Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2016**

MARK SCHEME

Maximum Mark: 30

Published

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Question 1 Planning (15 marks)

Defining the problem (2 marks)

P λ is the independent variable, or vary λ. [1]

P V is the dependent variable, or measure V. [1]

Methods of data collection (4 marks)

M Circuit diagram showing <u>d.c. power supply</u> in series with diode (correct symbol needed) and method to measure potential difference across diode. Circuit must be correct. [1]

M Instrument to change p.d. across LED e.g. variable power supply/potential divider/variable resistor. [1]

M Record wavelength of light of LED from data sheet or use Young's slits/diffraction grating. [1]

M (Slowly) increase potential difference across LED until LED (just) emits light (or reverse procedure). [1]

Method of analysis (3 marks)

A Plot a graph of lg V against lg λ (allow natural logs). Allow lg λ against lg V. [1]

A n = gradient [1]

A $k = 10^{y\text{-intercept}}$ [1]

Additional detail (6 marks)

Relevant points might include: [6]

1 Use of a <u>protective</u> resistor (can be shown on the diagram).

2 Polarity of LED correct in <u>circuit diagram</u>.

3 Instrument to determine when LED just lights e.g. light meter/detector, LDR.

4 <u>Method</u> to use light detector/LDR to determine point at which LED emits light.

5 Expression that gives λ (symbols need to defined) from experimental determination of wavelength of light, e.g. Young's slits/diffraction grating.

6 Perform experiment in a dark room/LED in tube.

7 Relationship is valid if graph is a straight line.

8 $\lg V = n \lg \lambda + \lg k$

9 Repeat V and average for the same λ or LED.

Do not allow vague computer methods.

Question 2 Analysis, conclusions and evaluation (15 marks)

	Mark	Expected Answer	Additional Guidance
(a)	A1	$\dfrac{4LF}{\pi E}$	
(b)	T1	$\dfrac{1}{d^2}$ / 10^6 m^{-2}	
	T2	13 or 12.8 9.8 or 9.77 6.9 or 6.93 4.7 or 4.73 3.2 or 3.19 1.9 or 1.93	All values to 2 s.f. or 3 s.f. Allow a mixture of significant figures. Must be values in table.
	U1	From ± 2 to ± 0.1	Allow more than one significant figure.
(c) (i)	G1	Six points plotted correctly	Must be within half a small square. Do not allow "blobs". ECF allowed from table.
	U2	Error bars in $\dfrac{1}{d^2}$ plotted correctly	All error bars to be plotted. Must be accurate to less than half a small square.
(ii)	G2	Line of best fit	If points are plotted correctly then lower end of line should pass between (3.2, 3.0) and (3.6, 3.0) **and** upper end of line should pass between (11.2, 10.0) and (11.6, 10.0).
	G3	Worst acceptable straight line. Steepest or shallowest possible line that passes through all the error bars.	Line should be clearly labelled or dashed. Examiner judgement on worst acceptable line. Lines must cross. Mark scored only if error bars are plotted.
(iii)	C1	Gradient of line of best fit	The triangle used should be at least half the length of the drawn line. Check the read-offs. Work to half a small square. Do not penalise POT. (Should be about 9×10^{-10}.)
	U3	Absolute uncertainty in gradient	Method of determining absolute uncertainty Difference in worst gradient and gradient.
(d) (i)	C2	$\dfrac{4LF}{\pi \times \text{gradient}} = \dfrac{60.479}{\text{gradient}}$	Do not penalise POT. (Should be about 7×10^{10}.)
	C3	$N\,m^{-2}$ or Pa	Allow in base units: $kg\,m^{-1}\,s^{-2}$.
(ii)	U4	Percentage uncertainty in *E*	Must be larger than 3%.

	Mark	Expected Answer	Additional Guidance
(e)	C4	e in the range 15.5×10^{-3} to 18.0×10^{-3} and given to 2 or 3 s.f.	Allow mm.
	U5	Absolute uncertainty in e	Note $e = \dfrac{\text{gradient}}{d^2}$ is possible.

Uncertainties in Question 2

(c) (iii) Gradient [U3]

uncertainty = gradient of line of best fit – gradient of worst acceptable line

uncertainty = ½ (steepest worst line gradient – shallowest worst line gradient)

(d) (ii) [U4]

$$\text{percentage uncertainty} = \left(\frac{\Delta\text{gradient}}{\text{gradient}} + \frac{0.01}{2.50} + \frac{0.5}{19.0}\right) \times 100 = \left(\frac{\Delta\text{gradient}}{\text{gradient}}\right) \times 100 + 3.03\%$$

$$\max E = \frac{4 \times \max L \times \max F}{\pi \times \text{min gradient}} = \frac{4 \times 2.51 \times 19.5}{\pi \times \text{min gradient}} = \frac{62.319}{\text{min gradient}}$$

$$\min E = \frac{4 \times \min L \times \min F}{\pi \times \text{max gradient}} = \frac{4 \times 2.49 \times 18.5}{\pi \times \text{max gradient}} = \frac{58.652}{\text{max gradient}}$$

(e) [U5]

$$\text{percentage uncertainty} = \left(\frac{0.5}{19.0} + \frac{0.01}{2.50} + 2 \times \left(\frac{0.02}{0.23}\right)\right) \times 100 + \%E = 20.4\% + \%E$$

$$\text{percentage uncertainty} = \left(\frac{\Delta\text{gradient}}{\text{gradient}} + 2 \times \left(\frac{0.02}{0.23}\right)\right) \times 100$$

$$\max e = \frac{\text{max gradient}}{d_{\min}^2}$$

$$\max e = \frac{4 \times L_{\max} \times F_{\max}}{\pi \times E_{\min} \times d_{\min}^2}$$

$$\min e = \frac{\text{min gradient}}{d_{\max}^2}$$

$$\min e = \frac{4 \times L_{\min} \times F_{\min}}{\pi \times E_{\max} \times d_{\max}^2}$$