**UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS**

**GCE Advanced Subsidiary Level and GCE Advanced Level**

# MARK SCHEME for the May/June 2011 question paper

# for the guidance of teachers

## 9702 PHYSICS

**9702/51** Paper 5 (Planning, Analysis and Evaluation), maximum raw mark 30

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**1 Planning (15 marks)**

**Defining the problem (3 marks)**

P1 $n$ is the independent variable and $V$ is the dependent variable or vary $n$ and measure $V$ [1]
P2 Keep distance from light to photocell constant [1]
P3 Keep intensity of light constant. Allow constant voltage across lamp/current through lamp/brightness. Do not allow 'same lamp/output'. [1]

**Methods of data collection (5 marks)**

M1 Labelled diagram of apparatus: lamp, glass sheet and photocell in line. [1]
M2 Voltmeter connected to photocell. Penalise unworkable photocell circuit. [1]
M3 Use micrometer (screw gauge) to measure thickness of glass sheet. [1]
M4 Take many readings of thickness and average. [1]
M5 Perform experiment in a dark room or shield apparatus. [1]

**Method of analysis (2 marks)**

A1 Plot a graph of ln $V$ against $n$. Allow ln $V$ against $nt$ [1]
A2 $\alpha$ = (–)gradient / $t$. (ln $V$ against $nt$ then $\alpha$ = (–)gradient) [1]

**Safety considerations (1 mark)**

S Reasoned method to prevent burns from hot source, e.g. use gloves
Reasoned method to prevent eye damage from bright/intense source, e.g. shield lamp/ dark glasses/do not look at source directly
Reasoned method to prevent cuts from glass e.g. use gloves. [1]

**Additional detail (4 marks)**

D Relevant points might include [4]
1 Use small distance/high intensity to gain large reading.
2 Method to check output of lamp is constant e.g. measure current through/p.d. across lamp/regularly check $V_0$ with no glass.
3 Reasoned method to ensure output of lamp is constant e.g. workable circuit diagram with variable resistor or variable power supply.
4 Clean sheets of glass before use.
5 Direction of light is perpendicular to glass sheets/constant orientation.
6 $\ln V = -\alpha nt + \ln V_0$.
7 Further safety consideration.

Do not allow vague computer methods.

**[Total: 15]**

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## 2 Analysis, conclusions and evaluation (15 marks)

| Part | Mark | Expected Answer | Additional Guidance |
|---|---|---|---|
| **(a)** | A1 | $NkT/A$ | $290Nk/A$ |
| **(b)** | T1 | $\frac{1}{h}$ / $m^{-1}$ | Column heading. Allow equivalent unit. e.g. $h^{-1}$ / $m^{-1}$ |
| | T2 | 2.5 or 2.50<br>2.8 or 2.78<br>3.1 or 3.13<br>3.6 or 3.57<br>4.2 or 4.17<br>4.8 or 4.76 | A mixture of 2sf and 3sf is allowed. |
| | U1 | From $\pm$ 0.03 to $\pm$ 0.1, $\pm$ 0.11 or $\pm$ 0.12 | Allow more than one significant figure. |
| **(c) (i)** | G1 | Six points plotted correctly | Check second and fifth plots and other anomalous plots. Must be less than half a small square. Ecf allowed from table. |
| | U2 | All error bars in $\frac{1}{h}$ plotted correctly | Half square or greater loses the mark. Ecf allowed from table. |
| **(ii)** | G2 | Line of best fit | If points are plotted correctly then lower end of line should pass between (2.20, 1.0) **and** (2.30, 1.0) and upper end of line should pass between (4.75, 2.1) and (4.85, 2.1). Allow ecf from points plotted incorrectly – examiner judgement. |
| | G3 | Worst acceptable straight line. Steepest or shallowest possible line that passes through all the error bars. | Line should be clearly labelled or dashed. Should pass from top of top error bar to bottom of bottom error bar **or** bottom of top error bar to top of bottom error bar. Mark scored only if error bars are plotted. |
| **(iii)** | C1 | Gradient of best fit line | 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. |
| | U3 | Uncertainty in gradient | Method of determining absolute uncertainty Difference in worst gradient and gradient. |
| **(d)** | C2 | Value of $N = \frac{\text{gradient} \times A}{kT}$ | Gradient must be used. Allow ecf from **(c)(iii)** but penalise POT. |
| | U4 | Determines uncertainty in $N$ | Method required. Do not check calculation. |
| **(e) (i)** | C3 | Method to determine $h$ | $h = \frac{NkT}{pA} = 1.111 \times 10^{-20} \times N$ ; $T$ = 278 K<br>Must use answer from **(d)**. |
| | C4 | Between 0.361 and 0.391 given to 2 or 3 sf | Must be in range. Allow 0.36, 0.37, 0.38 or 0.39. Assume metres unless otherwise specified. |
| **(ii)** | U5 | Percentage uncertainty | % uncertainty in $N$ + % uncertainty in $T$) [Allow $\Delta T$ to be 0.5 or 1] |

**[Total: 15]**

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**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)** [U4]
Uncertainty = worst $N - N$

$$\Delta N = \frac{\Delta m}{m} \times N$$

$$\Delta N = \Delta m \times \frac{A}{kT}$$

**(e)** [U5]

Percentage uncertainty = $\frac{\Delta h}{h} \times 100$

Percentage uncertainty = percentage uncertainty in $N$ + percentage uncertainty in $T$

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