Cambridge International AS & A Level

PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2023**

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.

Cambridge International will not enter into discussions about these mark schemes.

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6	<u>Calculation specific guidance</u> Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'. For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values. For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme. Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.
7	<u>Guidance for chemical equations</u> Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme. State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

Question	Answer	Marks
1	**Defining the problem**	
	θ is the independent variable and t is the dependent variable **or** vary θ and measure t	**1**
	keep d constant	**1**
	Methods of data collection	
	labelled diagram of workable experiment including: • plane supported by stand / support • stand/support on bench/floor/horizontal surface • minimum of two labels from cube, cylinder, (inclined) plane, method of support, bench/floor/horizontal surface, pulley, string	**1**
	diagram showing method to measure d, e.g. clamped vertical rule near cylinder **or** drawn rule on plane used to measure d **or** distance d marked on plane and rule used to determine d	**1**
	use a protractor to measure θ **or** use a rule(r) to measure appropriate lengths for a trigonometric calculation	**1**
	use a timer/stop-watch to measure t **or** light gates connected to a timer to measure t	**1**

Question	Answer	Marks
1	**Method of Analysis**	
	plot a graph of $\frac{1}{t^2}$ against sin θ or equivalent (e.g. sin θ against $\frac{1}{t^2}$) Do not accept logarithms.	**1**
	$H = -\frac{2d(A+B) \times \text{gradient}}{A}$ (for sin θ against $\frac{1}{t^2}$: $H = -\frac{2d(A+B)}{A \times \text{gradient}}$)	**1**
	$K = -\frac{2d(A+B) \times y\text{-intercept}}{A}$ (for sin θ against $\frac{1}{t^2}$: $K = -H \times y$-intercept)	**1**

Question	Answer		Marks
1	**Additional detail including safety considerations**		**6**
	D1	Safety precaution linked to <u>falling</u> cylinder, e.g. use of cushion/sand box to collect cylinder/prevent damage to cylinder/floor/bench/injury	
	D2	protractor correctly positioned on diagram **or** appropriate trigonometric relationship for marked lengths	
	D3	keep *A* **and** *B* <u>constant</u>	
	D4	use a (top-pan) balance to measure *A* **and** *B*	
	D5	correct positioning of light gates to determine *t*, e.g. two light gates either end of distance *d*, connected to a timer **or** correct <u>position</u> of video camera with <u>timer in frame</u> of the video to <u>determine *t*</u>	
	D6	method to release cylinder/cube, e.g. cube held by set square, set square moved to release cube.	
	D7	reasoned method to keep *d* constant <u>as θ changes</u>, e.g. (when measuring *d* by position of cylinder) adjust the length of the string or adjust the position of vertical marks or adjust the position of the vertical rule or initial position of the cube **or** (when measuring *d* by position of cube) use fixed marks on the plane or ruler placed on the plane with *d* measured between the marks	
	D8	method to increase *t* for cylinder to fall, e.g. use large *d* to increase *t*	
	D9	repeat measurements of *t* for the same θ and average *t*	
	D10	relationship valid <u>if</u> a straight line is produced (not passing through the origin) Do not accept straight line passing through the origin.	

Question	Answer	Marks
2(a)	gradient = $-R\ln\left(\dfrac{V}{V_0}\right)$	**1**
2(b)	<table><tr><th>C / 10^{-4} F</th><th>T / s</th></tr><tr><td>0.89 or 0.892</td><td>13.7 ± 0.8</td></tr><tr><td>1.3 or 1.32</td><td>20.4 ± 0.7</td></tr><tr><td>1.6 or 1.58</td><td>24.3 ± 0.6</td></tr><tr><td>1.0 or 1.03</td><td>16.1 ± 0.8</td></tr><tr><td>1.2 or 1.18</td><td>18.3 ± 0.7</td></tr><tr><td>2.1 or 2.08</td><td>31.5 ± 0.6</td></tr></table> Values of C and T correct as shown above.	**1**
	Absolute uncertainties in T correct as shown above.	**1**
2(c)(i)	Six points from **(b)** plotted correctly. Must be within half a small square. Diameter of points must be less than half a small square.	**1**
	Error bars in T plotted correctly. All error bars to be plotted. Total length of bar must be accurate to less than half a small square and symmetrical.	**1**

Question	Answer	Marks
2(c)(ii)	Straight line of best fit drawn. Do not accept line from top point to bottom point. Points must be balanced. Line must pass between (1.42, 22.0) and (1.45, 22.0) **and** between (1.95, 30.0) and (2.00, 30.0)	**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 $\Delta y / \Delta x$. Distance between data points must be greater than half the length of the drawn line.	**1**
	Gradient of worst acceptable line determined 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(d)	– 0.69 or – 0.693 **and** ± 0.06	**1**
2(e)(i)	R determined using gradient **and** R given to 2 or 3 significant figures. $R = -\frac{\text{gradient}}{\ln\left(\frac{V}{V_0}\right)} = \frac{\textbf{(c)(iii)}}{\textbf{(d)}}$	**1**
	R correctly determined using gradient **and** SI unit with correct power of ten for R (e.g. Ω).	**1**

Question	Answer	Marks
2(e)(ii)	Percentage uncertainty in *R* with method shown. $\text{percentage uncertainty} = \left(\dfrac{\Delta\left(\ln\left(\dfrac{V}{V_0}\right)\right)}{\ln\left(\dfrac{V}{V_0}\right)} + \dfrac{\Delta\text{gradient}}{\text{gradient}} \right) \times 100$ **or** Correct substitution for max/min methods.	**1**

Question	Answer	Marks
2(f)	*C* determined to a minimum of 2 significant figures from **(c)(iii)** or **(d)** and **(e)(i)** with correct substitution. $C = \frac{T}{\text{gradient}} = \frac{60.0}{\text{gradient}}$ **or** $C = \frac{-T}{-R\ln\left(\frac{V}{V_0}\right)} = \frac{-60.0}{\textbf{(e)(i)} \times \textbf{(d)}}$	**1**
	Absolute uncertainty in C determined with <u>correct method</u> used: Using gradient to determine *C*: $\Delta C = \left(\frac{\Delta\text{gradient}}{\text{gradient}}\right) \times C$ Allow using *R* to determine *C*: $\Delta C = \left(\frac{\Delta\left(\ln\left(\frac{V}{V_0}\right)\right)}{\ln\left(\frac{V}{V_0}\right)} + \frac{\textbf{(e)(ii)}}{100}\right) \times C$	**1**