Question Number	Answer		Mark
18(a)	Use of $A = \pi r^2$ Use of $R = \rho l / A$ $R = 23.5$ (Ω) (Units are in brackets, as this is a "show that" question, where the units have already been given in the question) (For a "show that" question, the answer needs to be given to at least one more significant figure than that given in the question, so an answer of 24 Ω would not score MP3 unless it is shown to a greater number of significant figures beforehand) (If a candidate uses diameter instead of radius, MP2 can still be awarded if the substituted value for A is dimensionally-correct) <u>Example of calculation</u> $A = \pi r^2 = \pi \times (0.0905 \times 10^{-3}\ \text{m})^2 = 2.57 \times 10^{-8}\ \text{m}^2$ $R = \rho l / A = (1.10 \times 10^{-6}\ \Omega\text{m}) \times (0.550\ \text{m}) / (2.57 \times 10^{-8}\ \text{m}^2)$ $= 23.5\ \Omega$	(1) (1) (1)	**3**
18(b)	Maximum power when total resistance of circuit is the lowest Calculation of total resistance when X and Y are closed Use of $P = V^2/R$ Maximum power = 9W, which is less than 12 W, so student incorrect (allow full e.c.f. from (a), including situations where power is calculated to be more than 12W so student is correct) (MP1 and MP2 can be awarded if candidate clearly calculates the power when switches X and Y are closed with no explanation). (MP3 can be awarded when candidate has only switch X or switch Y closed) (For MP4 there needs to be a clear conclusion of whether the student is correct or incorrect) (Some students might calculate the power of each individual resistor when both switches X and Y are closed – this is an acceptable method that can gain full credit – look for 6W, 1.5W and 1.5W added to give 9W) <u>Example of calculation</u> When X is closed, $R_{tot} = 23.5\ \Omega + 23.5\ \Omega = 47\ \Omega$ When Y is closed, $R_{tot} = 23.5\ \Omega$ When X and Y are closed, $R_{tot} = \left(\frac{1}{47\ \Omega} + \frac{1}{23.5\ \Omega}\right)^{-1} = 15.7\ \Omega$ $P = V^2 / R$, so greatest power when resistance is lowest, $= (12.0\ \text{V})^2 / (15.7\ \Omega) = 9.2$ W (If using the "show that" value from (a), power = 9W)	(1) (1) (1) (1)	**4**

18(c)(i)	Use of $R = V / I$ to calculate I (1) Use of $I = Q / t$ **and** number of electrons = Q / e (1) Number of electrons = 3.2×10^{18} (no units) (1) (allow full e.c.f. from (a)) <u>Example of calculation</u> $I = V / R$ = 12.0 V / 23.5 Ω = 0.511 A. $Q = It$ (for 1 second) = 0.511A × 1.0 s = 0.511 C Number of electrons = 0.511 C / (1.60×10^{-19} C) = 3.2×10^{18} electrons (if using the "show that" value from (a), answer = 3.1×10^{18})	**3**
18(c)(ii)	Temperature of resistor increases (1) Resistance of resistor increases (1) Use of $P = V^2 / R$ to explain that power output falls (1) (For MP3, allow use of $P = VI$ as long as it is clear that I decreases)	**3**
	Total for question 18	**13**