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.

Question	Answer	Marks
1	**Defining the problem**	
	R is the independent variable and *T* is the dependent variable, or vary *R* and measure *T*	**1**
	keep *C* constant	**1**
	Methods of data collection	
	labelled diagram or correct symbols of workable circuit including: • (d.c.) power supply correctly positioned • (neon) lamp correctly positioned do not accept ohmmeter in circuit	**1**
	circuit diagram to determine resistance of resistors e.g. using ammeter and voltmeter OR ohmmeter	**1**
	method to determine period or *T*, e.g. use a stopwatch / timer / oscilloscope do not accept counting the flashes in a specified time	**1**
	circuit diagram showing voltmeter(s) or oscilloscope(s) to determine V_i and V_F	**1**
	Method of Analysis	
	plots a graph of *T* against *R*	**1**
	$K = \frac{\text{gradient}}{C}$	**1**
	$V_L = V_i - (V_i - V_F)e^K = V_i - (V_i - V_F)e^{\frac{\text{gradient}}{C}}$	**1**

Question	Answer	Marks
1	**Additional detail including safety considerations**	**Max 6**
	switch off (high voltage) circuit (before changing the resistor) / wear insulating gloves to prevent electrocution / shock	**D1**
	resistance of resistors linked to diagram is V / I for ammeter / voltmeter method or gradient of appropriate graph or resistance from ohmmeter	**D2**
	input voltage or V_i is constant	**D3**
	repeat experiment for each value of R and average T	**D4**
	90 V (or larger) power supply do not accept a.c. or signal generator	**D5**
	for stopwatch method: time 10 or more flashes and divide by number of flashes for oscilloscope method: length of wave × timebase	**D6**
	record value of capacitance from the capacitor or method to determine capacitance	**D7**
	appropriate circuit to enable capacitance to be determined	**D8**
	relationship valid if a straight line passing through the origin is produced	**D9**
	method to obtain a measurable time period e.g. do a preliminary experiment to choose appropriate resistors, use large values of R or C	**D10**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)</td><td>gradient = q
y-intercept = lg p</td><td>1</td></tr>
<tr><td rowspan="2">2(b)</td><td><table>
<tr><td>1.58 or 1.580</td><td>1.61 or 1.613</td></tr>
<tr><td>1.66 or 1.663</td><td>1.51 or 1.505</td></tr>
<tr><td>1.74 or 1.740</td><td>1.40 or 1.398</td></tr>
<tr><td>1.81 or 1.806</td><td>1.30 or 1.301</td></tr>
<tr><td>1.86 or 1.857</td><td>1.23 or 1.230</td></tr>
<tr><td>1.90 or 1.898</td><td>1.15 or 1.146</td></tr>
</table></td><td>1</td></tr>
<tr><td>absolute uncertainties in lg η: $\pm$ 0.01 to $\pm$ 0.03</td><td>1</td></tr>
<tr><td rowspan="2">2(c)(i)</td><td>six points plotted correctly
must be accurate to the nearest half small square
diameter of points must be less than half a small square</td><td>1</td></tr>
<tr><td>error bars in lg η 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>
<tr><td rowspan="2">2(c)(ii)</td><td>line of best fit drawn
points must be balanced
do not allow line from top plot to bottom plot
if points are plotted correctly then lower end of line should pass between (1.820, 1.275) and (1.835, 1.275) and upper end of line should pass between (1.640, 1.525) and (1.650, 1.525)</td><td>1</td></tr>
<tr><td>worst acceptable line drawn
steepest or shallowest possible line
mark scored only if all error bars are 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 at least half the length of the drawn line must be negative	**1**
	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 of correct point 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) no ECF from false origin method	**1**
2(d)	$p = 10^{y\text{-intercept}}$ and given to 2 or 3 sf	**1**
	q = gradient and q and p have correct power of ten from **(c)(iii)** and **(c)(iv)**	**1**
	absolute uncertainty in p = $10^{y\text{–intercept of WAL}} - p$ absolute uncertainty in q = uncertainty in gradient correct substitution of numbers must be seen	**1**
2(e)	$\theta = \sqrt[q]{\frac{100}{p}}$ or $\lg\theta = \frac{\lg(100) - \lg p}{q} = \frac{2 - y\text{ – intercept}}{\text{gradient}}$ correct substitution of numbers must be seen	**1**