

Question number	Answer	Mark
4(a)(i)	Digital / vernier calipers (1)	1
4(a)(ii)	Any <b>PAIR</b> from: Check for zero error (1) to eliminate <u>systematic</u> error (1) <b>OR</b> Repeat at different places <b>and</b> calculate a mean (1) to reduce the effect of <u>random</u> errors (1) [MP2 dependent on MP1]	2
4(a)(iii)	area of slot = <u>1.03</u> (cm <sup>2</sup> ) (1) Calculation of U shown (1) U = 0.02 (cm <sup>2</sup> ) [d.p. consistent with area] (1)  <u>Example of calculation</u> Area of slot = $a \times b = 0.47 \text{ cm} \times 2.19 \text{ cm} = 1.03 \text{ cm}^2$ %U in Area = $(0.01/0.47) \times 100 + (0.005/2.19) \times 100$ = 2.13% + 0.23% = 2.4% U = $1.03 \text{ cm}^2 \times 2.4\% = 0.02 \text{ cm}^2$ Area of slot = $1.03 \text{ cm}^2 \pm 0.02 \text{ cm}^2$	3
4(b)(i)	Use of area = $\pi d^2/4$ (1) Area = 10.4 (cm <sup>2</sup> ) [ecf 4(a)(iii) 3 s.f. only] (1)  <u>Example of calculation</u> Whole area = $\pi d^2/4 = \pi \times (3.81 \text{ cm})^2/4 = 11.4 \text{ cm}^2$ Shaded area = whole area – area of slot = $11.4 \text{ cm}^2 - 1.03 \text{ cm}^2$ = 10.4 cm <sup>2</sup>	2
4(b)(ii)	Calculation of %U in $d$ using 0.005 shown (1) Double %U in $d$ shown (1) U = 0.05 (cm <sup>2</sup> ) [ecf 4(a)(iii)] (1)  <u>Example of calculation</u> %U in $d^2$ = $2 \times 0.005/3.81 \times 100 = 0.26\%$ U in whole area = $11.4 \text{ cm}^2 \times 0.26\% = 0.03 \text{ cm}^2$ U in shaded area = $0.03 \text{ cm}^2 + 0.02 \text{ cm}^2 = 0.05 \text{ cm}^2$	3

4(c)(i)	<p>Use of <math>\rho = \frac{m}{V}</math> (1)</p> <p><math>\rho = 8.47 \text{ (g cm}^{-3}\text{)}</math> [ecf 4(b)(i), 3 s.f. only] (1)</p> <p><u>Example of calculation</u></p> <p><math>V = 10.4 \text{ cm}^2 \times 1.137 \text{ cm} = 11.8 \text{ cm}^3</math></p> <p><math>\rho = 100 \text{ g} / 11.8 \text{ cm}^3 = 8.47 \text{ g cm}^{-3}</math></p>	2
4(c)(ii)	<p>Calculation of half range in <math>t</math> shown (1)</p> <p>Addition of %U in <math>t</math> and %U in shaded area shown (1)</p> <p>% U in <math>\rho = 0.66\%</math> [ecf 4(b)(ii)] (1)</p> <p><u>Example of calculation</u></p> <p>Half range in <math>t = (11.39 - 11.35)/2 = 0.02 \text{ mm}</math></p> <p>%U in <math>t = (0.02/11.37) \times 100 = 0.18\%</math></p> <p>% U in shaded area <math>= (0.05/10.4) \times 100 = 0.48\%</math></p> <p>% U in <math>\rho = 0.18\% + 0.48\% = 0.66\%</math></p>	3
4(d)	<p>Correct calculation of upper and/or lower limit shown [ecf 4(c)] (1)</p> <p>With comparison of limit with value for brass and valid conclusion based on comparison (1)</p> <p><b>OR</b> (1)</p> <p>Correct calculation of %D shown [ecf 4(c)] (1)</p> <p>Comparison of %D with %U and valid conclusion based on comparison</p> <p><u>Example of calculation</u></p> <p>Uncertainty in <math>\rho = 8.47 \text{ g cm}^{-3} \times 0.66\% = \pm 0.06 \text{ g cm}^{-3}</math></p> <p>Range of <math>\rho</math> is <math>8.41 \text{ g cm}^{-3}</math> to <math>8.53 \text{ g cm}^{-3}</math></p> <p>The value for brass lies within this range therefore the mass could be made of brass</p> <p><b>OR</b></p> <p>Uncertainty in <math>\rho = 8.47 \text{ g cm}^{-3} \times 0.66\% = \pm 0.06 \text{ g cm}^{-3}</math></p> <p><math>\%D = \frac{8.5-8.47}{8.5} \times 100\% = 0.35\%</math></p> <p>As the %D is less than the %U the mass could be made of brass</p>	2
Total mark for Question 4 = 18		