Question	Answer	Marks
1	**Additional detail including safety considerations**	**6**
	D1 precaution linked to hot coil (P) / hot resistor, e.g. use of (heat-proof) gloves, wait until circuit cools down **or** precaution linked to shocks from high voltages e.g. use of (insulating) gloves or switch off supply before touching the circuit (to change *R*)	
	D2 keep the number of turns on (both) coils constant	
	D3 keep *f* constant	
	D4 keep distance between the coils constant	
	D5 method to keep distance between the coils constant, e.g. fix/clamp coils to bench	
	D6 method to measure *f*, e.g. read from signal generator or use of oscilloscope	
	D7 method to determine *f* from oscilloscope, e.g. period from oscilloscope T = time-base × horizontal distance **and** $f = 1/T$	
	D8 method to determine *V* or *E* from oscilloscope, e.g. V = *y*-gain × vertical distance	
	D9 method to increase *E* e.g. use iron core/more turns on coil Q/high frequency/high p.d. (across *R* and coil *P*)	
	D10 relationship valid if a straight line is produced (not passing through the origin) Do not accept straight line passing through the origin.	

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)</td><td>gradient = $\frac{Yk}{p}$
y-intercept = $\frac{YkZ}{p}$</td><td>1</td></tr>
<tr><td rowspan="2">2(b)</td><td><table><tr><th>V / 10^{-5} m^3</th><th>absolute uncertainty</th></tr><tr><td>3.81 or 3.815</td><td>± 0.03</td></tr><tr><td>3.99 or 3.986</td><td>± 0.03</td></tr><tr><td>4.16 or 4.163</td><td>± 0.04</td></tr><tr><td>4.33 or 4.335</td><td>± 0.04</td></tr><tr><td>4.48 or 4.481</td><td>± 0.04</td></tr><tr><td>4.65 or 4.652</td><td>± 0.04</td></tr></table>Values of V correct as shown above.</td><td>1</td></tr>
<tr><td>Absolute uncertainties in V correct as shown above.</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 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 (27.5, 3.90) and (29.5, 3.90) **and** between (82.0, 4.60) and (84.0, 4.60).	**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.	**1**
	Gradient of worst acceptable line determined with clear substitution of data points into $\Delta y / \Delta x$. 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 *y* 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) Do not accept ECF from false origin method.	**1**

Question	Answer	Marks
2(d)(i)	*Y* determined using gradient **and** *Y* and *Z* given to 2 or 3 significant figures. $Y = \frac{p \times \text{gradient}}{k} = 7.3188 \times 10^{27} \times \text{gradient}$	**1**
	Z determined using *y*-intercept **and** *Y* and *Z* given with SI units. $Z = \frac{p \times y\text{-intercept}}{Yk}$ **or** $Z = \frac{y\text{-intercept}}{\text{gradient}}$ Units: Y: no unit Z: °C	**1**
2(d)(ii)	Percentage uncertainty in *Y* with method shown. $\text{percentage uncertainty} = \left(\frac{\Delta p}{p} + \frac{\Delta\text{gradient}}{\text{gradient}}\right) \times 100$ **or** Correct substitution for max/min methods.	**1**

Question	Answer	Marks
2(e)	θ determined to a minimum of 2 significant figures from **(c)(iii)** and **(c)(iv)** or **(d)(i)** with correct substitution and correct powers of ten. $V = \frac{\pi \times (0.0279)^2 \times 0.0600}{4} = 3.67 \times 10^{-5}$ **and** $\theta = \frac{pV}{Yk} - Z$ **or** $\theta = \frac{V}{\text{gradient}} - Z$ **or** $\theta = \frac{V - y\text{-intercept}}{\text{gradient}}$ **or** using h directly: $\theta = \frac{p\pi d^2 h}{4Yk} - Z$ **or** $\theta = \frac{\pi d^2 h}{4 \times \text{gradient}} - Z$ **or** $\theta = \frac{\frac{\pi d^2 h}{4} - y\text{-intercept}}{\text{gradient}}$	**1**