Question	Answer	Marks
Section A		
1	**Correct answer as below and key is D.** % uncertainty in current = $\frac{8}{120} \times 100 = 6.67$ % % uncertainty in p.d. = $\frac{0.2}{1.8} \times 100 = 11.11$ % % uncertainty in resistance = 6.67 + 11.11 = 17.8 % **Distractors:** **A** 4.4 % – incorrect subtraction, 11.11 – 6.67 = 4.4 % **B** 6.7 % – just the value for current **C** 11 % – just the value for p.d **D** 18 % – correct answer (as above)	1
2	**Correct answer as below and key is B.** $E = \frac{1}{2} \times 100 \times (0.05^2 - 0.03^2) = 0.080$ J **Distractors:** **A** 0.020 J – Incorrect, $E = \frac{1}{2} \times 100 \times (0.05 - 0.03)^2 = 0.020$ J **B** 0.080 J – Correct answer (as above) **C** 0.140 J – Incorrect, $E = \frac{1}{2} \times 100 \times (0.08^2 - 0.06^2) = 0.140$ J **D** 1.00 J – Incorrect, F and k confused; $E = \frac{1}{2} \times 100 \times (0.05 - 0.03)$ = 1.00 J	1
3	**Correct key is D.**	1
4	**Correct key is B.**	1
5	**Correct answer as below and key is B.** 1.30 sin 60 = 1.50 sin θ, $\theta = 49°$ **Distractors:** **A** 42° – Incorrect, $\sin\theta = \frac{1}{1.5}$ used, $\theta = 42°$ **B** 49° – Correct answer (see above) **C** 60° – Incorrect, sin $\theta = \frac{1.30}{1.50}$, 60° **D** 88° – Incorrect, 1.50 sin 60 = 1.30 sin θ, $\theta = 88°$	1
6	**Correct key is C.**	1
7	**Correct answer as below and key is D.** $R = (6.0^{-1} - 10^{-1})^{-1} = 15\ \Omega$ **Distractors:** **A** 0.067 Ω – Incorrect, answer not inversed ... $R = (6.0^{-1} - 10^{-1}) = 0.067\ \Omega$ **B** 3.8 Ω – Incorrect, $R = (6.0^{-1} + 10^{-1})^{-1} = 3.8\ \Omega$ **C** 4.0 Ω – Incorrect, $R = 10 - 6.0 = 4.0\ \Omega$ **D** 15 Ω – Correct answer (as above)	1
8	**Correct answer as below and key is A.** $E = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3.00 \times 10^8}{5.0 \times 10^{-7}} = 4 \times 10^{-19}$ J **Distractors:** **A** 4×10^{-19} J – Correct answer (see above). **B** 4×10^{-18} J – Incorrect, wavelength 5×10^{-8} m used **C** 4×10^{-16} J – Incorrect, wavelength 5×10^{-10} m used **D** 4×10^{-11} J – Incorrect, wavelength 5×10^{-15} m used	1
9	**Correct key is D.**	1

Question	Answer	Marks
10	**Correct key is C.**	1
Section B		
11 (a)	velocity = rate of change of displacement	1
11 (b) (i)	speed = $\frac{70000}{3600}$ KE = $\frac{1}{2} \times 130 \times \left(\frac{70000}{3600}\right)^2$ KE = 2.5×10^4 J	1 1 1
11 (b) (ii)	The mass of the Mononykus is $\frac{1}{8}$ of the mass of the ostrich. Correct reasoning: The volume decreases by a factor of 8 and the density is assumed to be the same.	1 1
12 (a)	$a = g\sin10° = 9.81 \times \sin10°$ $a = 1.7$ m s^{-2}	1 1
12 (b)	$s = \frac{1}{2}at^2$ $t = \sqrt{\frac{2 \times 0.45}{1.7}}$ $t = 0.73$ s	1 1 1
12 (c)	Start the stopwatch when the block is released and stop it when the block reaches the bottom of the ramp. Calculate the average speed by dividing 0.45 m by the time recorded on the stopwatch. The final speed v = 2 × average speed.	1 1 1
13 (a)	stress = $\sigma = \frac{F}{A} = \frac{15}{3.1 \times 10^{-7}}$ $\sigma = 4.84 \times 10^7$ Pa strain $\varepsilon = \frac{\sigma}{E} = \frac{4.84 \times 10^7}{4.2 \times 10^{10}}$ $\varepsilon = 1.15 \times 10^{-3}$	1 1 1
13 (b)	Measure the length L of the wire using a metre rule. Connect an ammeter and a battery in series with the wire (use crocodile clips to make connections to the wire) and record the current I. Place a voltmeter in parallel with the wire and record the p.d V. The resistivity ρ of the metal is given by $\rho = \frac{RA}{L}$, where $A = 3.1 \times 10^{-7}$ m^2, and $R = \frac{V}{I}$.	1 1 1 1
13 (c)	$R = (30^{-1} + 35^{-1})^{-1}$ $R = 16.1\ \Omega$	2 1
14 (a)	Waves that have a constant phase difference between them.	1
14 (b)	A progressive wave does not have nodes and antinodes like a stationary wave. A progressive wave transfers energy (between two points) and stationary does not transfer energy.	1 1
14 (c) (i)	wavelength = 2 × 2.5 wavelength = 5.0 cm	1 1
14 (c) (ii)	$v = f\lambda = 110 \times 0.05$ $v = 5.5$ m s^{-1}	1 1
15 (a)	A graph of E against f shows a straight line passing through the origin.	1
15 (b) (i)	$E = hf = 6.63 \times 10^{-34} \times 8.94 \times 10^{14}$ $E = 5.93 \times 10^{-19}$ J	1 1
15 (b) (ii)	$KE_{max} = (5.93 - 3.20) \times 10^{-19} = 2.73 \times 10^{-19}$ J $2.73 \times 10^{-19} = \frac{1}{2} \times 9.11 \times 10^{-31} \times v^2$ $v = 7.74 \times 10^5$ m s^{-1}	1 1 1

Question	Answer	Marks
16 (a)	refractive index = speed of light in vacuum/speed of light in material.	1
16 (b)	$n_1 \sin\theta_1 = n_2 \sin\theta_2$	1
16 (c) (i)	refractive index n = gradient A straight best-fit line drawn and gradient = 1.40 (allow ± 0.05)	1 1
16 (c) (ii)	$\sin c = (1.40)^{-1}$ $c = 45.6°$	1 1
16 (d)	Place the glass block on paper and shine light from the ray box into the curved surface of the block. Rotate either the ray-box or the block until the refracted ray from the glass block makes an angle of 90°. Use a protractor to measure the angle of incidence of the ray of light within the block; this is the critical angle c. The refractive index n is calculated using $n = (\sin c)^{-1}$.	1 1 1 1
17 (a)	The current in a metallic conductor is directly proportional to the potential difference cross its ends, as long as its temperature remains constant.	1
17 (b) (i)	The resistance of the component is infinite for $V < 0.60$ V because the current is zero (or negligible). For $V > 0.60$ V, the current increases and the resistance of the component decreases. The resistance R of the component is equal to $\frac{V}{I}$ and one sample calculation done to support the answer.	1 1 1
17 (b) (ii)	A supply/battery connected the component. The variable resistor included in the circuit to change the current or a variable (d.c.) supply is used. A voltmeter placed across the component and an ammeter placed in series with the component. Correct circuit symbols used for all components.	1 1 1
17 (c) (i)	$I = \frac{6.0}{(36 + 12)}$ current = 0.125 A	1 1
17 (c) (ii)	$V = 0.125 \times 12 = 1.5$ V	1
17 (c) (iii)	The p.d. across the 10 Ω resistor is 3.0 V. The p.d. across P and Q = 3.0 – 1.5 = 1.5 V	1 1