into the modelling clay, wait for 1 minute before measuring the diameter of the indentation, *d*.
5. Calculate the area of the indentation using $A = \pi d^2/4$.
6. Find the force exerted on modelling clay using $F = 3y/x$.
7. Repeat steps (3) to (6) five more times by varying the position of the glass ball along the wooden strip.
8. Record the values in a table as shown below,

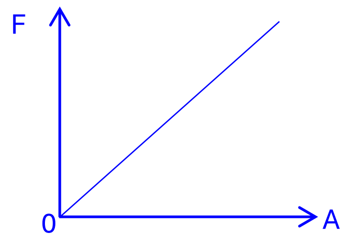
x/cm	y/cm	d/cm	A/cm^2	F/N
20.0				
30.0				
40.0				
50.0				
60.0				
70.0				

9. After each set of reading, ensure that the modelling clay is knead back into a rectangular block.

....

Analysis

- Plot a graph of F against A. If a straight line through the origin is obtained, this shows that F is directly proportional to A.



....

....[5]

[Total: 10]

2 *In this experiment you will investigate the rate of cooling of water at the top and at the bottom of a beaker of hot water.*

You are provided with:

- a boss, clamp and stand
- two 250 cm^3 beakers
- a thermometer
- a stop-watch
- a supply of hot water
- paper towels to mop up any water spillages.

(a) Collect about 250 cm^3 of hot water from a dispenser using a beaker. As a safety precaution, **wrap a towel around the beaker** while holding onto the beaker.

Pour the collected hot water into the other beaker until it reaches the 200 cm^3 mark on the side of the beaker.

Lower the thermometer into the beaker by adjusting the position of the boss, until the bulb of the thermometer is **just covered by the hot water**.

The arrangement of apparatus is shown in Fig. 2.1.

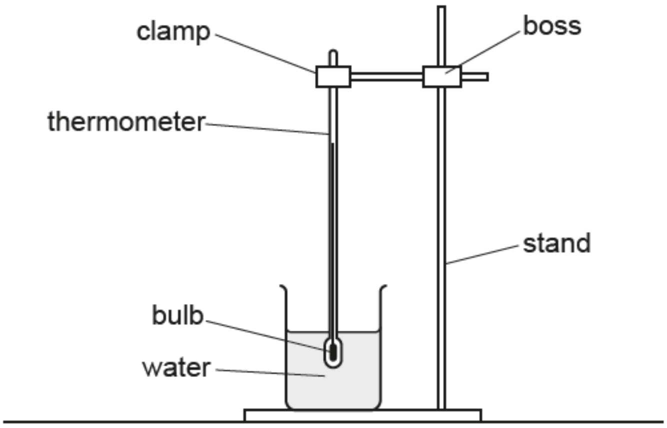


Fig. 2.1

(i) Record the temperature reading of hot water, θ_1, at time t = 0 min.

θ_1 = 82.0 °C .... [1]

(ii) Wait for 3 minutes.

Record the temperature reading θ_2 at time t = 3.0 min.

θ_2 = 73.5 °C .... [1]

(iii) Other than recording the reading of the thermometer at eye level, suggest another precaution to ensure accurate measurement of the temperature of hot water at t = 0 min.

Wait for 30 seconds before recording the thermometer reading and starting the stopwatch. This is to allow the thermometer to reach thermal equilibrium with the hot water. [1]

(b) Remove the thermometer from the beaker and pour the water away.

Pour another 200 cm^3 of hot water into the beaker.

Repeat the procedure in **(a)** but positioning the thermometer lower in the beaker so that the bulb is **just above, but not touching, the bottom of the beaker**.

The arrangement of apparatus is shown in Fig. 2.2.

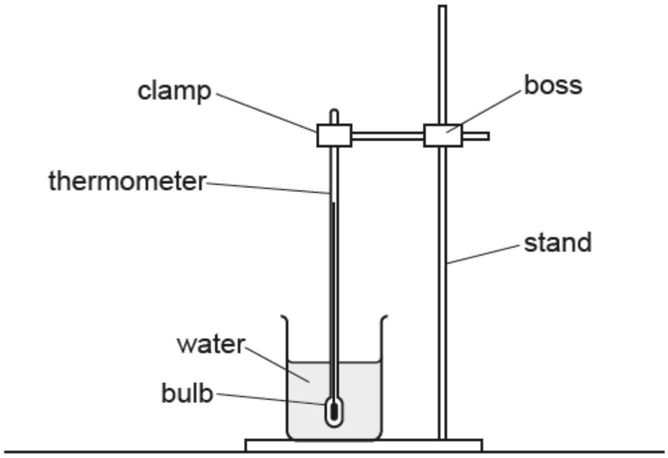


Fig 2.2

Record the temperatures of the water θ_3 and θ_4 at times t = 0 min and t = 3.0 min respectively below.

θ_3 = 81.0 °C [1]

θ_4 = 72.0 °C [1]

(c) **(i)** Calculate the average rate of cooling P_T of the hot water at the top of the beaker.

Use the equation:

$$\text{average rate of cooling} = \frac{\text{decrease in temperature of the water}}{\text{time taken}}$$

$$P_T = \frac{82.0 - 73.5}{3.0}$$

= 2.8 °C/ min

P_T = 2.8 °C/ min [1]

(ii) Calculate the average rate of cooling P_B of the hot water at the bottom of the beaker.

$$P_B = \frac{81.0 - 72.0}{3.0}$$

$= 3.0\ °C/min$

P_B = 3.0 °C/ min [1]

(d) **(i)** Use your results to suggest why a hot liquid should be stirred before measuring its temperature.

The rate of cooling is faster at the bottom than top as shown in c(i) and c(ii), hence it is necessary to stir to ensure uniform temperature throughout. [1]

(ii) Using ideas from *Thermal Processes*, account for the differences in your answers to **(c)(i)** and **(c)(ii)**.

Energy is transferred at a faster rate at the bottom because the base of the retort stand is metallic which is a good thermal conductor. [1]

(e) The experiment is repeated to check the results.

Suggest **two** variables that must be kept constant.

Volume of water used and initial temperature of water.

[1]

[Total: 10]

Section B

3 *In this experiment you will investigate the resistance of a solution.*

You are provided with:

- a power supply
- a beaker of water with two wooden rods wrapped in wire
- a voltmeter (0 – 5.00 V)
- an ammeter (0 – 100 mA)
- a switch
- connecting leads
- a small vial containing 10 m*l* of salt solution
- a syringe
- a stop-watch
- a stirring rod
- a wash bottle containing deionized water.

(a) Set up the apparatus as shown in Fig. 3.1. Fill the beaker with 200 m*l* of deionized water.

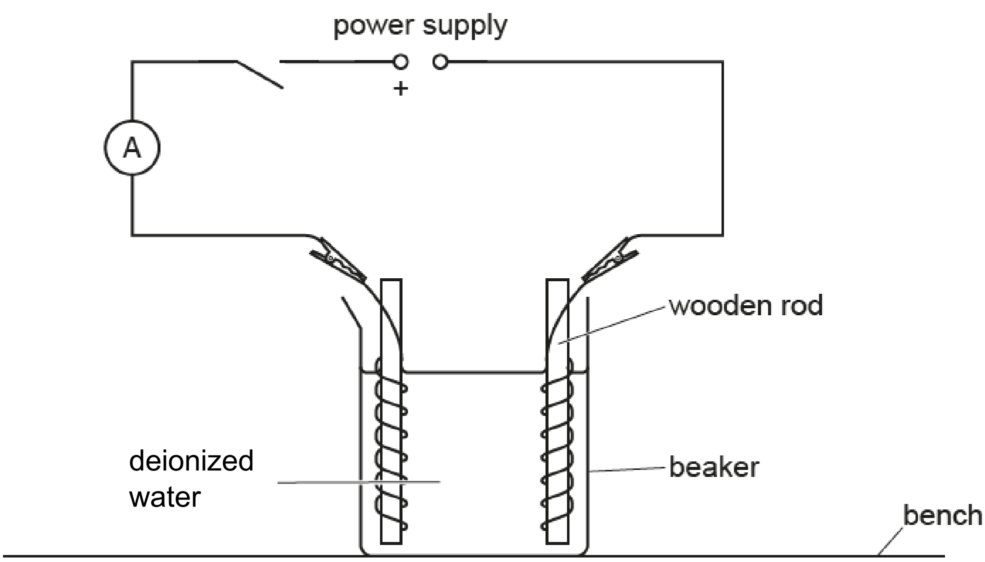


Fig. 3.1

Connect the voltmeter across the terminals of the power supply.

(i) Record the voltage reading *V* on the voltmeter.

V = ...4.50 V.. [1]

Remove the voltmeter from the circuit.

(b) Use the syringe to add 1.0 cm^3 (1.0 ml) of the salt solution to the water in the beaker and stir gently.

(i) Record total volume of salt solution, X, in the beaker of water.

X = 1.0 cm^3

Close the switch.

After one minute, record the current reading I on the ammeter.

Open the switch immediately.

I = 10 mA

[1]

(ii) The resistance R of the solution is given by the equation:

$$R = \frac{V}{I}$$

$$R = \frac{4.50}{\left(\frac{10}{1000}\right)}$$

Calculate R.

$= 450\ \Omega$

R = 450 Ω [1]

(iii) Describe how to ensure that the syringe dispenses exactly 1.0 cm^3 of the salt solution to the water in the beaker.

Ensure that there are no bubbles inside the syringe and push out excess solution until level with 1 cm^3 mark then squirt the 1 ml into the water.

[1]

(iv) Suggest why the reading on the ammeter is recorded one minute after the salt solution is added to the water in the beaker.

The reading changes more slowly after one minute.

[1]

(c) By adding volumes of salt solution to the beaker, repeat **(b)(i) and (b)(ii)** for additional values of R.

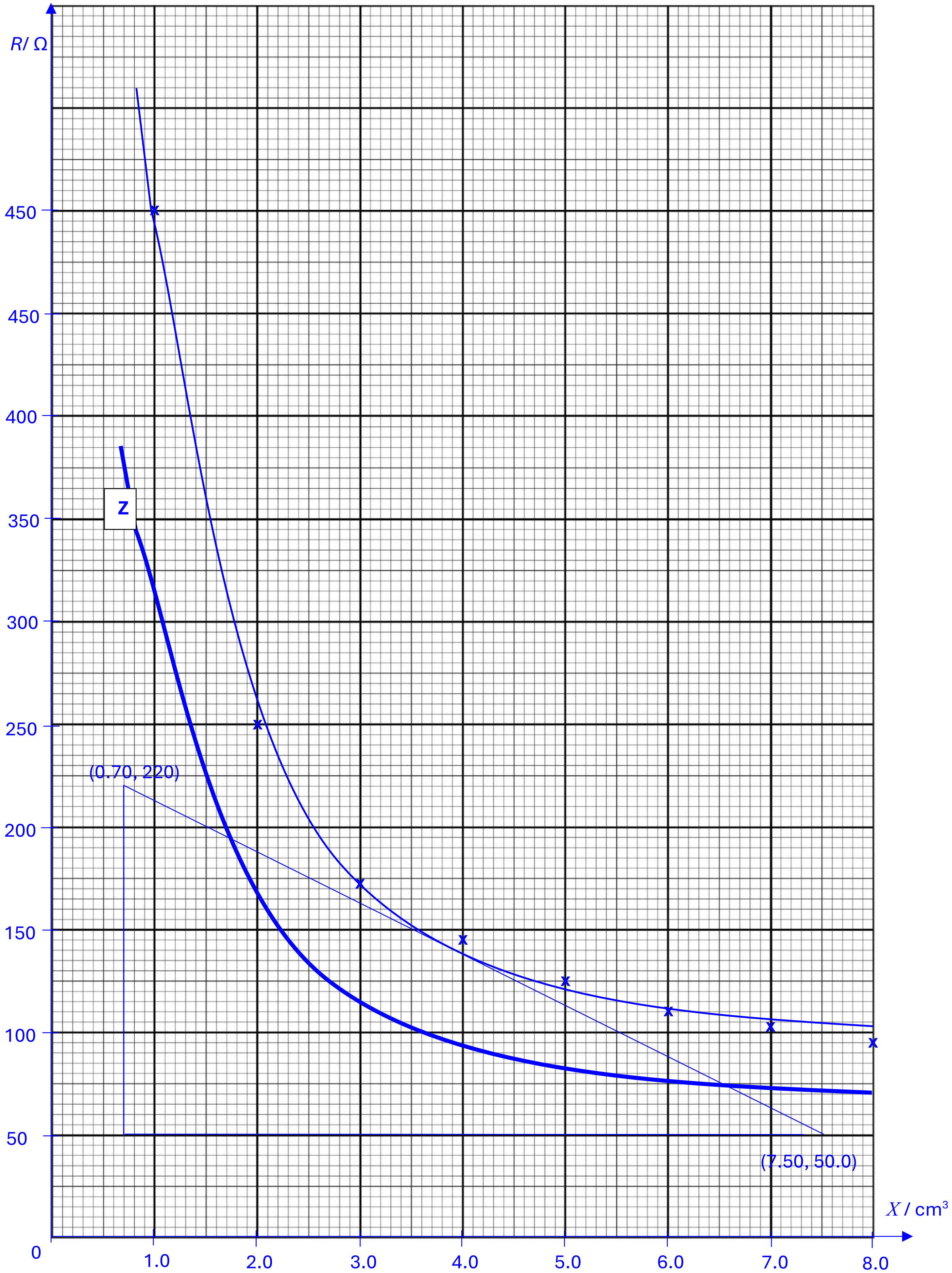
Assume that the voltage V across the terminals of the power supply recorded in **(a)(i)** remains unchanged throughout the investigation.

Record your values for X, I, and R in a table. Also include your result from **(b)** in the table.

X / cm^3	I / mA	R / Ω
1.0	10	450
2.0	18	250
3.0	26	170
4.0	31	150
5.0	36	130
6.0	40	110
7.0	44	100
8.0	48	94

[4]

(d) Using the grid on page 13, plot a graph of R against X. [4]



R/ Ω
450
450
400
350
300
250
200
150
100
50
0
Z
(0.70, 220)
(7.50, 50.0)
X / cm³
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0

(e) **(i)** Draw a tangent to the curve at X = 4.0 cm^3.

Determine the gradient G of this tangent.

Gradient = $\frac{y_1 - y_2}{x_1 - x_2}$

$= \frac{220-50}{0.70-7.50}$

= -25 (2 s.f.)

G = -25 [2]

(ii) Explain the trend in your graph.

Resistance decreases as the amount of salt solution increases. This is because of the increased number of free moving ions in the water which increases the amount of current being conducted between the two rods. [1]

(iii) Water provided in **(a)** at the start of the experiment is deionized, to remove the charged ions in it.

If the experiment is repeated using tap water instead of deionized water, sketch and label a line "Z" on the grid on page 13 to represent the expected results. [1]

(f) Describe **three** improvements to the experiment to obtain an accurate value of R.

Any of the points below:

1
- Resistance of the wire has not been taken into account. Obtain the resistance of wire separately and subtract it from R to obtain resistance of solution.

2
- As R includes the resistance of wire, use a wire of lower resistance or a shorter length of wire to reduce resistance due to wire.

3
- Clip the wire as close to the surface of water as possible to reduce the length of wire that the current passes through so as to reduce the wire's resistance. [3]
- Connect the voltmeter across both ends of the wire submerged in the water instead of across the power supply.

[Total: 20]

SPECIFIC MARK SCHEME

Qn	Answer	Marks
1(a)(i)	**MMO** temperature recorded to the nearest 0.5ºC	**1**
1(a)(ii)	**MMO** temperature recorded and < (a)(i)	**1**
1(a)(iii)	**MMO** to give the (thermometric) liquid time to expand / to allow thermometer to reach the temperature of the hot water / to allow thermometer to respond / reach its maximum reading	**1**
1(b)	**MMO** both temperatures recorded for thermometer in the lower position	**2**
1(c)(i)	**ACE** calculation correct ; unit consistent with calculation: ºC / minute	**1**
1(c)(ii)	**ACE** calculation correct and consistent with their results	**1**
1(d)(i)	**ACE** Clear <u>reference to their results</u> and stirring needed to make the temperature uniform throughout the liquid / to ensure the cooling rate is the same throughout	**1**
1(d)(ii)	**ACE** Answer should tally with experimental results in (c)(i) and (c)(ii). If $P_B < P_T$ Evaporation takes place at the top but not at the bottom of the beaker / water is a poor conductor hence energy transfer occurs at a slower rate at the bottom. If $P_B > P_T$ Energy is transferred at a faster rate at the bottom because the base of the retort stand which is made of metal helps to conduct the heat away.	**1**
1(e)	**P** any two from: • mass / volume / quantity of water • room temperature • initial temperature of water • same beaker • same thermometer • timing of the experiment	**1**

Qn	Answer	Marks
2(a)(i)	**MMO** repeated measurement of d_1 *d_1 < less than or equal to diameter of marble, to nearest mm*	**1**
2(a) (ii)	**ACE** correct calculation of A_1 using candidate's d_1 value	**1**
2(b) (i)	**MMO** x and y recorded in m to nearest mm	**1**
2(b) (ii)	**ACE** correct substitution shown of y and x	**1**
2(b) (iii)	**MMO & ACE** repeated measurement of d_2 *$d_2 > d_1$, to nearest mm*	**1**

Qn	Answer	Marks
	and A_2 >A_1 with correct calculation of A_2 using candidate's value ;	
2(c)	**PDO** Definition of variables – correct variables (independent, dependent and control) identified, and method described on how to keep control variables constant. - do not accept: *d, y or x* as independent variable Procedure - procedure listed leads to a workable experiment i.e. how variables are to be measured and recorded have been described clearly; steps to be repeated and how many times to repeat are mentioned - expected table with correct column headings shown. Table is populated with possible values of *x* to display range of readings - accuracy or safety steps are included Analysis - Correct axis of graph is chosen. Graph statement: description of how the validity of the given relationship is obtained from the graph. Answer must include the phrase "pass through origin". Correct sketch of expected graph shown.	 **1** **1** **1** **1** **1**

Qn	Answer	Marks
3(a)	**MMO** 4.5 (V) *V* recorded to the correct d.p. with units	**1**
3(b)(i)	**MMO** 1.0 cm^3 mA Sensible current 1–20 *X* and *I* recorded to the correct d.p. with units	**1**
3(b)(ii)	**ACE** (their voltage) / their current) k Ω *R* calculated to the correct s.f. with units	**1**
3(b)(iii)	**MMO** *Filling correctly: any one from* • At start ensure there is no air / liquid in the syringe • Ensure the nozzle is submerged in the liquid • Raise the plunger/pull up the liquid so more than 1 ml goes in liquid goes in • Ensure there are no bubbles inside the syringe *Accuracy of volume delivered*: *any one from* • push out excess solution until level with 1 cm^3 mark then squirt the 1 ml into the water • ensure the eye is on the line perpendicular to the 1 ml (graduation) mark	**1**
3(b)(iv)	**MMO** the reading changes more slowly after one minute / time needed for the salt solution to mix evenly	**1**
3(c)	**MMO** At least 6 sets of data (*X*, *I*, *R*, 1/*X*) with correct trend, as *X*↑ *R*↓.	**4**

Qn	Answer	Marks
	PDO Column headings with quantities (X, I, R, $1/X$) with correct units. **PDO** all values of X, I recorded to correct d.p. **PDO** all values of R recorded to correct s.f.	
3(d)	**PDO** axes labelled with units and correct orientation (allow ecf from wrong unit in table but not no units) **PDO** Suitable scale, not based on 3, 6, 7 etc. with plotted data occupying ⩾ half the page **PDO** all points plotted correctly (points must be ⩽ ½ small square from the correct position) **PDO** best fit curve and fine crosses	**4**
3(e)(i)	**ACE** measurements taken from large triangle and coordinates of points used seen (marked on graph and substituted into working) gradient correctly calculated and within acceptable range	**2**
3(e)(ii)	**ACE** Correct observation and reasoning for student's trend.	**1**
3(e)(iii)	**ACE** Line Z is drawn lower than the original curve and is approximately parallel to it to show a consistent reduction in resistance.	**1**
3(f)	**ACE** Any of the points below: • Resistance of the wire has not been taken into account. Obtain the resistance of wire separately and subtract it from R to obtain resistance of solution. • As R includes the resistance of wire, use a wire of lower resistance or a shorter length of wire to reduce resistance due to wire. • Clip the wire as close to the surface of water as possible to reduce the length of wire that the current passes through so as to reduce the wire's resistance. • Connect the voltmeter across both ends of the wire submerged in the water instead of across the power supply.	**3**