

Question Number	Answer	Mark
4(a)(i)	<p>EITHER</p> <p>Repeat at different places and calculate a mean (1)</p> <p>To reduce (the effect of) <u>random error</u> (1)</p> <p>MP2 dependent on MP1 [Allow MP2 if MP1 partially correct]</p> <p>OR</p> <p>Use the ratchet to avoid squashing the rubber (1)</p> <p>To reduce (the effect of) <u>random error</u> (1)</p> <p>MP2 dependent on MP1 [Allow MP2 if MP1 partially correct]</p> <p>OR</p> <p>Check and correct for zero error (1)</p> <p>To eliminate <u>systematic error</u> [Accept reduce for eliminate] (1)</p> <p>MP2 dependent on MP1 [Allow MP2 if MP1 partially correct]</p>	2
4(a)(ii)	<p>Mean $t = 1.04$ (mm) 3 SF only (1)</p> <p><u>Example of calculation</u></p> $\text{Mean } t = \frac{(1.02 + 1.06 + 1.05 + 1.01)\text{mm}}{4} = 1.035 = 1.04 \text{ (mm)}$	1
4(a)(iii)	<p>Calculation using half range shown</p> <p>Or</p> <p>Calculation of furthest from the mean shown (1)</p> <p>Percentage uncertainty in $t = 3\%$ e.c.f. (a)(ii) Accept 2 SF (1)</p> <p><u>Example of calculation</u></p> $\text{Half range} = \frac{(1.06 - 1.01)\text{mm}}{2} = 0.025 = 0.03 \text{ (mm)}$ $\%U = \frac{0.03\text{mm}}{1.04\text{mm}} \times 100 = 2.9\% = 3\%$ <p>Note: use of 0.025 in calculation gives 2.4% or 2%</p>	2

4(a)(iv)	<p>The measurement is larger but the uncertainty is the same Or The measurement is larger but the resolution (of the micrometer) is the same (1) (1)</p> <p>So the percentage uncertainty is reduced (by a factor of 4)</p> <p>MP2 dependent on MP1</p>	2
4(a)(v)	<p>The length x of the rubber band does not take into account the fold (at the ends). (1)</p> <p>The (length x of the) rubber band could be measured when it is not taut Or The width w could be measured when the rubber band is compressed (1)</p>	2

4(b)(i)	<p>EITHER</p> <p>Uses $2 \times$ percentage uncertainty in D [Accept $2 \times \frac{\Delta D}{D}$] (1)</p> <p>Uncertainty in $D = 0.069 \text{ (cm}^2\text{)}$ 2 SF only (1)</p> <p><u>Example of calculation</u></p> <p>$\%U \text{ in } D^2 = 2 \times \frac{0.01}{3.45} \times 100 = 0.58\%$</p> <p>$U \text{ in } D^2 = 3.45^2 \times \frac{0.58}{100} = 0.069 \text{ (cm}^2\text{)}$</p> <p>OR</p> <p>Calculation of half range of D^2 shown (1)</p> <p>Uncertainty in $D = 0.069 \text{ (cm}^2\text{)}$ 2 SF only (1)</p> <p><u>Example of calculation</u></p> <p>$U \text{ in } D^2 = \frac{3.46^2 - 3.44^2}{2} = 0.069 \text{ (cm}^2\text{)}$</p>	<p>2</p>
4(b)(ii)	<p>EITHER</p> <p>Addition of uncertainties shown (1)</p> <p>$U \text{ in } A = 0.052 \text{ (cm}^2\text{)}$ 2 SF only e.c.f. (b)(i) (1)</p> <p><u>Example of calculation</u></p> <p>$U \text{ in } A = (0.07 + 0.06 + 0.07) \times \frac{\pi}{12} = 0.052 \text{ (cm}^2\text{)}$</p> <p>OR</p> <p>Calculation of maximum and minimum A shown (1)</p> <p>$U \text{ in } A = 0.053 \text{ (cm}^2\text{)}$ 2 SF only (1)</p> <p><u>Example of calculation</u></p> <p>Maximum $A = (11.97 + 9.42 + 10.63) \times \frac{\pi}{12} = 8.383 \text{ cm}^2$</p> <p>Minimum $A = (11.83 + 9.30 + 10.49) \times \frac{\pi}{12} = 8.278 \text{ cm}^2$</p> <p>$U \text{ in } A = \frac{8.383 - 8.278}{2} = 0.053 \text{ (cm}^2\text{)}$</p>	<p>2</p>

4(c)	<p>Calculation of a relevant limit using percentage uncertainty shown Or Calculation of a relevant uncertainty using percentage uncertainty shown (1)</p> <p>Upper limit ρ for rubber band = $1.20 \text{ (g cm}^{-3}\text{)}$ and Lower limit ρ for rubber bung = $1.50 \text{ (g cm}^{-3}\text{)}$ (1)</p> <p>They are not made from the same type of rubber as the upper limit of the rubber band does not overlap the lower limit for the rubber bung (1)</p> <p>MP3 dependent MP2</p> <p><u>Example of calculation</u></p> <p>Upper limit ρ for rubber band = $1.15 \times (1 + \frac{4.3}{100}) = 1.20 \text{ (g cm}^{-3}\text{)}$ Lower limit ρ for rubber bung = $1.52 \times (1 - \frac{1.2}{100}) = 1.50 \text{ (g cm}^{-3}\text{)}$</p>	3
	Total for question 4	16