Cambridge International AS & A Level

PHYSICS **9702/53**

Paper 5 Planning, Analysis and Evaluation **May/June 2024**

MARK SCHEME

Maximum Mark: 30

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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Question	Answer	Marks
1	**Defining the problem**	
	t is the independent variable and T_C is the dependent variable **or** vary t and measure T_C	**1**
	keep T_R <u>constant</u>	**1**
	Methods of data collection	
	labelled diagram of workable experiment including: • solid cylinder cooling • insulation surrounding all of the cylinder • thermometer touching cylinder inside insulation • insulation and thermometer labelled	**1**
	method to heat the cylinder uniformly, e.g. place in oven/immerse in hot water **or** diagram showing cylinder in oven or hot water	**1**
	method to determine time t, e.g. stopwatch or temperature sensor connected to a data logger	**1**
	method to measure L e.g. use a ruler/calipers/micrometer **and** method to measure d e.g. use calipers/micrometer	**1**
	Method of Analysis	
	plot a graph of ln (T_C – T_R) against t or equivalent	**1**
	$U = -\dfrac{mc \times \text{gradient}}{A}$	**1**
	$Z = e^{y\text{-intercept}}$	**1**

Question	Answer	Marks
1	**Additional detail including safety considerations**	**6**
	D1 precaution to <u>prevent burns</u> or use of <u>hot cylinder</u> / <u>oven</u> / <u>hot water</u> e.g. use of gloves, use of tongs	
	D2 keep thickness of the insulating material constant (for each T_C)	
	D3 method to measure *m*, e.g. use a (top-pan) balance	
	D4 for water bath/oven methods, wait for initial temperature of the cylinder to become <u>uniform</u> or <u>constant throughout the cylinder</u>	
	D5 (surface) $A = \pi dL + \frac{\pi d^2}{2}$ **or** $\pi dL + 2\left(\frac{\pi d^2}{4}\right)$	
	D6 repeat measurements of *d* <u>along the length</u> of the cylinder / in <u>different directions</u> **and** determine the average value of *d*	
	D7 description of how *c* is determined from a separate experiment by heating the cylinder using electrical heater **and** $c = \frac{\Delta E}{m\Delta\theta}$	
	D8 method of determining energy supplied to electrical heater to determine *c*, e.g. use of joulemeter for ΔE or electrical method using ammeter and voltmeter to determine IVt	
	D9 use several temperature sensors **and** determine the average T_C	
	D10 relationship valid <u>if</u> a straight line is produced (with *y*-intercept = ln *Z*) Do not accept line passing through the origin.	

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)</td><td>gradient = $-\dfrac{1}{kf_s}$
y-intercept = $\dfrac{1}{f_s}$</td><td>1</td></tr>
<tr><td rowspan="2">2(b)</td><td>
<table>
<tr><th>v / m s^{-1}</th><th>$\dfrac{1}{f}$ / 10^{-3} Hz^{-1}</th></tr>
<tr><td>3.5 ± 0.4</td><td>1.118 or 1.1183</td></tr>
<tr><td>6.3 ± 0.4</td><td>1.110 or 1.1096</td></tr>
<tr><td>8.7 ± 0.5</td><td>1.101 or 1.1013</td></tr>
<tr><td>11.4 ± 0.5</td><td>1.092 or 1.0919</td></tr>
<tr><td>13.9 ± 0.6</td><td>1.083 or 1.0827</td></tr>
<tr><td>16.2 ± 0.6</td><td>1.074 or 1.0739</td></tr>
</table>
Values of v and $\dfrac{1}{f}$ correct as shown above.</td><td>1</td></tr>
<tr><td>Uncertainties in v correct as shown above.</td><td>1</td></tr>
<tr><td rowspan="2">2(c)(i)</td><td>Six points from (b) plotted correctly.
Must be within half a small square. Diameter of points must be less than half a small square.</td><td>1</td></tr>
<tr><td>Error bars in v plotted correctly.
All error bars to be plotted. Total length of bar must be accurate to less than half a small square and symmetrical.</td><td>1</td></tr>
</table>

Question	Answer	Marks
2(c)(ii)	Straight line of best fit drawn. Do not accept line from top point to bottom point. Line must pass between (14.5, 1.080) and (14.9, 1.080) **and** between (4.5, 1.115) and (4.8, 1.115).	**1**
	Worst acceptable line drawn (steepest or shallowest possible line that passes through all the error bars). All error bars must be plotted.	**1**
2(c)(iii)	Gradient determined with clear substitution of data points into $\Delta y / \Delta x$. Gradient must be negative. Distance between data points must be greater than half the length of the drawn line.	**1**
	Gradient determined of worst acceptable line with clear substitution of data points into $\Delta y / \Delta x$. uncertainty = (gradient of line of best fit – gradient of worst acceptable line) **or** uncertainty = ½ (steepest worst line gradient – shallowest worst line gradient)	**1**
2(c)(iv)	*y*-intercept determined by substitution of correct point with consistent power of ten in *m* and *y* into $y = mx + c$.	**1**
	y-intercept of worst acceptable line determined by substitution into $y = mx + c$. uncertainty = *y*-intercept of line of best fit – *y*-intercept of worst acceptable line **or** uncertainty = ½ (steepest worst line *y*-intercept – shallowest worst line *y*-intercept) Do not accept ECF from false origin method.	**1**

Question	Answer	Marks
2(d)(i)	f_s determined using *y*-intercept **and** f_s given to 2, 3 or 4 significant figures **and** *k* given to 2 or 3 significant figures. $f_s = \dfrac{1}{y\text{-intercept}}$	**1**
	k determined using gradient with method shown **and** f_s <u>and</u> *k* given with SI units with appropriate powers of ten. $k = -\dfrac{y\text{-intercept}}{\text{gradient}}$ **or** $k = -\dfrac{1}{\text{gradient} \times f_s}$ Units of f_s: Hz Units of *k*: m s^{-1}	**1**
2(d)(ii)	Percentage uncertainty in *k* with method shown. $\text{percentage uncertainty} = \left(\dfrac{\Delta y\text{-intercept}}{y\text{-intercept}} + \dfrac{\Delta\text{gradient}}{\text{gradient}}\right) \times 100$ **or** correct substitution for max/min methods.	**1**
2(e)	*v* determined (non-zero) to a minimum of 2 significant figures from **(c)(iii)** and **(c)(iv)** or **(d)(i)** with correct substitution. $v = \dfrac{\frac{1}{f} - y\text{-intercept}}{\text{gradient}}$ **or** $v = k - \dfrac{kf_s}{f}$	**1**