Question Number	Answer		Mark
1(a)	Mean velocity of charge carriers	**(1)**	**1**
1(b)(i)	*v* for Y is twice *v* for X **Or** *v* for X is half *v* for Y $I = nqvA$ and *n* and *q* are constant **Or** *v* inversely proportional to *A*	**(1)** **(1)**	**2**
***1(b)(ii**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Resistance of Y is greater than the resistance of X (*v* greater for Y…) therefore electrons gain more ke between collisions (with lattice ions) **Or** therefore more frequent collisions (with lattice ions) **Or** therefore more energy lost per collision (with lattice ions) **Or** therefore more energy lost in a given time in collisions (with lattice ions) therefore greater pd required for a given current (MP2 and 3 accept reverse argument in terms of *v* for X)	**(1)** **(1)** **(1)**	**3**
	Total for Question		**6**

Question Number	Answer		Mark
2(a)(i)	Determines width of at least 9 coils Use of half of their diameter in πr^2 Area = (1.96 to 2.42) $\times 10^{-7}$ (m^2) <u>Example of calculation</u> 18 coils = 1.00 cm Diameter = 0.0100 m ÷ 18 = 5.56×10^{-4} m Area = $\pi \times (5.56 \times 10^{-4} \div 2)^2$ Area = 2.42×10^{-7} m^2	**(1)** **(1)** **(1)**	**3**
2(a)(ii)	Use of $R=\rho l/A$ Resistivity magnitude = 4.4×10^{-7} (show that value gives 3.7×10^{-7}) Unit Ωm <u>Example of calculation</u> $\rho=RA / l$ = 22 Ω x 2.4×10^{-7} m^2 / 12 m = 4.4×10^{-7} Ωm	**(1)** **(1)** **(1)**	**3**
2(a)(iii)	A sensible response with some detail, e.g. • Avoid difficulty in reading a small scale while holding it and counting turns • it can be enlarged and done more accurately • compare with unravelling and using a micrometer • remains stationary, so easier to measure accurately • you can mark the coils as you go so you don't lose count (treat parallax as neutral and)	**(1)**	**1**
2(b)	Use of ratio of lengths × pd V = 8.2 V <u>Example of calculation</u> V = (7.0 cm / 10.2 cm) × 12 V = 8.2 V	**(1)** **(1)**	**2**
	Total for question		**9**

Question Number	Answer	Mark
3 (a)	Use of $R = \rho l/A$ **(1)** $R = 17\ \Omega$ **(1)** Example of calculation $R = 4.9 \times 10^{-7}\ \Omega\ m \times 1.0\ m / 2.9 \times 10^{-8}\ m^2$ $R = 17\ \Omega$	**2**
3 (b)	Area decreases **(1)** Resistance inversely proportional to area **Or** quote $R = \rho l/A$ **(1)** So this change (also) increases resistance **(1)** (Accept for 2nd mark, $I = nAqv$, I decreases if A decreases, $R = V/I$) (Final mark dependent on presenting a logical explanation linking area change and resistance – not just stating increased resistance.)	**3**
	Total for question	**5**

Question Number	Answer		Mark
4(a)	Conversion of kW to W Use of $P = V^2/R$ **OR** $P = VI$ **and** $V = IR$ R = 53 (Ω) (to at least 2 s.f.) [no ue] Example of calculation R = (230 V × 230 V) / 1000 A R = 52.9 Ω	**(1)** **(1)** **(1)**	**3**
4(b)	Use of $R = \rho l/A$ l = 6.3 m ('Show that' value gives 5.9 m) Example of calculation $l = RA/\rho$ l = 53 Ω × 1.3 × 10^{-7} m^2 /1.1 × 10^{-6} Ω m l = 6.3 m	**(1)** **(1)**	**2**
4(c)	If length halved, area must half (for same resistance) / state $A \propto l$ Use of area = πr^2 Diameter = 0.28 mm or 0.29 mm **OR** Use of the resistivity formula Use of area = πr^2 To give correct diameter for their values of length and resistance (0.14 mm scores 2 marks)	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
	Total for question		**8**

Question Number	Answer	Mark
5(a)	Use of $Q = It$ **(1)** Q = 450 C / A s **(1)** Example of calculation Q = 15 000 A × 3.0 × 10^{-2} s Q = 450 C	**2**
5(b)	Use of $R = \rho l/A$ **(1)** Length of conductor = 24 (m) **(1)** Height of statue = length – 1 m = 23 m **(1)** *Assumption:* **ANY ONE** Included height of plinth. Conductor/wire doesn't carry on in ground Conductor/wire vertical/straight/parallel **(1)** Example of calculation $l = \frac{RA}{\rho}$ $l = \frac{2.7 \times 10^{-3}\ \Omega \times 1.5 \times 10^{-4}\ \text{m}^2}{1.7 \times 10^{-8}\ \Omega\, m}$ l = 23.8 m Height of statue = 23.8 – 1 = 22.8 m	**4**
5(c)	**ANY ONE** The idea that the lightning is attracted to /strikes/hits the conductor **OR** Lightning takes shortest path (from cloud) /strikes highest point **OR** Action of points **(1)**	**1**
	Total for question	**7**

Question Number	Answer	Mark
6(a)	Resistivity is a constant for the material / metal OR resistivity depends on / is a property of the material / metal Resistance depends on (resistivity and) length / area /dimensions OR $R = \rho l / A$ with terms defined (do not credit rearranged equation)	**(1)** **(1)**
6(b)	Correct substitution into the $R = \rho l / A$ formula $R = 0.0085\ \Omega$ [ue applies. Common error is to rearrange eqn and confuse R and ρ gives answer 3.4×10^{-14} scores zero] <u>Example of calculation</u> $R = (1.7 \times 10^{-8}\ \Omega\ m \times 0.5\ m) / 1 \times 10^{-6}\ m^2$ $R = 0.0085\ \Omega$	**(1)** **(1)**
12	**Total for question**	**4**

Question Number	Answer	Mark
7(a)	There must be a circuit with a power supply **and** a labelled wire/identifiable ends of a wire/wavy line/resistor/lamp in order to score any marks **ANY TWO** Ammeter symbol in series with wire (not in the middle of) Voltmeter symbol in parallel with wire Variable power supply/variable resistor	 **(1)** **(1)** **(1)** **(max 2)**
7(b)	Use of $P = VI$ Rate of work = 4.5 W / J s^{-1}	**(1)** **(1)**
7(c)(i)	Correct use of $I = nqvA$ with e = 1.6×10^{-19} C $v = 3.0 \times 10^{-5}$ ms^{-1} <u>Example of calculation</u> $v = 1.5 / (1.0 \times 10^{29} \times 1 .6 \times 10^{-19} \times 3.1 \times 10^{-6}$ $v = 3.02 \times 10^{-5}$ ms^{-1}	**(1)** **(1)**
7(c)(ii)	Increased lattice/ions/atoms vibrations (causing) resistance to increase OR increased electron collisions with ions/atoms (This leads to a) reduction in the drift velocity / v	**(1)** **(1)** **(1)**
	Total for question	**9**

Question Number	Answer		Mark
8	(As temperature of thermistor increases) its resistance decreases (do not credit the converse) (Large) increase in: n **Or** electrons (per unit volume) **Or** charge carriers (per unit volume) **Any One from (conditional on mark 2 and not awarded if there are contradictory statements about any of these quantities)** (slight) decrease in v / velocity / drift velocity A and Q remain constant Reference to $R = V/I$	**(1)** **(1)** **(1)**	 **3**
	Total for question		**3**

Question Number	Answer		Mark
9(a)	Resistivity is a property of a material **Or** is constant for a material Resistance is a property of a wire/component/object **Or** Resistance depends on dimensions of a wire/component/object	**(1)** **(1)**	**2**
***9(b)**	*Circuit diagram* Wire and a power supply (accept resistor symbol for wire) Ammeter in series and voltmeter in parallel with wire (an Ohmmeter across a wire with no supply scores 2 marks, an Ohmmeter across a wire with a supply scores 0 marks.) (QWC- Work must be clear and organised in a logical manner using technical wording where appropriate.) *Quantities measured* Current and potential difference **Or** resistance (consistent with diagram) Length of wire Diameter/thickness of wire (not area or radius) *Graph* Graph of R against l **Or** graph of V against l (for constant I) **Or** Graph of R against l/A **Or** Graph of RA against l (this mark is only awarded for a graph including different values of length) *Determination of resistivity* Determine the gradient of a relevant graph (allow for a graph of V against I) $A = \pi d^2/4$ **Or** $A = \pi r^2$ Correct processing to find ρ consistent with the graph (if no gradient, award final mark for statement that $\rho=RA/l$, ρ must be the subject)	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**9**
	Total for question		**11**