

Mark Scheme

Q1.

Question Number	Answer	Mark
	A is the correct answer as $\rho = VA / Il$, where $A = x^2$ and $l = x$ B is not the correct answer C is not the correct answer D is not the correct answer	(1)

Q2.

Question Number	Answer	Mark
	Use of $A = \pi r^2$ (1)	3
	Use of $R = \rho l / A$ (1)	
	Resistivity = $2.5 \times 10^{-8} \text{ } (\Omega \text{ m})$ so aluminium (1)	
	(If candidates calculate A as $1.02 \times 10^{-7} \text{ m}^2$ they get $2.6 \times 10^{-8} \text{ } \Omega \text{ m}$)	
	<u>Example of calculation</u> $A = \pi (0.18 \times 10^{-3})^2 = 1.0 \times 10^{-7} \text{ m}^2$. $\rho = RA / l = (50 \times 10^{-3} \text{ } \Omega) (1.0 \times 10^{-7} \text{ m}^2) / (0.200 \text{ m}) = 2.5 \times 10^{-8} \text{ } \Omega \text{ m}$	
	Total for question	3

Q3.

Question Number	Acceptable Answer	Additional Guidance	Mark
	Use of $R = \frac{\rho l}{A}$ (1)		3
	calculates $A = \pi r^2$ (1)		
	Diameter = 5.2×10^{-4} m (1)		
		<u>Example of calculation</u> $A = \frac{5.6 \times 10^{-8} \Omega \text{ m} \times 0.25 \text{ m}}{65 \times 10^{-3} \Omega}$ $= 2.15 \times 10^{-7} \text{ m}^2$ $d = \sqrt{\frac{4 \times 2.15 \times 10^{-7} \text{ m}^2}{\pi}}$ $= 5.24 \times 10^{-4} \text{ m}$	

Q4.

Question Number	Acceptable Answer	Additional Guidance	Mark
	Calculates cross-sectional area of wire (1) Reading two pairs of corresponding values from the graph (1) Uses gradient = $\frac{\rho}{A}$ (1) Or Use of $R = \frac{\rho l}{A}$ ρ in the range $4.75 \times 10^{-7} \Omega \text{ m}$ to $4.95 \times 10^{-7} \Omega \text{ m}$ (1) Calculated value of ρ compared with value in table and consistent conclusion (1)	<u>Example of calculation</u> $A = \frac{\pi \times (2.4 \times 10^{-4} \text{ m})^2}{4}$ $= 4.52 \times 10^{-8} \text{ m}^2$ Gradient = $10.7 \Omega \text{ m}$ $10.7 \Omega \text{ m} = \frac{\rho}{4.52 \times 10^{-8} \text{ m}^2}$ $\rho = 4.83 \times 10^{-7} \Omega \text{ m}$ $4.83 \times 10^{-7} \Omega \text{ m}$ is closest to $4.90 \times 10^{-7} \Omega \text{ m}$ so wire is constantan	5
	Total for question		5

Q5.

Question Number	Answer	Mark
(a)	(As temperature increases) the metal lattice vibrations increase (1) There is an increase in the frequency of collisions of electrons with the lattice (1) So the resistance increases (1) MP3 dependent on MP2 or MP1	3
(b)	Calculates cross-sectional area of wire (1) Use of $R = \frac{\rho l}{A}$ (1) $\rho = 9.8 \times 10^{-7} \Omega \text{ m}$ (1) <u>Example calculation</u> $A = \frac{\pi \times (0.51 \times 10^{-3} \text{ m})^2}{4} = 2.04 \times 10^{-7} \text{ m}^2$ $\rho = \frac{0.67 \Omega \times 2.04 \times 10^{-7} \text{ m}^2}{0.14 \text{ m}} = 9.76 \times 10^{-7} \Omega \text{ m}$	3
Total for question		6

Q6.

Question Number	Answer	Mark																								
a	<u>Diameter</u> of wire with a micrometer or digital calliper (1) <u>Length</u> of wire using a metre rule (1) Potential difference (in parallel with the wire) with a voltmeter and current (in series with the wire) with an ammeter (1) Or resistance, using an ohmmeter (in parallel with the wire) (1)	(3)																								
b	Use of πr^2 or $\pi d^2/4$ (1) Suitable axes (1) Corresponding gradient to give resistivity (MP3 dependent on MP2) (1) Some examples of appropriate axes <table border="1"> <thead> <tr> <th>y-axis</th><th>x-axis</th><th>gradient</th></tr> </thead> <tbody> <tr> <td>R</td><td>l</td><td>ρ / A</td></tr> <tr> <td>R</td><td>l/A</td><td>ρ</td></tr> <tr> <td>RA</td><td>l</td><td>ρ</td></tr> <tr> <td>l</td><td>R</td><td>A / ρ</td></tr> <tr> <td>l</td><td>RA</td><td>$1 / \rho$</td></tr> <tr> <td>l/A</td><td>R</td><td>$1 / \rho$</td></tr> <tr> <td>V</td><td>Il</td><td>ρ / A</td></tr> </tbody> </table>	y-axis	x-axis	gradient	R	l	ρ / A	R	l/A	ρ	RA	l	ρ	l	R	A / ρ	l	RA	$1 / \rho$	l/A	R	$1 / \rho$	V	Il	ρ / A	(3)
y-axis	x-axis	gradient																								
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Total for question		6																								

Q7.

Question Number	Answer	Mark
(a)	Use of cross-sectional area = width $\times$ thickness (1) Use of factor of 6 to determine total length of metal strips (1) Or Use a factor of 6 to determine the resistance of one strip Use of $R = \frac{\rho l}{A}$ (1) $\rho = 4.8 \times 10^{-7} \Omega \text{ m}$ (1) <u>Example calculation</u> $A = 1.40 \times 10^{-3} \text{ m} \times 0.23 \times 10^{-3} \text{ m} = 3.22 \times 10^{-7} \text{ m}^2$ $l_{\text{total}} = 6 \times 18 \times 10^{-3} \text{ m} = 0.108 \text{ m}$ $\rho = \frac{0.16 \Omega \times 3.22 \times 10^{-7} \text{ m}^2}{0.108 \text{ m}} = 4.77 \times 10^{-7} \Omega \text{ m}$	4
(b)	The cross-sectional area of each metal strip is $\frac{\text{volume}}{l}$ (1) So the resistance of each strip is $\frac{\rho l^2}{\text{volume}}$ (1) So resistance is proportional to l^2 (which gives a straight line through the origin) (1)	3
Total for question		7

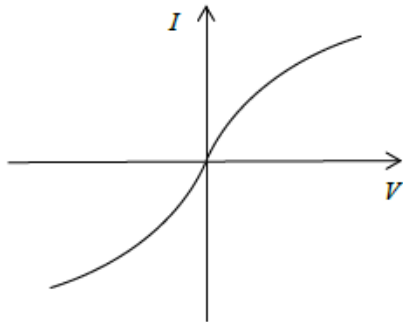
Q8.

Question Number	Answer	Mark
(a)	Use of $R = \frac{\rho l}{A}$ (1) Use of cross-sectional area = width $\times$ thickness (1) Thickness of layer of carbon = $1.2 \times 10^{-5} \text{ m}$ (1) <u>Example of calculation</u> $8.8 \, \Omega = \frac{3.7 \times 10^{-5} \, \Omega \text{ m} \times 0.12 \text{ m}}{0.042 \text{ m} \times t}$ $t = 1.2 \times 10^{-5} \text{ m}$	3
(b)(i)	Use of $R = V/I$ to calculate I (1) Or ratio of resistances = ratio of p.d.s (1) Calculate p.d. across the internal resistance (see 0.1 V) (1) Or calculate whole circuit resistance (see 9.4 Ω) (1) $r = 0.63 \, \Omega$ (1) <u>Example of calculation</u> $I = \frac{1.4}{8.8} = 0.16 \text{ A}$ $r = \frac{0.1 \text{ V}}{0.16 \text{ A}} = 0.63 \, \Omega$	3
(b)(ii)	Reading on voltmeter = 0.35 V (1) <u>Example of calculation</u> $\frac{V}{1.4 \text{ V}} = \frac{3.0 \text{ cm}}{12.0 \text{ cm}}$ $V = 0.35 \text{ V}$	1
Total for question		7

Q9.

Question Number	Answer	Mark
a	Use of $P = V^2 / R$ Or Use of $P = VI$ and $R = V/I$ (1) Use of $R = \rho l / A$ (1) Use of $A = \pi r^2$ or $\pi d^2 / 4$ (1) Length of wire = 2.1 m (1) <u>Example of calculation</u> $R = V^2 / P = (12V)^2 / 60 W = 2.4 \Omega$. $A = \pi r^2 = \pi \times (0.125 \times 10^{-3} m)^2 = 4.9 \times 10^{-8} m^2$ $l = RA / \rho = (2.4 \Omega)(4.9 \times 10^{-8} m^2) / (5.6 \times 10^{-8} \Omega m) = 2.1m$	4
b	A has a lower resistance than B (1) Or (at 12V) $R_A = 2.4\Omega$. $R_B = 4.8\Omega$ (1) p.d. will not be shared equally between them Or B requires/has greater p.d. than A (1) A will have less than 12V so will not operate normally (so the student is incorrect) Or B will have more than 12V so will not operate normally (so the student is incorrect) (1) OR (at 12V) $I_A = 5A$, $I_B = 2.5A$ (1) (Circuit is series so) current should be the same for both (1) Either A will have too little current, so will not operate normally (so student is incorrect) Or B will have too much current, so will not operate normally (so student is incorrect) (1) (For MP2 in second alternative, do not allow a calculation of total circuit current = 3.3 A, as this would not be the current in this circuit) (1)	3
Total for question		7

Q10.

Question Number	Answer	Mark
a	Correct shape of graph for positive quadrant Correct symmetry in negative quadrant 	(1) (1) 2
13bi	Use of $A = \pi r^2$ Use of $I = nqvA$ $v = 1.3 \times 10^{-2} \text{ m s}^{-1}$ <u>Example of calculation</u> $A = \pi r^2 = \pi \times (0.023 \times 10^{-3} \text{ m})^2 = 1.66 \times 10^{-9} \text{ m}^2$ $v = \frac{I}{nAq} = \frac{0.44 \text{ A}}{(1.26 \times 10^{29} \text{ m}^{-3})(1.66 \times 10^{-9} \text{ m}^2)(1.60 \times 10^{-19} \text{ C})} = 0.0131 \text{ m s}^{-1}$	(1) (1) (1) 3
bii	Use of $R = V/I$ Use of $R = \rho l/A$ $\rho = 9.1 \times 10^{-7} (\Omega \text{ m})$, so approximately 2700°C (MP2 e.c.f. for A value from part b(i)) <u>Example of calculation</u> $R = \frac{140 \text{ V}}{0.44 \text{ A}} = 318 \Omega$ $\rho = \frac{RA}{l} = \frac{(318 \Omega)(1.66 \times 10^{-9} \text{ m}^2)}{0.580 \text{ m}} = 9.1 \times 10^{-7} \Omega \text{ m}$, so this most closely matches the resistivity value at 2700°C.	(1) (1) (1) 3
Total for question		8

Q11.

Question Number	Answer	Mark
(a)	Use of $A = \pi r^2$ (1) Use of $R = \frac{\rho l}{A}$ (1) $l = 63 \text{ m}$ (1) <u>Example calculation</u> $A = \pi \times \left(\frac{12 \times 10^{-3} \text{ m}}{2} \right)^2 = 1.13 \times 10^{-4} \text{ m}^2$ $l = \frac{0.078 \Omega \times 1.13 \times 10^{-4} \text{ m}^2}{1.4 \times 10^{-7} \Omega \text{ m}} = 63.0 \text{ m}$	3
(b)	Use of $W = VIt$ (1) $W = 1.3 \times 10^8 \text{ J}$ (1) Or c Use of $I = \frac{\Delta Q}{\Delta t}$ and $V = \frac{W}{Q}$ (1) $W = 1.3 \times 10^8 \text{ J}$ (1) Or Use of $P = VI$ and $P = \frac{W}{t}$ (1) $W = 1.3 \times 10^8 \text{ J}$ (1) <u>Example calculation</u> $W = 1.5 \times 10^8 \text{ V} \times 1.2 \times 10^4 \text{ A} \times 70 \times 10^{-6} \text{ s} = 1.26 \times 10^8 \text{ J}$	2
(c)	The copper cable has a lower resistance (because length and diameter are the same but copper has a lower resistivity) (1) (With the same p.d.) there is a greater current in the copper cable (1) Since $I = nqvA$, it is not possible to say whether the student is correct Or Since $I = nqvA$, the student might be correct (1)	3
Total for question		8

Question Number	Answer	Mark
(a)	Power supply, ammeter, variable resistor and nichrome wire all in series (1) Voltmeter in parallel across nichrome wire (1)	2
(b)(i)	Gradient calculated (1) Or value of p.d. read off for a corresponding length (1) Gradient uses more than half of the graph Or value of p.d. used is greater than 2.0V (1) Or value of length used is greater than 0.5m (1) Use of $R = \rho l / A$ and $R = V / I$ (1) Or Use of $\rho = (\text{gradient} \times A) / l$ (1) $\rho = 1.1 \times 10^{-6} \Omega \text{m}$ (1) (MP1 – Values read off graph need to be within $\frac{1}{2}$ a square) (MP1 – Gradient should be in the range $4.1 - 4.2 \text{ Vm}^{-1}$) <u>Example of calculation</u> Gradient = $V / l = (4.15 \text{ V} / 1.00 \text{ m}) = 4.15 \text{ Vm}^{-1}$ $V / l = \rho l / A$, so $\rho = (\text{gradient} \times A) / l$ $= (4.15 \text{ Vm}^{-1} \times 5.31 \times 10^{-8} \text{ m}^2) / 0.200 \text{ A} = 1.10 \times 10^{-6} \Omega \text{m}$	4
(b)(ii)	V value read from graph = 3.1V (1) Use of $P = VI$ (1) $P = 0.62 \text{ W}$ (1) (MP1 – allow use of resistivity equation with answer from (i) used to calculate V or R) (MP2 – allow combination of equations e.g. $R = V/I$ followed by $P = I^2 R$) (MP3 – allow variation of value if using resistivity value that rounds to $1.1 \times 10^{-6} \Omega \text{m}$ from (i)) <u>Example of calculation</u> $P = VI = (3.1 \text{ V} \times 0.200 \text{ A}) = 0.62 \text{ W}$	3
Total for Question		9

Q13.

Question Number	Answer	Mark
a	Use of speed = distance / time (1) Calculates distance travelled by sound in 3s = 1020 (m) Or calculates time taken for sound to travel 1 km = 2.94 (s) Or calculates speed to travel 1000m in 3 seconds = 333 (ms⁻¹) (1) Time taken by light to reach 1 km is almost instantaneous / 3.3×10^{-6} s so teacher is (approximately) correct. (1) <u>Example of calculation</u> For light, $t = d/v = 1000 \text{ m} / 3.00 \times 10^8 \text{ ms}^{-1} = 3.33 \times 10^{-6} \text{ s}$ For sound, $t = d/v = 1000 \text{ m} / 340 \text{ ms}^{-1} = 2.94 \text{ s}$ Difference in arrival time = 2.94 s $\approx$ 3 s	(3)
bi	Use of $Q = It$ (1) $Q = 0.75 \text{ C}$ (1) <u>Example of calculation</u> $Q = It = 25,000 \text{ A} \times (30 \times 10^{-6} \text{ s}) = 0.75 \text{ C}$	(2)
bii	Use of $P = VI$ (1) $P = 3.0 \times 10^{13} \text{ W}$ (1) <u>Example of calculation</u> $P = VI = (1.2 \times 10^9 \text{ V}) \times 25,000 \text{ A} = 3.0 \times 10^{13} \text{ W}$	(2)
biii	Use of $A = \pi r^2$ (1) Use of $R = \rho l/A$ (1) $\rho = 0.24 (\Omega \text{ m})$ (1) <u>Example of calculation</u> Cross sectional area of wire = $\pi r^2 = \pi (2.5 \times 10^{-2})^2 = 1.96 \times 10^{-3} \text{ m}^2$ $R = V/I = (1.2 \times 10^9 \text{ V}) / 25,000 \text{ A} = 48,000 \Omega$ $\rho = RA/l = (48,000 \Omega) (1.96 \times 10^{-3} \text{ m}^2) / 400 \text{ m} = 0.235 \Omega \text{ m}$	(3)
biv	Air in the lightning channel has been ionised Or Lightning channel unlikely to have a uniform diameter / CSA (1)	(1)

ci	Energy levels (in atoms) are discrete/specific (1) (Energy makes) <u>electrons</u> move up energy levels Or <u>Electrons</u> are excited (1) (Electrons) move back down energy levels, releasing <u>photons</u> Or (Electrons) are de-excited, releasing <u>photons</u> (1) Energy difference (between levels) is proportional to frequency of photon (resulting in line spectrum being produced) Or Photon energy is proportional to frequency (resulting in line spectrum being produced) (1)	(4)
cii	Different atoms/elements have different (differences in) energy levels (1)	(1)