



Cambridge International AS & A Level

PHYSICS

9702/51

Paper 5 Planning, Analysis and Evaluation

May/June 2022

MARK SCHEME

Maximum Mark: 30

Published

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

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This document consists of **10** printed pages.

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 <u>constant</u>	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 $A = \text{length} \times \text{breadth}$	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
	$K = \frac{\text{y-intercept} \times C}{\text{gradient} \times A} \text{ or } K = \frac{C}{\text{gradient} \times AW}$ (for d against $\frac{1}{V}$: $K = -\frac{\text{y-intercept} \times C}{A}$)	1

Question	Answer	Marks
1	$W = \frac{1}{\text{y-intercept}}$ (for d against $\frac{1}{V}$: $W = -\frac{\text{gradient}}{\text{y-intercept}}$ 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)	

Question	Answer		Marks														
2(a)	gradient = n y-intercept = $\lg SZ$		1														
2(b)	<table><tr><th>$\lg (M / 10^{30} \text{ kg})$</th><th>$\lg (L / 10^{28} \text{ W})$</th></tr><tr><td>0.68 or 0.681 ± 0.03 or 0.04</td><td>0.15 or 0.146</td></tr><tr><td>0.81 or 0.806 ± 0.02 or 0.03</td><td>0.49 or 0.491</td></tr><tr><td>1.08 or 1.079 ± 0.07 or 0.08</td><td>1.51 or 1.505</td></tr><tr><td>1.36 or 1.362 ± 0.04</td><td>2.54 or 2.544</td></tr><tr><td>1.63 or 1.633 ± 0.04</td><td>3.56 or 3.556</td></tr><tr><td>1.96 or 1.959 ± 0.02</td><td>4.82 or 4.820</td></tr></table>		$\lg (M / 10^{30} \text{ kg})$	$\lg (L / 10^{28} \text{ W})$	0.68 or 0.681 ± 0.03 or 0.04	0.15 or 0.146	0.81 or 0.806 ± 0.02 or 0.03	0.49 or 0.491	1.08 or 1.079 ± 0.07 or 0.08	1.51 or 1.505	1.36 or 1.362 ± 0.04	2.54 or 2.544	1.63 or 1.633 ± 0.04	3.56 or 3.556	1.96 or 1.959 ± 0.02	4.82 or 4.820	1
	$\lg (M / 10^{30} \text{ kg})$	$\lg (L / 10^{28} \text{ W})$															
	0.68 or 0.681 ± 0.03 or 0.04	0.15 or 0.146															
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	1.96 or 1.959 ± 0.02	4.82 or 4.820															
Values of $\lg (M / 10^{30} \text{ kg})$ and $\lg (L / 10^{28} \text{ W})$ correct as shown above.																	
Absolute uncertainties in $\lg (M / 10^{30} \text{ kg})$ 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 $\lg (M / 10^{30} \text{ kg})$ plotted correctly. All error bars must be plotted. Total length of bar must be accurate to less than half a small square and symmetrical.	1															
2(c)(ii)	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)	1															
	Worst acceptable line drawn (steepest or shallowest possible line that passes through all the error bars). All error bars must be plotted.	1															

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 = $\frac{1}{2}$ (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 = $\frac{1}{2}$ (steepest worst line y-intercept – shallowest worst line y-intercept) Do not allow methods using a false origin.	1

Question	Answer	Marks
2(d)	$n = \text{gradient} = \text{(c)(iii)}$ 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. $Z = \frac{10^{y\text{-intercept}} \times 10^{28}}{S} = \frac{10^{\text{(c)(iv)}} \times 10^{28}}{3.85 \times 10^{26}}$ or $Z = 10^{y\text{-intercept} - \lg S} \times 10^{28}$ or $Z = 10^{\text{(c)(iv)} - \lg 3.85 \times 10^{26}} \times 10^{28}$	1
	Absolute uncertainty in $n = \text{absolute uncertainty in gradient}$ and $\Delta Z = \frac{(10^{y\text{-intercept}} - 10^{\text{WAL } y\text{-intercept}}) \times 10^{28}}{S}$ Correct substitution of numbers must be seen.	1
2(e)	L determined from (d) or (c)(iii) and (c)(iv) with correct substitution <u>and</u> correct power of ten(s). Do not accept incorrect POT for n or Z . $L = 3.85 \times 10^{26} \times \text{(d)} \times 3.0^{\text{(c)(iii)}}$ or $\lg L = \text{(c)(iii)} \times \lg 3.0 + y\text{-intercept}$	1