Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/53**

Paper 5 Planning, Analysis and Evaluation **May/June 2022**

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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Annotations

✓	Correct point Method of analysis marks in **Question 1**
✓$_{1–10}$	Additional detail marks in **Question 1**
X	Incorrect point
^	Omission
BOD	Benefit of the doubt
NBOD	No benefit of the doubt given
ECF	Error carried forward
P	Defining the problem marks in **Question 1** Power of ten error in **Question 2**
M0	Methods of data collection marks in **Question 1**
SF	Incorrect number of significant figures

Question	Answer	Marks
1	**Defining the problem**	
	d is the independent variable and *V* is the dependent variable **or** vary *d* and measure *V*	**1**
	keep *A* or area (of overlap) of plates constant	**1**
	Methods of data collection	
	labelled diagram of workable experiment including: • circuit diagram with voltmeter connected in parallel with the capacitor • capacitor and voltmeter connected to the metal plates with no power supply in discharge part of the circuit • correct symbols for capacitor and voltmeter	**1**
	method to charge parallel plates, e.g. separate circuit diagram showing plates connected to a d.c. power supply or combined circuit with switches and d.c. power supply	**1**
	use calipers to measure *d* **or** use micrometer/calipers to measure thickness of spacers	**1**
	use rule(r) to measure lengths to determine *A* **and** *A* = length × breadth	**1**
	Method of analysis	
	plot a graph of $\frac{1}{V}$ against *d* or equivalent (e.g. *d* against $\frac{1}{V}$) (Do not accept log graphs.)	**1**
	$K = \frac{y\text{-intercept} \times C}{\text{gradient} \times A}$ or $K = \frac{C}{\text{gradient} \times AW}$ (for *d* against $\frac{1}{V}$: $K = -\frac{y\text{-intercept} \times C}{A}$)	**1**

Question	Answer	Marks
1	$W = \frac{1}{y\text{-intercept}}$ (for d against $\frac{1}{V}$: $W = -\frac{\text{gradient}}{y\text{-intercept}}$ or $W = \frac{\text{gradient} \times C}{AK}$)	**1**
	Additional detail including safety considerations	**6**
	D1 use gloves <u>to prevent</u> electric shock **or** do not touch metal plates to avoid shocks	
	D2 keep the <u>initial</u> p.d. across plates **or** initial charge <u>constant</u>	
	D3 method to determine the value of C, e.g. description of an experiment to measure p.d. or current against time during discharge through a resistor	
	D4 method of operation of circuit(s) using switch(es)	
	D5 description of method to fully discharge capacitor, e.g. between experiments, short-circuit the capacitor **or** use of switch in parallel with capacitor	
	D6 repeat measurements of d <u>at different points across plates</u> **and** average	
	D7 repeat measurements of V for same d **and** average V	
	D8 bottom plate resting on insulating material **or** top plate supported by strings	
	D9 use high voltage power supply to increase charge on plates **or** use a very small value of capacitance to increase voltmeter reading	
	D10 relationship valid <u>if</u> a straight line is produced (not passing through the origin)	

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)</td><td>gradient = n
y-intercept = lg SZ</td><td>1</td></tr>
<tr><td rowspan="2">2(b)</td><td>
<table>
<tr><th>lg (M / 10^{30} kg)</th><th>lg (L / 10^{28} W)</th></tr>
<tr><td>0.68 or 0.681 $\pm$ 0.03 or 0.04</td><td>0.15 or 0.146</td></tr>
<tr><td>0.81 or 0.806 $\pm$ 0.02 or 0.03</td><td>0.49 or 0.491</td></tr>
<tr><td>1.08 or 1.079 $\pm$ 0.07 or 0.08</td><td>1.51 or 1.505</td></tr>
<tr><td>1.36 or 1.362 $\pm$ 0.04</td><td>2.54 or 2.544</td></tr>
<tr><td>1.63 or 1.633 $\pm$ 0.04</td><td>3.56 or 3.556</td></tr>
<tr><td>1.96 or 1.959 $\pm$ 0.02</td><td>4.82 or 4.820</td></tr>
</table>
Values of lg (M / 10^{30} kg) and lg (L / 10^{28} W) correct as shown above.</td><td>1</td></tr>
<tr><td>Absolute uncertainties in lg (M / 10^{30} kg) 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 lg (M / 10^{30} kg) plotted correctly.
All error bars must be plotted. Total length of bar must be accurate to less than half a small square and symmetrical.</td><td>1</td></tr>
<tr><td rowspan="2">2(c)(ii)</td><td>Straight line of best fit drawn.
Points must be balanced. Do not accept line from top point to bottom point.
Line must pass between (0.92, 1.0) and (0.96, 1.0) and between (1.86, 4.5) and (1.90, 4.5)</td><td>1</td></tr>
<tr><td>Worst acceptable line drawn (steepest or shallowest possible line that passes through all the error bars).
All error bars must be plotted.</td><td>1</td></tr>
</table>

Question	Answer	Marks
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. 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 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 allow methods using a false origin.	**1**

Question	Answer	Marks
2(d)	n = gradient = **(c)(iii) and** n and Z both given to two or three significant figures.	**1**
	Value of Z determined using y-intercept. Correct method must be seen. $Z = \frac{10^{y\text{-intercept}} \times 10^{28}}{S} = \frac{10^{\textbf{(c)(iv)}} \times 10^{28}}{3.85 \times 10^{26}}$ **or** $Z = 10^{y\text{-intercept} - \lg S} \times 10^{28}$ **or** $Z = 10^{\textbf{(c)(iv)} - \lg 3.85 \times 10^{26}} \times 10^{28}$	**1**
	Absolute uncertainty in n = absolute uncertainty in gradient **and** $\Delta Z = \frac{\left(10^{y\text{-intercept}} - 10^{\text{WAL } y\text{-intercept}}\right) \times 10^{28}}{S}$ Correct substitution of numbers must be seen.	**1**
2(e)	L determined from **(d) or (c)(iii)** and **(c)(iv)** with correct substitution and correct power of ten(s). Do not accept incorrect POT for n or Z. $L = 3.85 \times 10^{26} \times$ **(d)** $\times 3.0^{\textbf{(c)(iii)}}$ **or** $\lg L =$ **(c)(iii)** $\times \lg 3.0 + y$-intercept	**1**