1) D
2) A
3) C
4) C
5) B
6) C
7) D
8) C
9) C
10) B
11) C
12)

(a) allow 50 g - 500 g ..... B1 [1]

(b) allow 3 MJ - 4 MJ ..... B1 [1]

(c) allow $(6.0 - 8.0) \times 10^{-7}$ m ..... B1 [1]

(d) allow $(5 \times 10^{4}) \rightarrow (5 \times 10^{5})$ Pa ..... B1 [1]

(Ignore sig. fig. in **(a)**, **(b)**, **(c)** and **(d)**.

13)

(a) because all readings have same error
OR can't be eliminated by repeating and averaging B1
error is systematic ..... B1 [2]
(do not allow 'systematic' if argument is fallacious)

(b) micrometer measures to fraction of millimetre so is precise
OR if repeated, reading is (almost constant) B1
but all readings have error so is not accurate ..... B1 [2]

14)

(a) 1.6 ± 0.2 cm ..... B1 [1]

(b) 1.6 / 50 = 0.032 ...(ignore any uncertainties)..... B1 [1]

(c) idea of adding fractional uncertainties C1
(0.2 / 1.6) + (0.1 / 50)
= 0.127 OR 12.7% ...(-2 marks if uncertainties not added) A1
actual uncertainty = (±) 0.004 ..... A1 [3]
(do not allow more than 2 sig. fig)

15)

(i) scatter of points (about the line) B1
(ii) intercept (on t^2 axis) B1 **[2]**
(note that answers must relate to the graph)

16)

(a)	allow 100 m s^{-1} → 900 m s^{-1}	B1	**[1]**
(b)	allow 0.5 kg m^{-3} → 1.5 kg m^{-3}	B1	**[1]**
(c)	allow 5 g → 50 g	B1	**[1]**
(d)	allow 2 × 10^3 cm^3 → 9 × 10^3 cm^3	B1	**[1]**

17)

(a) (i)	e.g. check for zero error (on micrometer)/zero the micrometer	**B1**	
(ii)	take readings along the length of the wire/at different points	**B1**	
(iii)	take readings spirally/around the wire	**B1**	**[3]**
(b) (i)	4%	**A1**	
(ii)	8%	**A1**	**[2]**

18)

(a)

systematic: e.g.	constant error (in all readings) cannot be eliminated by averaging error in measuring instrument	B1	
random: e.g.	readings scattered (equally) about true value error due to observer can be eliminated by averaging (*only if averaging not included for systematic*)	B1	[2]

(b)

$15 = \pi \times R^2 \times 20$		
R = 0.4886 cm (accept any number of s.f.)	C1	
% uncertainty in V = 3.3 % (or 0.5/15)	C1	
% uncertainty in L = 0.5 % (or 0.1/20)	C1	
% uncertainty in R = 1.9 % (i.e. one half of the sum)	C1	
$R = 0.489 \pm 0.009$ cm	A1	[5]

19)

(a)	allow anything in range 20 Hz → 20 kHz	B1	[1]
(b)	allow anything in range 10 nm → 400 nm	B1	[1]
(c)	allow anything in range 10 g → 100 g	B1	[1]
(d)	allow anything in range 0.1 kg m^{-3} → 10 kg m^{-3}	B1	[1]

20)

(a) (i) micrometer (screw gauge) / travelling microscope ..... B1 [1]

(ii) *either* ohm-meter *or* voltmeter and ammeter
or multimeter/avo on ohm setting ..... B1 [1]

(iii) *either* (calibrated) c.r.o. *or* a.c. voltmeter and × √2 ..... B1 [1]

(b) density = mass / volume C1
= 580 / 6^3 = 2.685 g cm^{-3} …(*allow 2.68, 2.69, 2.7*) A1

% uncertainty in mass = (10 / 580) × 100 = 1.7% C1
% uncertainty in volume = 3 × (0.1 / 6) × 100 = 5.0% C1
uncertainty in density = 0.18 g cm^{-3}
density = 2.7 ± 0.2 g cm^{-3} ..... A1 [5]
(*answer 2.69 ± 0.09 g cm^{-3} scores 4 marks*)

21)

(a) θ (rad) = 2π *x* (10.3/360) 1
= 0.180 rad (n.b. 3 sig. fig.) 1 **[2]**

(b) (i) tan θ = 0.182 (n.b. 3 sig. fig.) 1

(ii) percentage error = (0.002/0.180) x 100 1

= 1.1 (%) 1 **[3]**

(allow 0.002/0.182 and allow 1→ 4 sig. fig.)