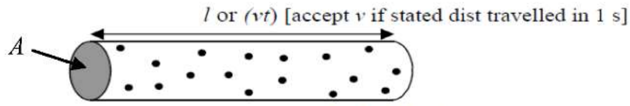
Marking Scheme

1.

5	*(a)*		Rearrangement of $R = \frac{\rho l}{A}$ seen [or implied by 2[nd] mark]. (1) $\frac{\Omega\ m^2}{m}$ seen (1) Accept equivalent working in terms of showing homogeneity: 1[st] mark insertion of units in equation; 2[nd] mark explicit conclusion	2
	(b)	(i)	Convincing demonstration, e.g $\pi\left(\frac{1.3\times10^{-3}}{2}\right)^2$ seen [Ans = 1.327×10^{-9} m^2]	1
		(ii)	$R = \frac{1.7\times10^{-8}\times20}{1.3(\text{or }1.33)\times10^{-6}}$ [=0.26 Ω]	1
		(iii)	$\frac{0.26(\text{ecf})}{14}$ [or correct use of parallel formula] (1) = 0.019 Ω (1) If resistivity formula used, 1[st] mark for $A \times 14$.	2
		(iv)	Use of $P = I^2R$ [or equiv, e.g. $P = IV$ and $V = IR$] (1) $\left(\frac{9\times0.26}{9\times0.19}\right)$ [NB 9 not 3] or $\left(\frac{I^2R}{I^2 R/14}\right)$ (1) Answer in range 13 – 14.5 : 1 (1)	3
		(v)	I. Less power loss in whole / larger cable [for a given current] / or smaller resistance [accept: if 1 strand breaks there will still be continuity.]	1
			II. More flexible [or less prone to snap with repeat bending] /if 1 strand breaks there will still be continuity [accept only once]	1
	(c)	(i)	7.52 – 7.7 × 10^{28} m^{-3}	1
		(ii)	Substitution in or re-arrangement of $I = nAve$ to give v: $v = \frac{I}{nAe}$ or $3.0 = 7.7 \times 10^{28}(\text{ecf}) \times 1.3 \times 10^{-6} \times 1.6 \times 10^{-19} v$ (1) [NB No ecf on n if 2.0×10^{24} used] $v = 1.9 \times 10^{-4}$ m s^{-1} (1)	2
		(iii)	I, n and e do not change (1) A increased by × 14 (1) v reduced by same ration → 1.36 [1.4] × 10^{-5}m s^{-1}.(1)	3
				[17]

2.

Question				Marking details	Marks Available
3	*(a)*	(i)		[Free] electrons forced to move by applied pd (Need a reference to drift velocity or electron flow but does not need to be explicitly stated) (1) They collide with atoms/nuclei/ions/lattice of the wire (1) don't accept particles or molecules	2
		(ii)		Power = $\frac{1.8}{60}$ = 0.03 [W] (1) $R = \frac{0.03(\text{ecf})}{1.6^2}$ = 0.0117 [Ω] (1) **Alternative solution possible** for the first 2 marks using $V = \frac{W}{Q}$ and $R = \frac{V}{I}$ $\rho = \frac{0.0117 \text{x} 2 \text{x} 10^{-6}}{0.4}$ (1) [**ecf** on *R*] = 5.9×10^{-8} [Ω m] (1)	4
	(b)	(i)		 [NB free electrons not required to be labelled] Number of free electrons = *nAvt* [**or** *nAl*] (1) Total change = *nAvte* [**or** *nAle*] (1) $I = \frac{nAvte}{t}$ with cancelling shown [or $\frac{nAle}{t}$, where $\frac{l}{t} = v$ shown] (1) Volume defined either from diagram [e.g. *A* and *l* labelled as shown] or in body of derivation [e.g. vol = *Al*] and *n* identified correctly– **for the first mark**	4
		(ii)		$1.6 = 6.4 \times 10^{28} \times 2 \times 10^{-6} \times v \times 1.6 \times 10^{-19}$ (1: substitution) $v = 7.8 \times 10^{-5}$ [m s^{-1}] (1)	2
		(iii)	(I) (II) (III)	**less than 1.6 A** identified/circled (1) **the same as** identified/circled (1) **half** identified/circled (1)	3
				Question 3 Total	**[15]**

3.	(a)	(i)	[For a metallic conductor] the potential difference and current are [directly] proportional/ I α V (1), provided the temperature remains constant / all physical factors remain constant (1) V = IR only no marks	2
		(ii)	It is constant / stays the same /increases as the temperature increases	1
	(b)	(i)	$A = 1.5(3) \times 10^{-8}$ [m²](1) $R = \frac{\rho l}{A} = \frac{95\times10^{-8}\times3.2}{1.5(3)\times10^{-8}}$ (1) = 199 [Ω] (1)	3
		(ii)	$\frac{230^2}{200}$ = 265 [W] allow e.c.f. from (b)(i)	1
		(iii)	$\frac{1}{66.7(1)} = \frac{1}{200} + \frac{1}{R_2}$ (1) R_2 = 100 [Ω] (1)	3
		(iv)	R_2 (1) either reference to $\frac{V^2}{R}$ so lower *R* / same V across lower R or reference to I^2R so greater *I* or reference to *IV* so *I* increased [for constant *V*] or correct calculation of R_2 (1)	2
		(v)	$\frac{230}{66.7}$ = 3.5 [A] allow e.c.f. from (b)(iii)	1

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	(v)	$\frac{230}{66.7}$ = 3.5 [A] allow e.c.f. from (b)(iii)	1

4.	*(a)*	(i)	Ruler and wire shown and labelled (1) Moving pointer or jockey or crocodile clip indicated (1) **Either**: Correctly positioned ohmmeter with no power supply; **or** correctly positioned voltmeter and ammeter with power supply (1) [No labelling required for either method].	[3]
		(ii)	Diagonal line through origin	[1]
		(iii)	CSA from <u>diameter of wire</u> (1) Gradient from graph = (R/l) or (ρ/A) Or stated take a pair of R and l values from the graph (1) ρ = gradient × CSA or use of $\rho = RA/l$ (1)	[3]
	(b)	(i)	$R = \frac{144}{32} = 4.5\,[\Omega]$ (1) Correct substitution into $R = \rho l/A$ (1) $l = 0.375$ [m] (1) (ecf on R)	[3]
		(ii)	$I = 2.7$ [A] (from V/R or P/V etc) (1) (ecf on I) Correct substitution into $I = nAve$ (1) $v = 1.24 \times 10^{-2}$ [m s^{-1}] (1) accept 0.01 m s^{-1}	[3]

5.	*(a)*	(i)	Correct and convincing use of $\rho = \frac{RA}{l}$ (including unit conversion)	[1]
		(ii)	$\left(\frac{2000}{11.2}\right) = 179$ A **unit mark**	[1]
		(iii)	$v = \frac{I}{nAe}$ rearranged (or shown numerically) (1) $n = 6.0 \times 10^{28} \times 3$ (1) $v = 1.55 \times 10^{-5}$ [m s^{-1}] (ecf on I and n) (1)	[3]
	(b)	(i)	Same (or equivalent)	[1]
		(ii)	v increased (1) because…; A decreased, I, n, e unchanged by implicaton (1)	[2]
		(iii)	Increased frequency / more collisions <u>**between electrons and lattice**</u> / atoms / ions or electrons carry greater kinetic energy (1) leading to <u>**increased vibrational / kinetic energy of lattice atoms**</u> (1)	[2]