Question Number	Answer	Mark
1(a)	Substitution into $R = \rho l/A$ (ignore powers of 10) (1) Conversion cm to m (1) R = 540 (Ω) (1) <u>Example of calculation</u> $R = (5.4 \times 10^{-3}\ \Omega\ \text{m} \times 0.15\ \text{m})/1.5 \times 10^{-6}\ \text{m}^2$ R = 540 Ω	**3**
1(b)(i)	Resistance/resistivity changes with temperature (allow wire gets hotter etc)(1) As t<u>emperature</u> increases, resistance/resistivity decreases (this statement implies 1st mark so scores 2)	**2**
1(b)(ii)	Current flow causes a heating effect (1) Resistance of lead decreases/ number of charge carriers increases (1) Relates to $V = IR$ e g $R \alpha 1/I$ or 'because V is constant, as R↓ I↑' (1)	**3**
	Total for question	**8**

Question Number	Answer	Mark
2(a)	Use of $I = nqvA$ with e 1.6 × 10^{-19} C and 8 × 10^{-3} A v = 2.8 × 10^{-7} m s^{-1}	**1** **1**
(b)	Value for semiconductor is much greater n for semiconductor (much) less than for conductor	**1** **1**
(c)	Its resistance decreases because (as temperature increases) n increases OR there are more electrons /charge carriers.	**1** **1**
		6

Question Number	Answer	Mark
3(a)	n; number of charge carriers per unit volume OR number of charge carriers m^{-3} OR charge carrier density (1) v; drift velocity (of charge carriers) OR average velocity OR drift speed (1) (accept free electrons or charge carriers throughout)	**2**
(b)	Units of I and q A and A s OR C s^{-1} and C (1) Units of n m^{-3} (1) Units of v and A m s^{-1} and m^2 (1)	**3**
	Total for question	**5**

Question Number	Answer		Mark
4(a)	best fit line use of gradient **Or** use of *R/l* from graph or table use of $\rho = RA/l$ resistivity = $4.7 \times 10^{-7}\ \Omega$ m (range 4.5 to $4.8 \times 10^{-7}\ \Omega$ m) <u>Example of calculation</u> gradient = $4.4\ \Omega \div 1.0$ m = $4.4\ \Omega\ \text{m}^{-1}$ $\rho = A \times$ gradient = $1.06 \times 10^{-7}\ \text{m}^2 \times 4.4\ \Omega\ \text{m}^{-1}$ resistivity = $4.66 \times 10^{-7}\ \Omega$ m	**(1)** **(1)** **(1)** **(1)**	**4**
4(b)	temperature increases (with increasing current) resistance/resistivity would have increased (with temperature)	**(1)** **(1)**	**2**
4(c)	Precaution Explanation E.g. ensure good contact (e.g. tight croc clips); so pd across contact resistance doesn't make V results inaccurate E.g. Avoid pressing too hard on wire; as a deformation would affect cross-sectional area and therefore resistance e.g. ensure wire is straight so length measurement is accurate e.g ensure eyes perpendicular to scale to avoid parallax erro **Do not credit:** diameter of wire since area is not in the table repeat and average high resistance voltmeter keep temperature constant	**(1)** **(1)**	**2**
	Total for question		**8**

Question Number	Answer		Mark
5(a)	The (maximum) length is (directly) proportional to the area	**(1)**	**1**
5(b)(i)	Use of $\rho l/A = R$ $R = 1.34$ (Ω) <u>Example of calculation</u> $R = 1.68 \times 10^{-8}$ Ω m × 80 m ÷ 1.0 × 10^{-6} m^2 $R = 1.34$ Ω	**(1)** **(1)**	**2**
5(b)(ii)	Use of $P = I^2R$ $P = 160$ W allow ecf from (i) <u>Example of calculation</u> $P = (11\text{ A})^2 \times 1.34$ Ω $P = 162$ W (157 W if they use 1.3 Ω)	**(1)** **(1)**	**2**
5(b)(iii)	Use of $V = IR$ **Or** use of $P = VI$ **Or** use of $P = V^2/R$ V = 15 V allow ecf from (i) and/or (ii) <u>Example of calculation</u> V = 11 A × 1.34 Ω = 14.7 V (14.3 V if 1.3 Ω is used)	**(1)** **(1)**	**2**
5(c)	To prevent (use of a cable with) resistance that is too large (Accept answers that refer to maintaining or not exceeding a resistance of about 1.3 Ω) Meaning more energy / power / p.d. available for the shredder	**(1)** **(1)**	**2**
	Total for Question		**9**

Question Number	Answer		Mark
6(a)	State (V =) $E – Ir$ Correct substitution p.d. = 11V **OR** Use of (V =) Ir to attempt to find lost volts Subtraction from E p.d. = 11V **OR** Use of $E = I(R+r)$ to attempt to find R Use of $V = IR$ with the value of R calculated p.d. = 11V <u>Example of calculation</u> $V = 12\text{ V} – 3 \times 10^{-3}\ \Omega \times 400\text{ A}$ p.d. = 10.8 V	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
6(b)	To prevent large energy dissipation / wire heating up / wire melting / large pd across the wires OR to allow a large current Resistance of cable low (cross-sectional) area large [Not surface area] [Reverse argument in terms of a thin wire acceptable for all points]	**(1)** **(1)** **(1)**	**3**
	Total for question		**6**

Question Number	Answer	Mark
7(a)	Use of $W = VIt$ **(1)** W = 69 000 (J) **(1)** Use of efficiency = (useful energy / total energy) (x 100%) **(1)** Efficiency = 0.42 (or 42%) **(1)** **Or** Use of $P = IV$ **(1)** Use of $P = W/t$ (to calculate rate of increase of internal energy of water) **(1)** Use of efficiency = (output power / input power) (x 100%) **(1)** Efficiency = 0.42 (or 42%) **(1)** <u>Example of calculation</u> W = 5.0 A × 230 V × 60 s = 69 000 J Efficiency = 29 000 J / 69 000 J = 0.42	**4**
7(b)	Human body contains water molecules **Or** body has same structure as food **(1)** So cells/tissues would gain internal energy **(1)** (Accept cells/tissues would be heated)	**2**
7(c) (i)	Waves spread out **(1)** After passing through a gap **Or** after passing around an obstacle **(1)**	**2**
7(c)(ii)	Use of $c = f\lambda$ with $c = 3.0 \times 10^8$ m s^{-1} **(1)** λ = 0.12 m **(1)** <u>Example of calculation</u> $\lambda = 3.0 \times 10^8$ m s^{-1} ÷ 2.5×10^9 Hz λ = 0.12 m	**2**
7(c)(iii)	Diameter = 2mm **(1)**	**1**
***7(c)(iv)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Diffraction greatest when wavelength is about the same as gap size **(1)** Diameter of holes much greater than wavelength of light **and** diameter of holes less than microwave wavelength **(1)** so no/little diffraction of light takes place **Or** so microwave radiation still diffracted through large angle but intensity is very small. **(1)** MP3 must follow on from relevant part of MP2	**3**
	Total for Question	**14**