2026 6091 Physics Prelim Paper 3 Answers

Cap of 1 mark per instrument read to the wrong precision for the whole paper (reading off the graph is considered as 1 instrument).
Cap of 1 mark for s.f. errors for each question.
Cap of 1 mark for d.p. errors for each question.
Cap of 1 mark for same type of units for each question.

All working must be shown. No marks will be awarded for calculation question with no working.

Calculations handling raw data => need to follow d.p./s.f. rule
Calculations handling processed data => can give to 2 or 3 s.f.

Copying error: Student drops zeros for a quantity.
For eg:
1(c) V = 3.0 $cm^{3,}$ then 1(d) writes 3 cm^3 in the working → Penalise 1 mark for copying error

ecf for sf/dp: Give ecf and mark the sf/dp based on what student has written in working if there is no copying error.
For eg:
1(c) V = 3 cm^3 then 1(d) B = $\rho V g$ = 1 x 3 x 0.010 = 0.03 N (1 s.f) is the correct answer
Penalise if students write 1(d) B = $\rho V g$ = 1 x 3 x 0.010 = 0.030 N (2 s.f)

Two mistakes (eg: sf error and unit error made in part a) → Penalise 1 mark.
If mistake is repeated (eg: the same unit error in part b) → Penalise another 1 mark

1(a)(i)	**MMO** M is measured to 2 d.p and with correct unit M = 27.48 g	B1
1(a)(ii)	**MMO** m is measured to 2 d.p with correct unit and range of 49.00 g – 51.00 g m = 50.53 g Note: 1a(i) and 1a(ii) penalized once only for 2 d.p and unit.	B1
1(b)	**MMO** V is measured to 1 d.p and V ≤ 5.0 cm^3 V = 3.0 cm^3 AWW: Do not penalize if working is missing.	B1
1(c)	**PDO** $B = \rho V g$ = 1 x 3.0 x 0.010 = 0.030 N Correct calculation and correct unit and calculated to 2 s.f	B1

1(d)	**MMO** p and q are measured to 1 d.p and must be less than 50.0 cm and p < q. p = 11.0 cm q = 25.0 cm Accept answers in metre.	B1
1(e)(i)	**PDO** $B = Mg - mg(\frac{x}{L})$ = (27.48)(0.010) – (50.53)(0.010)(11.0 / 25.0) = 0.2748 (4 s.f) - 0.222 (3 s.f) = 0.053 N (3 dp) Correct calculation and correct unit and calculated to correct dp	 B1
1(e)(ii)	**ACE** Appropriate calculation with values of *B* from (c) and (e)(i) % difference = (B_1 - B_2) / B_1 x 100 = (0.030 – 0.053) / 0.030 x 100 = -76.7 % Appropriate conclusion with explanation. The experiment <u>does not agree</u> with the suggestion as the two values are <u>not within the limits of experimental error</u> as the percentage difference is more than <u>10 % (or 5 %).</u> *Accept: % difference = (B_2 - B_1) / B_2 x 100	M1 A1

1(f)

ACE

Correct source of error identified that can be improved — M1

Correct improvement that will reduce the error identified — A1

Any one

	Sources of error	**Improvement**
1	The weight of the metre rule is not uniformly distributed.	Ensure the metre rule is balanced when pivoted at the 50 cm mark before doing the experiment and put blu-tack on the metre rule to balance it if necessary. Reject: Replace the metre rule with a uniform metre rule.
2	The metre rule may not be exactly balanced (when p and q are recorded) Accept: The metre rule is not horizontal (when p and q are recorded)	Measure the height of the metre rule above the table on its right and left side to ensure they are the same height. Reject: Repeat the experiment and take the average.
3	Only one set of p and q readings were measured but there could be other possible combinations which may cause differing B values to be calculated.	Obtain 2 more sets of p and q values and use them to calculate the average value for the buoyancy force B.

Reject: answers related to the surrounding environment (e.g: wind)

Reject (because it is an apparatus error not an experimental procedure error):

	The string is thick and prevents the marking from being read accurately.	Use thinner strings.

Reject (because it is not for part d):

	Volume of string (submerged in the water) may cause the measured volume to be greater / inaccurate.	Use thinner strings.

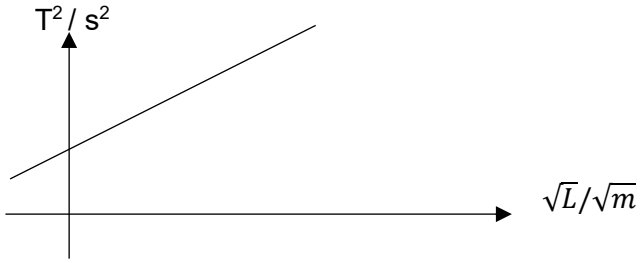
2a(i)	**MMO** - L is measured to 3 d.p - L is in the range of 0.495 m– 0.505 m - measured in metre L = 0.500 m	B1
2a(ii)	**MMO** - x is measured to 3 d.p - x is in the range of 0.105 m – 0.115 m - measured in metre Note: 2a(i) and 2a(ii) penalized once only for 3 d.p and metre. x = 0.110 m	B1
2a(iii)	**PDO** Average time for 10 oscillations = $\left(\frac{10.4+10.3}{2}\right)$ = 10.4 s T = $\frac{10.4}{10}$ = 1.04 s First mark: - Evidence of repeating the experiment (at least 2 readings) - Recording of time taken to 1 d.p. Second mark: - Evidence of taking at least 10 oscillations - Correct calculation of period T - T is in the range of 0.936 s – 1.14 s - T is calculated to correct sf (e.g: 3 sf) - Correct unit	 B1 B1

2(b)	**ACE** Mark allocation	B6

No	Item	Marks
1	• Description of how the experiment is performed by changing the independent variable and measuring the dependant variable. • At least two timings of minimum 10 oscillations are recorded. • Calculation of $\sqrt{L}$ or $\sqrt{x}$. (B.O.D if seen in table) • Calculating of T and T^2 (B.O.D if seen in table)	1
2	Repeating of steps to get at least 5 more values of the independent variable. • For independent variable L, L must be less than 150 cm.	1
3	Stating the control variable • Reject: angle of displacement (stated in question already)	1
4	Correct table with headers • Mark for L / m, $\sqrt{L}/\sqrt{m}$, T / s and T^2 / s^2	1
5	Correct graph • Do not need to mark for the units • Do not penalize if statement for graph is not written	1
6	Determination of how to find g using either gradient or y-intercept with a simple description	1

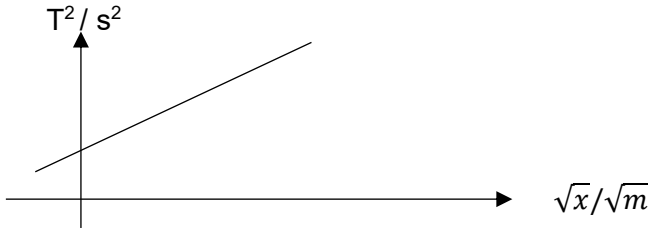
Example 1

independent variable: L, dependant variable: T, constant variable: x

No	Steps	Marks
1.	Set up apparatus as in Fig. 2.1. Do step (ai) for L=50 cm. Calculate $\sqrt{L}$.	B1
2	Do step (aii) for x=11 cm.	
3	Do step (aiii). Record the time taken for 20 oscillations, t_1. Repeat for another 20 oscillations, t_2. Calculate the average time for 20 oscillations. Calculate the period T. Calculate T^2.	
4	Repeat steps 1 to 3 for L= 45 cm, 40 cm, 35 cm, 30 cm, 25 cm.	B1
5	Keep x constant (at 11.0 cm by adjusting the bottom clamp).	B1
6	Record all values in the table below: **L/m** | $\sqrt{L}/\sqrt{m}$ | t_1 / s | t_2 / s | t_{ave} / s | **T/s** | **T^2 / s^2** | | | | | | | *- Mark for L / m, $\sqrt{L}/\sqrt{m}$, T / s and T^2 / s^2*	B1
7	Plot a graph of T^2 against $\sqrt{L}$. Graph:  *- Award mark only for a graph with line that **does not** pass through origin.* *- Do not need to mark for the units* *- Do not penalize if statement for graph is not written*	B1
8	(Choose two points on the line: (x_1, y_1) and (x_2, y_2).) Calculate gradient = $(y_2 - y_1) / (x_2 - x_1)$ Calculate $g = \frac{\pi^2}{\text{gradient}}$ OR The y-intercept is the point where the line cuts the y-axis. Calculate $g = \frac{\pi^2\sqrt{x}}{y-intercept}$ or $g = \frac{\pi^2\sqrt{11}}{y-intercept}$	1

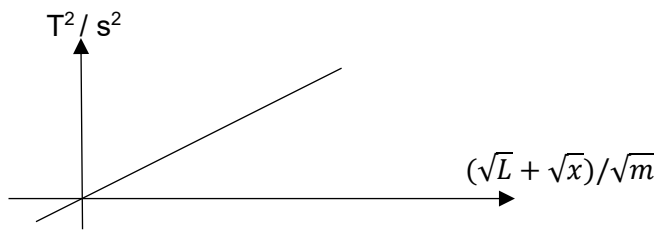
Example 2

independent variable: x, dependant variable: T, constant variable: L

No	Steps	Marks
1.	Set up apparatus as in Fig. 2.1. Do step (ai) for L=50 cm.	B1
2	Do step (aii) for x=11 cm. Calculate $\sqrt{x}$.	
3	Do step (aiii). Record the time taken for 20 oscillations, t_1. Repeat for another 20 oscillations, t_2. Calculate the average time for 20 oscillations. Calculate the period T. Calculate T^2.	
4	Repeat steps 1 to 3 for x= 15 cm, 20 cm, 25 cm, 30 cm, 35 cm (by adjusting only the bottom clamp.)	B1
5	Keep L constant (at 50.0 cm.)	B1
6	Record all values in the table below: **x/m** | $\sqrt{x}/\sqrt{m}$ | t_1 / s | t_2 / s | t_{ave} / s | **T/s** | **T^2 / s^2** | | | | | | | *- Mark for x / m, $\sqrt{x}/\sqrt{m}$, T / s and T^2 / s^2*	B1
7	Plot a graph of T^2 against $\sqrt{x}$. Graph:  *- Award mark only for a graph with line that **does not** pass through origin.* *- Do not need to mark for the units* *- Do not penalize if statement for graph is not written*	B1
8	(Choose two points on the line: (x_1, y_1) and (x_2, y_2).) Calculate gradient = $(y_2 – y_1) / (x_2 – x_1)$ Calculate $g = \frac{\pi^2}{\text{gradient}}$ OR The y-intercept is the point where the line cuts the y-axis. Calculate g =$\frac{\pi^2\sqrt{y}}{y-intercept}$ or g =$\frac{\pi^2\sqrt{50}}{y-intercept}$	B1

Example 3

independent variable: L, dependant variable: T, constant variable: x

No	Steps	Marks
1.	Set up apparatus as in Fig. 2.1. Do step (ai) for L=50 cm. Calculate $\sqrt{L}$.	B1
2	Do step (aii) for x=11 cm. Calculate $\sqrt{x}$.	
3	Do step (aiii). Record the time taken for 20 oscillations, t_1. Repeat for another 20 oscillations, t_2. Calculate the average time for 20 oscillations. Calculate the period T. Calculate T^2.	
4	Repeat steps 1 to 3 for L= 45 cm, 40 cm, 35 cm, 30 cm, 25 cm (by adjusting only the top clamp.)	B1
5	Keep x constant (at 11.0 cm by adjusting the bottom clamp.)	B1
6	Record all values in the table below: L/m | $\sqrt{L}$ / $\sqrt{m}$ | $(\sqrt{L}+\sqrt{x})$ / $\sqrt{m}$ | t_1 / s | t_2 / s | t_{ave} / s | T/s | T^2 / s^2 | | | | | | | | - Mark for L / m, $\sqrt{L}+\sqrt{x}/\sqrt{m}$, T / s and T^2 / s^2	B1
7	Plot a graph of T^2 against $\sqrt{L}+\sqrt{x}$. Graph:  *- Award mark only for a graph with line that* ***passes through origin.*** *- Do not need to mark for the units* *- Do not penalize if statement for graph is not written*	B1
8	(Choose two points on the line: (x_1, y_1) and (x_2, y_2).) Calculate gradient = $(y_2 - y_1) / (x_2 - x_1)$ Calculate $g = \frac{\pi^2}{\text{gradient}}$	B1

3(a)	**MMO** T_R is measured to 1 d.p (0.5 °C) and sensible value T_R = 31.0 °C (No marks awarded)	0
3(b)	**MMO** V_R is measured to 2 d.p (0.05 V) and V_R > 3.50 V V_R = 4.00 V	B1
3c(i)	**MMO** T_W is measured to 1 d.p (0.5 °C) and more than 70.0 °C T_W = 78.0 °C V_W is measured to 2 d.p (0.05 V) V_W = 2.10 V (No marks awarded)	B1 0
3c(ii)	**PDO** Correct calculation and correct unit and calculated to correct dp Working must be seen for marks to be awarded. $T_C = T_W - T_R$ = 78.0 – 31.0 = 47.0 °C $V_C = V_R - V_W$ = 4.00 - 2.10 = 1.90 V	 B1 B1

<table>
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<td>3(d)</td>
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PDO

First mark:
- Correct column headings with units

Second mark:
- Independent variable is V_w
- 6 sets of data
- Results from (c) included
- Raw data is within range: ($V_W \leq 3.00$ V and $T_W \geq 40.0$ °*C)*
- Correct d.p for raw data (V_W and T_W)

Third mark:
- Correct trend (when V_W increases, T_W decreases)
- No identical values

Fourth mark:
- Correct calculation and d.p. for V_C and T_C

<table>
<tr><th>V_W / V</th><th>T_W / °C</th><th>V_C / V</th><th>T_C / °C</th></tr>
<tr><td>2.10</td><td>76.0</td><td>1.80</td><td>44.5</td></tr>
<tr><td>2.20</td><td>73.0</td><td>1.70</td><td>41.5</td></tr>
<tr><td>2.25</td><td>70.0</td><td>1.65</td><td>38.5</td></tr>
<tr><td>2.30</td><td>67.5</td><td>1.60</td><td>36.0</td></tr>
<tr><td>2.35</td><td>65.5</td><td>1.55</td><td>34.0</td></tr>
<tr><td>2.40</td><td>63.0</td><td>1.50</td><td>31.5</td></tr>
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*Refer to the last page for full set of data taken for 1 hour.

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B1

B1

B1

B1

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<td>3e(i)</td>
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PDO
Refer to graph attached in the last page
- Axes with correct labelling
- Scale (no odd scale, size of graph more than half)
- Plotting of points (mark selected points)
- Line of best fit (straight line)

Students who use an odd scale for graph will lose 3 marks altogether:
- 1 mark for scale
- 1 mark for plotting of points in graph and
- 1 mark for gradient calculation in the next part

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B4

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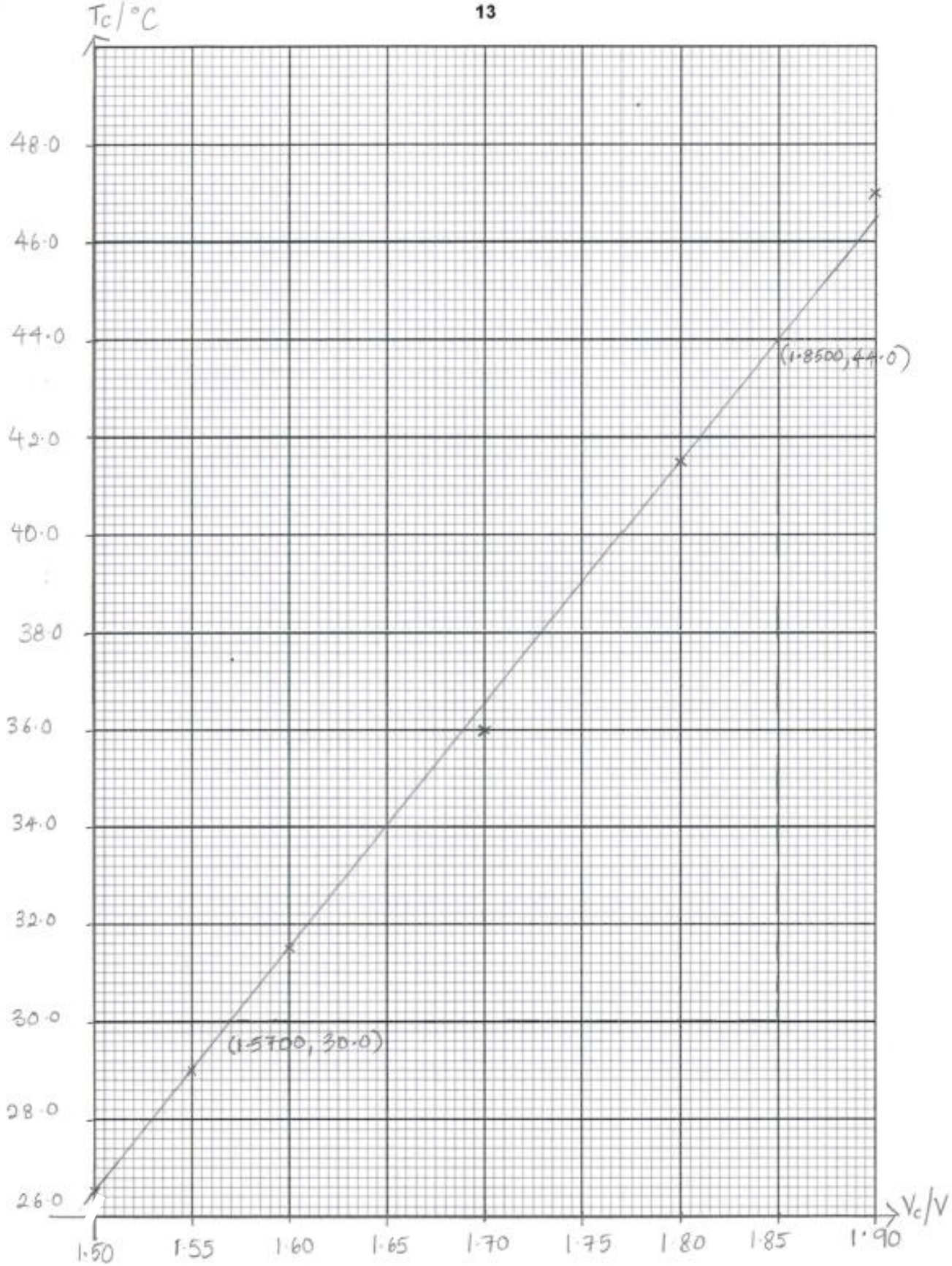
3e(ii)	**ACE** 1st mark - Large gradient triangle (length of triangle extends over more than half the data range) - Coordinates read to better than half a small square in calculation 2nd Mark - Correct calculation of gradient from sides of triangle - Final answer shown to 3 s.f. - Within acceptable range : 30 to 70 Gradient = (44.0 – 30.0) / (1.8500 – 1.5700) = 50 .0	 B1 B1
3e(iii)	**MMO** Correct calculation of y-intercept and final answer shown to 3 s.f. Substituting m= 50.0 and (1.570, 30.0) into y=mx +c: 30.0 = 50.0(1.570) + c c = - 48.5 *Check that student's x-axis starts from zero if y-intercept is read directly from the graph.	 B1
3f	**ACE** T_C is **linearly** related to V_C. Accept: As V_C increases, T_C increases **linearly** AWW: As T_C increases, V_C increases **linearly** AWW: As V_C decreases, T_C decreases **linearly** Reject: When V_C increases, T_C increases. Reject: directly proportional	 B1

3g	**ACE** Correct source of error identified with explanation that can be improved Correct improvement that will reduce the error identified Second correct source of error identified with explanation that can be improved Correct improvement that will reduce the error identified Any 2 of the following:	M1 A1 M1 A1

No.	Source of error and explanation	Suggestion for improvement
1	Energy transfer from the water to surroundings results in temperature difference between the thermistor and water.	Insulate/lag the beaker or Put a lid on the beaker
2	The thermometer is touching the base of the beaker, so it may not be measuring T_W accurately. AWW: walls / sides of beaker	Suspend the thermometer in the middle of the water (close to the thermistor using a retort stand.)
3	The water temperature may not be uniform (hence the T_w recorded may not be accurate)	Use a stirrer to stir the water continuously. AWW: use thermometer to stir.
4	There is a reaction time (delay) in looking at voltmeter and reading the thermometer (hence the V_W and T_w recorded may not be accurate)	Use a data logger to detect the temperature and voltage changes

Reject:

- Joule heating effect on wires → There is no practical and feasible way for improvement.
- Evaporation of water → mass is not required for any calculations in the question


T_c / °C
48·0
46·0
44·0
42·0
40·0
38·0
36·0
34·0
32·0
30·0
28·0
26·0
(1·8500, 44·0)
(1·5700, 30·0)
V_c / V
1·50
1·55
1·60
1·65
1·70
1·75
1·80
1·85
1·90

Full set of data for 1 hour conducted under exam conditons.

No.	Time of experiment	Time elapsed from start / min	V_W / V	T_W / °C	V_C / V	T_C / °C
1	10.25	0	1.90	82.5	2.00	51.0
2	10.26	1	2.00	80.5	1.90	49.0
3	10.28	3	2.10	76.0	1.80	44.5
4	10.29	4	2.20	73.0	1.70	41.5
5	10.30	5	2.25	70.0	1.65	38.5
6	10.32	7	2.30	67.5	1.60	36.0
7	10.33	8	2.35	65.5	1.55	34.0
8	10.35	10	2.40	63.0	1.50	31.5
9	10.38	13	2.45	60.0	1.45	28.5
10	10.40	15	2.50	59.0	1.40	27.5
11	10.42	17	2.55	55.5	1.35	24.0
12	10.44	19	2.60	54.0	1.30	22.5
13	10.48	23	2.65	51.5	1.25	20.0
14	10.51	26	2.70	49.5	1.20	18.0
15	10.55	30	2.75	47.5	1.15	16.0
16	10.59	34	2.80	45.5	1.10	14.0
17	11.05	40	2.85	43.0	1.05	11.5
18	11.14	49	2.90	41.0	1.00	9.5
19	11.21	56	2.95	39.5	0.95	8.0
20	11.27	62	3.00	38.0	0.90	6.5