Question	Answer	Marks
1	**Additional detail including safety considerations**	**6**
	D1 precaution linked to <u>oil spillage</u>, e.g. use of cushion/sand box/tray for falling beaker to land **or** use of bungs/lids on beakers **or** use foam on bench/floor **or** use foam to prevent rising beaker hitting pulley	
	D2 precaution linked to <u>oil contact with skin</u> e.g. use gloves to avoid contact with oil	
	D3 keep *M* constant	
	D4 use a (top-pan) balance to measure *M*	
	D5 method to keep *h* constant e.g. use a fiducial mark to release the beaker from the same position **or** release from the same position on the <u>clamped</u> rule each time	
	D6 equation to determine *z* for method used, e.g. for timing *h*, $z = 2h / t$ **or** for one light gate, $z = L / t$ where *L* is the length of the interrupted beam **or** for two light gates, *z* = distance between light gates / *t* Do not accept h / t.	
	D7 additional detail on diagram to measure *h*, e.g. clamp (metre) rule with stand on surface **or** use of set squares positioned on the surface to side of rule **or** spirit level positioned to side of rule	
	D8 use large value of *h* to increase time of fall of beaker	
	D9 repeat measurements of *z* for the same *V* <u>and</u> average *z*	
	D10 relationship valid <u>if</u> a straight line is produced (passing through $\left(\frac{1}{2bh}\right)$) Do not accept line passing through the origin.	

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)</td><td>gradient = $-\frac{t}{R}$

y-intercept = ln I_0R</td><td>1</td></tr>
<tr><td rowspan="3">2(b)</td><td><table><tr><th>$1 / C / 10^4$ F^{-1}</th><th>ln (V / V)</th></tr><tr><td>0.91 or 0.909</td><td>0.896 or 0.8961</td></tr><tr><td>0.76 or 0.758</td><td>1.012 or 1.0116</td></tr><tr><td>0.63 or 0.633</td><td>1.115 or 1.1151</td></tr><tr><td>0.61 or 0.606</td><td>1.131 or 1.1314</td></tr><tr><td>0.48 or 0.482</td><td>1.253 or 1.2528</td></tr><tr><td>0.36 or 0.357</td><td>1.348 or 1.3481</td></tr></table>Values correct as shown above.</td><td>1</td></tr>
<tr><td>Uncertainties in ln (V / V) from ± 0.021 or ± 0.020 to ± 0.010 or ± 0.013</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 ln (V / V) 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>
</table>

Question	Answer	Marks
2(c)(ii)	Straight line of best fit drawn. Do not accept line from top point to bottom point. Points must be balanced. Line must pass between (0.820, 0.95) and (0.845, 0.95) **and** between (0.400, 1.30) and (0.425, 1.30)	**1**
	Worst acceptable line drawn (steepest or shallowest possible line that passes through all the error bars). All error bars must be plotted.	**1**
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. Gradient must be negative.	**1**
	Gradient determined of worst acceptable line. 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 with consistent power of ten in *m* and *x* into $y = mx + c$.	**1**

Question	Answer	Marks
2(d)(i)	R determined using gradient. $R = -\frac{30.0}{\text{gradient}} = \frac{30.0}{\textbf{(c)(iii)}}$	**1**
	I_0 determined using y-intercept with method shown. $I_0 = \frac{e^{y\text{-intercept}}}{R} = \frac{e^{\textbf{(c)(iv)}}}{\textbf{(d)(i)}}$	**1**
	R and I_0 determined correctly using gradient and y-intercept **and** R and I_0 given to 2 or 3 significant figures **and** R and I_0 given with SI units with appropriate powers of ten. Units: R: Ω **or** s F^{-1} I_0: A **or** V F s^{-1} **or** $\text{V}\,\Omega^{-1}$	**1**
2(d)(ii)	Percentage uncertainty in R with method shown. $\text{percentage uncertainty in } R = \left(\frac{\Delta t}{t} + \frac{\Delta\text{gradient}}{\text{gradient}}\right) \times 100$ **or** Correct substitution for max/min methods.	**1**

Question	Answer	Marks
2(e)	C determined to a minimum of 2 significant figures from **(c)(iii)** and **(c)(iv)** or **(d)(i)** with correct substitutions. $C = \frac{\text{gradient}}{\ln V - y\text{-intercept}}$ **or** $C = -\frac{\text{gradient}}{y\text{-intercept} - \ln V}$ **or** $C = -\frac{t}{R(\ln V - \ln I_0 R)}$ **or** $C = \frac{t}{R(\ln I_0 R - \ln V)}$	**1**