2023 Prelim Practical Exam Mark Scheme and Examiners Comments

Question 1 [10 marks]

Part	Marking Point	Mark
(a)	Value of *b* in the range 11.8 to 12.2 cm Value of *c* in the range 15.8 to 16.2 cm	**[1]**
(b)	Value of *y* in measured to nearest 1 mm Value of *y* in the range 4.6 to 5.0 cm	**[1]** **[1]**
(c)(i)	Value of *c* in the range 9.8 to 10.2 cm	**[1]**
(c)(ii)	Value of *y* in the range 4.9 to 5.3 cm	**[1]**
(d)(i)	Value of *y* is calculated correctly with units and expressed to 2 or 3 s.f.	**[1]**
(d)(ii)	Correct identification of graph to be plotted. (Gradient and y-intercept expressions should not include *y* and/or *c*)	**[1]**
(d)(iii)	Correct expression stated for the gradient. Correct expression stated for the y-intercept. (Gradient and y-intercept expressions should not include *y* and/or *c*)	**[1]** **[1]**
(e)	Reasonable explanation why value of *y* is equal to 6 cm. (E.g. when *y* is zero, the card becomes a square or rectangle, hence the centre of gravity is at the midpoint/middle/centre of the card.	**[1]**

Question 2 [11 marks]

Part	Marking Point	Mark
(a)	Value of I_2 in the range 50.0 to 80.0 mA $I_2 > I_1$	**[1]**
(b)	6 sets of raw data + appropriate Ry range (accept 0 or 1 d.p precision) + correct trend of I_1 / I_2 ratio Column headings: Each column heading must contain a quantity, a unit and a separating mark where appropriate. The presentation of quantity and unit must conform to accepted scientific convention Correct precision for raw data and s.f for calculated data. Correct calculation.	**[1]** **[1]** **[1]**
(c)	Linearization: Graph of I_1/I_2 vs R_Y graph plotted. If wrong linearization, penalize R_x. Axes: Sensible scales must be used, no awkward scales (e.g. 3:10). Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. Scale markings should be no more than three large squares apart Plotting of points: All observations in the table must be plotted on the grid. Points must be plotted to an accuracy of half a small square. Line of best fit or BFL: Judge by balance of all points on the grid about the candidate's line (at least 5 points). There must be an even distribution of points either side of the line along the full length. If there are 6 or more points, allow one anomalous point only if clearly indicated by the candidate. Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. The method of calculation must be correct. Do not allow Δx / Δy. Both read-offs must be accurate to half a small square in both the x and y directions. R_X calculated correctly with units from gradient (e.g. = $1/2R_X$), appropriate range from 10 to 40 Ω. Penalise Rx if 1 s.f.	**[0]** **[1]** **[1]** **[1]** **[1]** **[1]**
(d)	As $R_Y = R_X$, R_X can be determined from the graph by identifying the R_Y value when $I_1 / I_2 = 1$.	**[1]**
(e)	Line W must have a gentler gradient and will always be lower than the original graph at all points except for the y-intercept. (if graph of I_1/I_2 vs R_Y plotted) Accept equivalent answer for graph of R_Y vs I_1/I_2 plotted.	**[1]**

Question 3 [21 marks]

Part	Marking Point	Mark
(a)(i)	Value of *x* in the range 3.0 to 3.5 cm Require repeated measurements for *x* Value of *h* in the range 12.5 to 13.5 cm Correct units for *x* and *h*	**[1]**
(a)(ii)	Value of Δ*x* in the range 0.2 to 0.5 cm Correct calculation	**[1]**
(b)(i)	Value of *θ* in the range 45° to 60° Require repeated measurement for *θ* Precision of *θ* should be 1° Correct unit for *θ*	**[1]**
	Value of *y* in the range 8.5 to 12.0 cm Require repeated measurements for *y* Precision of *y* should be 1 mm Correct unit for *y*	**[1]**
(b)(ii)	Correct calculation, using the *measured* value of *θ* from part (b)(i)	**[1]**
(c)(ii)	Value of *x* in the range 2.5 to 3.0 cm Value of *h* in the range 10.5 to 11.5 cm Correct units Correct calculation of tan *θ*, using the *measured* value of *θ*	**[1]**
	The value of *θ* should be **larger** than the one recorded in (b)(i)	**[1]**
(d)(i)	Both values of *k* are correctly calculated Values of *k* given to an appropriate number of s.f. (least s.f. or 1 more)	**[1]**
(d)(ii)	Percentage difference between two values for *k* correctly calculated Percentage difference between *k* values compared with the percentage uncertainty found in (a)(ii) Appropriate conclusion drawn	**[1]**
(e)(i)	Reasonable, *significant* sources of error, *while mentioning which measurement is affected* Possible answers: • It is very difficult to keep the cone in place after the ping-pong ball has dropped, *affecting measurements of y and θ.* • The cone is not a perfect shape, as the tip of the cone gets crumpled when we place the cone on the workbench*, affecting measurement of h and y*. • It is difficult to determine the exact instance or orientation of the cone when the ping-pong ball tips over*, affecting the measurement of y and θ.* • It is difficult to tilt the cone in a steady manner*, affecting the measurement of y and θ.* Not accepted: • Diameter not fixed due to pressing the cone (human error) The base of the cone may not be a perfect circle	**[2]**

(e)(ii)	Reasonable means of improvement, *that addresses one of the identified errors* Possible answers: • Clamp a ruler (vertically) behind the setup, so that *y* can immediately be read off when the ball drops. • Attach a small lump of Blu Tack with a depression in the centre to the tabletop, to pivot the cone. • Rest the cone at a slight inclination against a book or block of suitable size. Not accepted: • Use cones made out of a harder material such as wood or plastic Clamping the cone	**[1]**
(f)(i)	All points plotted accurately to a precision of half a small square Appropriate best-fit line drawn	**[1]**
(f)(ii)	Gradient correctly calculated 0 out of 2 marks are awarded if the gradient is incorrect Vertical intercept correctly calculated	**[1]** **[1]**
(f)(iii)	• Answer of (f)(ii) compared to the precision of cos θ in the graph (0.005) Appropriate conclusion drawn Alternatively, also accept: • Statement that the graph must pass through the origin Conclusion drawn based on the answer of (f)(ii)	**[1]**
(g)	Create at least **10 cones** of **varying height** and **constant diameter** Take a cone, place a **tennis ball** in it, tilt the cone until the tennis ball drops Record all data in a table: ***h*/cm**, *y*/cm *(optional)*, ***θ*/°** Plot a **graph** of θ against h **Fit a line or curve** through the points and **read off the value of *h* for *θ* = 60°**	**[1]** **[1]** **[1]** **[1]** **[1]**
(e)(i)	Reasonable, *significant* sources of error, *while mentioning which measurement is affected* Possible answers: • It is very difficult to keep the cone in place after the ping-pong ball has dropped, *affecting measurements of y and θ.* • The cone is not a perfect shape, as the tip of the cone gets crumpled when we place the cone on the workbench*, affecting measurement of h and y*. • It is difficult to determine the exact instance or orientation of the cone when the ping-pong ball tips over*, affecting the measurement of y and θ.* • It is difficult to tilt the cone in a steady manner*, affecting the measurement of y and θ.* Not accepted: • Diameter not fixed due to pressing the cone (human error) • The base of the cone may not be a perfect circle	**[2]**
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	Not accepted: • Use cones made out of a harder material such as wood or plastic • Clamping the cone	
(f)(i)	All points plotted accurately to a precision of half a small square Appropriate best-fit line drawn	**[1]**
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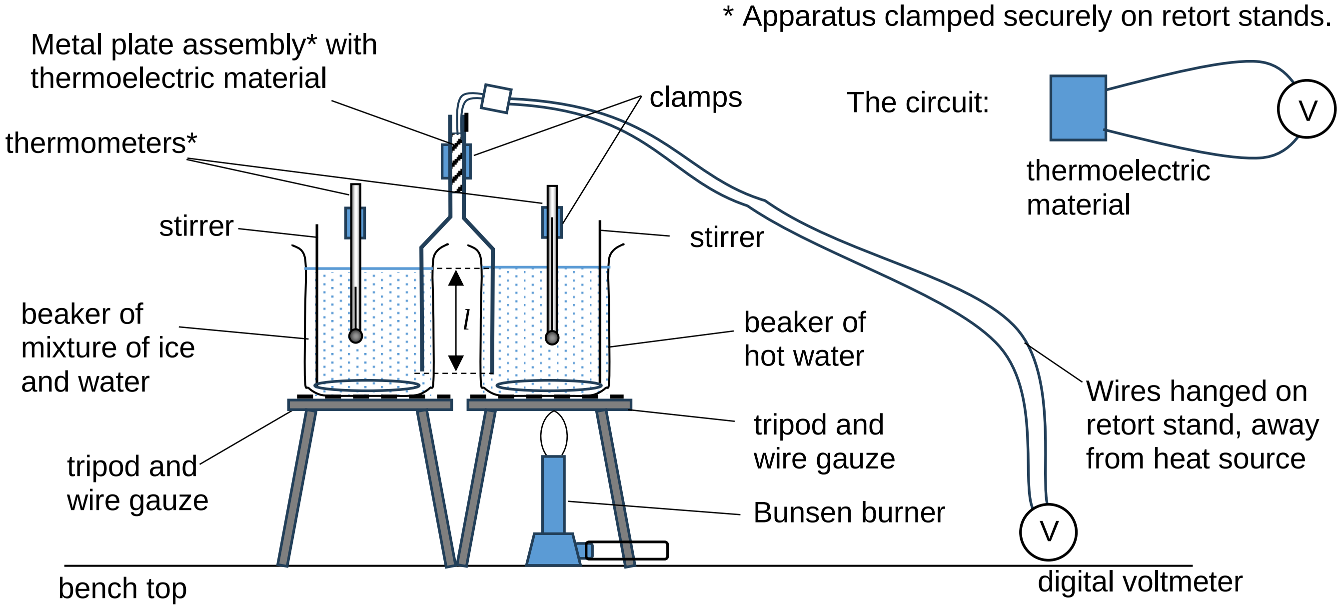
(g)	Create at least **10 cones** of **varying height** and **constant diameter** Take a cone, place a **tennis ball** in it, tilt the cone until the tennis ball drops Record all data in a table: ***h*/cm**, *y*/cm *(optional)*, ***θ*/°** Plot a **graph** of θ against h **Fit a line or curve** through the points and **read off the value of *h* for *θ* = 60°**	**[1]** **[1]** **[1]** **[1]** **[1]**

Question 4 [12 marks]

Aspects	**Marks**	**Code**	**Marking Points**
Diagram	1	D1	Clear, labelled diagram of the setup, inclusive of the simple thermoelectric generator having metal plates separately in hot and cold water; apparatus secured on retort stands or placed on a table, where appropriate. [inappropriate use of measuring instruments, or wrong connections in the diagram will only be penalized under variables]
Variables	5	V1	Apparatus and method to vary and measure l of each plate. (e.g use ruler, adjust vertical position of assembly to vary l)
		V2	Apparatus and method to measure temperatures of the metal plates and determine temp. difference θ. (e.g. use thermometer, $\theta = T_{High} - T_{Low}$)
		V3	Apparatus and method to vary θ (means of heating/ cooling) (e.g. keep one beaker at room temperature/ ice point, heat the other beaker to higher temperatures)
		V4	Apparatus and method to measure ε. (e.g. use voltmeter, show proper circuit) [accept voltmeter across fan/ resistor]
		V5	Two runs: 10 sets of (l, ε) keeping θ constant & 10 sets of (θ, ε) keeping l constant.
Analysis	2	A1	Correct linearization of equation: e.g. $\lg \varepsilon = \lg k + \alpha \lg \theta + \beta \lg l$ (can infer)
		A2	Appropriate graphs plotted and used to determine α and β. E.g. Plot a graph of $\lg \varepsilon$ vs $\lg \theta$ to obtain a straight line with gradient = α Plot a graph of $\lg \varepsilon$ vs $\lg l$ to obtain a straight line with gradient = β
Reliability	Max 3	R1	Method to monitor and keep l constant throughout experiments which require l to be kept constant. e.g. Measure l again after reading ε,. Add water to adjust the water level and repeat the measurements of the corresponding θ and ε if necessary.
		R2	Method to achieve thermal equilibrium between metal plates & water. E.g. Stir the water in each beaker to ensure even distribution of temp. of the metal plate.
		R3	Preliminary trial to determine a suitable range of θ / l for appreciable variations in ε.
		R4	Method to monitor and keep θ constant throughout the experiments which require θ to be kept constant.
		R5	Thermal insulation of the beakers (e.g. using lids & sleeves) to prevent heat exchange with the surroundings and keep respective water temperatures constant.
		R6	Methods to ensure visibility and accuracy in reading of l. E.g. Avoid using bubbling boiling water at 100 °C Avoid too much ice cubes floating on water in the ice and water mixture at 0 °C
Safety	Max 1	S1	Safety goggles should be worn when working with a Bunsen burner. The goggles also protect the eyes from accidental spillage of hot water into the eyes.
		S2	Wear rubber gloves and covered shoes to protect one from accidental spillage and breakage of the beaker of hot water.
		S3	Ensure that water should not be filled to the brim of the beaker to avoid spillage of hot water especially, while keeping sufficient water in each beaker to cover the maximum length of the metal plate.
		S4	Hang the wires on the retort stand, keeping it away from the tripod and Bunsen Burner to avoid fire hazards.

2023 Prelim Paper 4 Question 4 - Suggested Solution



Procedure

1. Using a fine permanent marker and a ruler, calibrate the ends of the metal plates to be immersed in water in cm. When immersed the plates in water, l can be read from the scale created on each plate.
2. Set up the apparatus as shown above, with the metal-plate assembly, vertical half-metre rules, and the thermometers securely clamped on separate retort stands. Fill the beakers separately with ice water and room temperature water, to the same level.

<u>Vary l, keep θ constant to obtain β:</u>

3. Adjust the metal-plate assembly vertically such that both metal plates are immersed to the same depth of minimum l.
4. Check that the beaker of mixture of ice and water is maintained at 0°C, using the thermometer. Stir the water using the stirrer to ensure uniformity of temperature of the metal plate. Record the temperature T_L.
5. Turn on the Bunsen burner and heat the other beaker of water to T_H = 40°C; stir the water in the process to ensure uniformity of temperature of the metal plate. Record T_H and calculate $\theta = T_H - T_L$.
6. Record the voltmeter reading ε.
7. Repeat steps 3 to 6, each time incrementally increase l in step 3, for ten sets of l and ε, keeping θ constant.
8. Plot a graph of lg ε against lg l. Since $\lg \varepsilon = \beta \lg l + \alpha \lg\theta + \lg k$, the plots will yield a straight line. The gradient is equal to β.

<u>Vary θ, keep l constant to obtain α:</u>

9. Repeat steps 3 to 6, keeping l constant at maximum in step 3, each time increasing T_H in step 5 incrementally, for ten sets of θ and ε. Check the value of l after each set, replenish water accordingly if there is evaporation.
10. Plot a graph of lg ε against lg θ. The gradient of the straight line is the value of α.

<u>Precautions</u>

11. A preliminary trial could be done to determine a suitable range of θ for appreciable variations in ε.
12. Wear goggles, rubber gloves and covered shoes while working with the Bunsen burner, to protect one's eyes hands and feet from accidental spillage of hot water and breakage of the beakers.
13. Hang the wires tidily on the retort stand, keeping them away from the tripod and Bunsen burner, to avoid fire hazards.