Cambridge Assessment International Education

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.

Cambridge International is publishing the mark schemes for the May/June 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1: Marks must be awarded in line with: • the specific content of the mark scheme or the generic level descriptors for the question • the specific skills defined in the mark scheme or in the generic level descriptors for the question • the standard of response required by a candidate as exemplified by the standardisation scripts.
GENERIC MARKING PRINCIPLE 2: Marks awarded are always **whole marks** (not half marks, or other fractions).
GENERIC MARKING PRINCIPLE 3: Marks must be awarded **positively**: • marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate • marks are awarded when candidates clearly demonstrate what they know and can do • marks are not deducted for errors • marks are not deducted for omissions • answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.
GENERIC MARKING PRINCIPLE 4: Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5: Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).
GENERIC MARKING PRINCIPLE 6: Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
2	The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	<u>‘List rule’ guidance</u> For questions that require ***n*** responses (e.g. State **two** reasons …): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked *ignore* in the mark scheme should not count towards ***n***. • Incorrect responses should not be awarded credit but will still count towards ***n***. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should **not** be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science.

6	Calculation specific guidance 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	Guidance for chemical equations 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 falling 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 constant	
	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 position of video camera with timer in frame of the video to determine t	
	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 as θ changes, 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 if a straight line is produced (not passing through the origin) Do not accept straight line passing through the origin.	

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)</td><td>gradient = $-R\ln\left(\frac{V}{V_0}\right)$</td><td>1</td></tr>
<tr><td rowspan="2">2(b)</td><td>
<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.</td><td>1</td></tr>
<tr><td>Absolute uncertainties in T 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 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.</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. 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. $R = -\dfrac{\text{gradient}}{\ln\left(\dfrac{V}{V_0}\right)} = \dfrac{\textbf{(c)(iii)}}{\textbf{(d)}}$	**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. $$\text{percentage uncertainty} = \left(\frac{\Delta\left(\ln\left(\frac{V}{V_0}\right)\right)}{\ln\left(\frac{V}{V_0}\right)} + \frac{\Delta\text{gradient}}{\text{gradient}} \right) \times 100$$ **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**