Name: ____

Resistivity

Mark Scheme

Date:

Time:

Total marks available:

Total marks achieved: ______

Mark Scheme

Q1.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• Use of $A = \pi r^2$ with r **(1)** • Use of $R = \frac{\rho L}{A}$ **(1)** • With at least one of the following values **(1)** $R = 18.1\ \Omega$ $L = 1.30$ m **(1)** $A = \pi \times (0.13 \times 10^{-3}\,\text{m})^2$ • $\rho = (7.3 \rightarrow 7.4) \times 10^{-7}\ \Omega\text{m}$	MP3 accept $R = 18.15\ \Omega$ MP3. Allow calculation of ρ using given values and subtraction of total % uncertainty. Example of calculation: $A = \pi r^2 = \pi \times (0.13 \times 10^{-3}\,\text{m})^2 = 5.31 \times 10^{-8}\,\text{m}^2$ $\rho = \frac{RA}{L} = \frac{18.1\Omega \times 5.31 \times 10^{-8}\,\text{m}^2}{1.30\,\text{m}} = 7.39 \times 10^{-7}\,\Omega\,\text{m}$	**4**

Q2.

Question Number	Acceptable answers	Additional guidance	Mark
(i)	• Use of $R = \rho l / A$ (1) • Using $A = 0.5 \times 28\ (\times 10^{-6}\,\text{m}^2)$ (1) • Use of $V = IR$ (1) • $I = 22$ (mA) (1)	Example of calculation $R = \frac{1.6\Omega\text{m} \times 0.6 \times 10^{-3}\,\text{m}}{0.5 \times 10^{-3}\,\text{m} \times 28 \times 10^{-3}\,\text{m}}$ $R = 68.6\Omega$ $1.5V = I \times 68.6\Omega$ $I = 1.5\text{V} / 68.6\Omega$ $I = 0.022\text{A} = 22\text{mA}$	**4**

Question Number	Acceptable answers	Additional guidance	Mark
(ii)	• Use of $F = BIL$ ecf values from (i) (1) • Force = 5.3×10^{-6} N (1)	Use of show that values gives 4.8×10^{-6} N Example of calculation $F = 0.40\text{T} \times 0.022\text{A} \times 0.6 \times 10^{-3}\,\text{m}$ $F = 5.3 \times 10^{-6}\,\text{N}$	**2**

Q3.

Question Number	Answer		Mark
(a)	Use of $R = \rho l/A$	**(1)**	
	$R = 17\ \Omega$	**(1)**	**2**
	<u>Example of calculation</u> $R = 4.9 \times 10^{-7}\ \Omega\ \text{m} \times 1.0\ \text{m} / 2.9 \times 10^{-8}\ \text{m}^2$ $R = 17\ \Omega$		
(b)	Area decreases	**(1)**	
	Resistance inversely proportional to area **Or** quote $R = \rho l/A$	**(1)**	
	So this change (also) increases resistance	**(1)**	**3**
	(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.)		
	Total for question		**5**

Q4.

Question Number	Answer		Mark
(a)	The (maximum) length is (directly) proportional to the area	(1)	**1**
(b)(i)	Use of $\rho l/A = R$	(1)	
	$R = 1.34\ (\Omega)$	(1)	**2**
	<u>Example of calculation</u> $R = 1.68 \times 10^{-8}\ \Omega\ \text{m} \times 80\ \text{m} \div 1.0 \times 10^{-6}\ \text{m}^2$ $R = 1.34\ \Omega$		
(b)(ii)	Use of $P = I^2R$	(1)	
	$P = 160$ W allow ecf from (i)	(1)	**2**
	<u>Example of calculation</u> $P = (11\ \text{A})^2 \times 1.34\ \Omega$ $P = 162$ W (157 W if they use 1.3 Ω)		
(b)(iii)	Use of $V = IR$ **Or** use of $P = VI$ **Or** use of $P = V^2/R$	(1)	
	$V = 15$ V allow ecf from (i) and/or (ii)	(1)	**2**
	<u>Example of calculation</u> $V = 11\ \text{A} \times 1.34\ \Omega = 14.7$ V (14.3 V if 1.3 Ω is used)		
(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)	(1)	
	Meaning more energy / power / p.d. available for the shredder	(1)	**2**
	Total for Question		**9**

Q5.

Question Number	Answer		Mark
(a)(i)	Determines width of at least 9 coils Use of half of their diameter in πr^2 Area = (1.96 to 2.42) × 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 = π × (5.56 × 10^{-4} ÷ 2)^2 Area = 2.42 × 10^{-7} m^2	(1) (1) (1)	3
(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
(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
(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**

Q6.

Question Number	Answer		Mark
(a)	best fit line use of gradient **Or** use of *R/l* from graph or table use of $\rho = RA/l$ resistivity = 4.7×10^{-7} Ω m (range 4.5 to 4.8×10^{-7} Ω m) <u>Example of calculation</u> gradient = 4.4 Ω ÷ 1.0 m = 4.4 Ω m^{-1} $\rho = A \times$ gradient = 1.06×10^{-7} $m^2 \times 4.4$ Ω m^{-1} resistivity = 4.66×10^{-7} Ω m	(1) (1) (1) (1)	4
(b)	temperature increases (with increasing current) resistance/resistivity would have increased (with temperature)	(1) (1)	2
(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 errors **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**

Q7.

Question Number	Acceptable Answers		Additional Guidance	Mark
(a)	A description that makes reference to **two** of the following: • No need for further calculation **Or** gives a value for resistance without calculation • No need for an additional power supply • Uncertainties caused by two devices is (possibly) greater than that caused by one device	(1) (1) (1)	Do not accept more precise **or** no parallax **or** quicker	2

Question Number	Acceptable Answers		Additional Guidance	Mark
(b)(i)	• (As applied force increases) the length (*l*) (of wire) increases/stretches **Or** the wire is longer • the resistance increases with reference to $R = \frac{\rho l}{A}$	(1) (1)	Reference to formula may be in terms of proportionality or direct quote of equation Do not accept change in resistivity	2

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(ii)	• Use of $GF = \frac{\Delta R}{\epsilon R}$ (1) • Substitution of $\epsilon = \frac{\Delta w}{w}$ into GF equation (1) • $\Delta w = 2.5 \times 10^{-5}$ m (1)	(x may seen in place of w) Example of calculation: $GF = \frac{\Delta R}{\epsilon R}$ $2 = \frac{0.001}{\Delta w/(5 \times 10^{-2})}$ $\Delta w = 2.5 \times 10^{-5}$ m Accept 2.5×10^{-3} cm / 2.5×10^{-2} mm	3

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)	An explanation that makes reference to the following: • As small changes (in w) are multiplied many times **Or** can use a longer wire (on a small gauge) **Or** to achieve a greater change in the length (1) • (So) greater sensitivity **Or** larger changes in R (for a given change in width) (1)		2

Q8.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	• As graphene is only 1 atom thick so the CSA/thickness is far smaller than for a sample of steel **Or** most applications need a thickness greater than one atom **Or** if more than one layer of graphene is used it will be weaker or the bonds between the layers will not be strong **Or** Graphene is difficult to manufacture because it has only one atomic layer (1) • Although graphene has a greater breaking stress it will break at a lower force (1)	MP1: accept graphene can only be 1 atom thick but steel can be any thickness (MP1, treat references to cost/energy as neutral)	2

Question Number	Acceptable Answer		Additional Guidance	Mark
(b)	• Use of depth of graphite = 100 × diameter of 1 carbon atom • Use of cross-sectional area = depth × (0.5×10^{-3} m) • Use of $\rho = \frac{RA}{l}$ • $\rho = 3.6 \times 10^{-5}\ \Omega$ m **Or** 36 μΩ m	(1) (1) (1) (1)	<u>Example of calculation</u> Depth of graphite = $100 \times 1.4 \times 10^{-10}$ m = 1.4×10^{-8} m CSA = 1.4×10^{-8} m × 0.50×10^{-3} m = 7.0×10^{-12} m^2 $\rho = \frac{1.029 \times 10^{6}\ \Omega \times 7.0 \times 10^{-12}\ \text{m}^2}{0.200\ \text{m}} =$ $3.6 \times 10^{-5}\ \Omega$ m	4

Question Number	Acceptable Answer		Additional Guidance	Mark
(c)	**Max 3** • Silicon will only release a (photo) electron for a limited range of frequencies/wavelengths • Silicon releases only one (photo) <u>electron</u> per incident photon • Greater current (for the same illumination) in graphene • Graphene (cells are) more efficient **Or** graphene cells could be smaller / cheaper / thinner	(1) (1) (1) (1)	MP1: accept single frequency for limited range	3