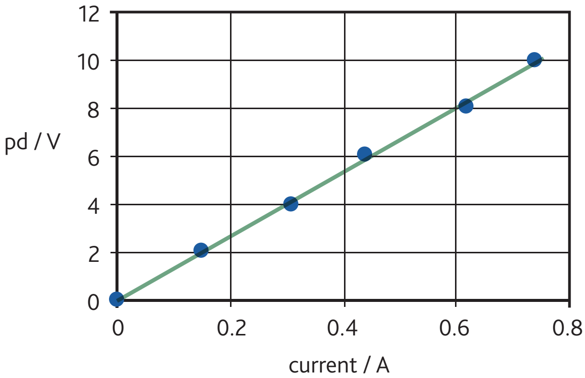
Answers to examination-style questions

Answers	Marks	Examiner's tips
1 (a) See figure EA 4.1.1 below	**4**	axes labelled correctly and units given, suitable scales, correctly plotted points, best fit line drawn.
(b) $V = IR$ and $R = \dfrac{\rho L}{A}$	**1**	
therefore $V = \dfrac{\rho L I}{A}$	**1**	
(c) gradient of graph $= R = \dfrac{\rho\, L}{A}$	**1**	
$= \dfrac{8.0\text{ V}}{0.6\text{ A}}$	**1**	
$= 13.3\ \Omega$	**1**	
Resistivity $\rho = \dfrac{R\,A}{L}$	**1**	
$= 13.3 \times \pi \times \dfrac{(0.14 \times 10^{-3})^2}{1.60}$	**1**	
$= 5.12 \times 10^{-7}\ \Omega\text{ m}$	**1**	



Answers	Marks	Examiner's tips
2 (a) $\Delta Q = I\,\Delta t = 40 \times 10^{-3} \times 3 \times 60$	**1**	Remember that current must be in A and time in s.
$= 7.2\text{ C}$	**1**	
(b) number of electrons $= \dfrac{7.2}{1.60 \times 10^{-19}}$ $= 4.5 \times 10^{19}$	**1**	From the Data Booklet, one electron has charge 1.6×10^{-19} C, so you divide the charge in C from **(i)** by this number to find the number of electrons.
(c) $V = \dfrac{\Delta W}{\Delta Q} = \dfrac{8.6}{7.2}$	**1**	This follows from the definition of 1V as 1 J C^{-1}. Throughout this question, an earlier arithmetical error (in finding ΔQ, say) would not be further penalised: a wrong value for ΔQ could still lead to full marks here.
$= 1.2\text{ V}$	**1**	
(d) $R = \dfrac{V}{I} = \dfrac{1.2}{40 \times 10^{-3}} = 30\ \Omega$	**1**	A wrong value of V from **(c)** could still allow you to gain this mark, provided you used **your** V correctly in **(d)**.

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3 (a) $R = \frac{V}{I} = \frac{12}{1.8}$	**2**	The first mark is for choosing $R = (V / I)$, and then using it correctly.
$= 6.7\ \Omega$	**1**	The second mark is for reading the V and I values from the top point of the graph, where the resistance is greatest. The third mark is for working out R correctly and showing its unit.
(b) current is zero for all negative voltages	**1**	You have to be familiar with the shape of these characteristic curves. A diode conducts in one direction only and conducts increasingly well once the positive voltage is greater than about 0.6 V.
for positive voltages, curve showing a steep rise in current starting at about +0.6 V (with voltage not greatly to exceed 1V)	**1**	
4 (a) (i) readings need to be taken more quickly than could be achieved by manual timing	**1**	The filament heats up very quickly, so you could not possibly take readings quickly enough if you were to try to use a stop watch. Note that the advantage of the computer is that it can take frequent results over a very short time; this is nothing to do with the **accuracy** of the readings.
(ii) *rate*: more than 40 samples per second	**1**	Use a ruler on the time axis to divide up and mark a scale, where only 0 and 2.0 s are marked. This should allow you to decide that initial rise takes place in about 0.1 s. A reliable graph requires several results to be taken in that time.
reason: the current rises very rapidly over the first 0.1s, and you should have about 4 results on this first section	**1**	
(b) *Relevant points include*: • initial resistance is low so initial current is high • temperature of filament increases (or filament heats up) • resistance increases as temperature rises • increase in resistance causes current to fall • current is steady when energy supplied = energy lost from filament (or when temperature is constant) • maximum heating is produced at start when current is highest • melting of filament causes it to fail (could be mechanical failure caused by temperature rise) • when switched on energy is supplied more rapidly than it is lost so filament melts	**6**	This question is about the effect of temperature on the resistance of a metal wire. When it is cold the resistance is low; the resistance increases as the wire heats up. Therefore the current increases greatly at the start and then decreases as the filament temperature increases. You can observe this effect with a sensitive ammeter. The filament in lamps (such as old-fashioned domestic light bulbs) sometimes fails when they are first switched on. If, however, they are supplied through a dimmer switch that allows you to increase the current gradually, this initial failure is less likely to happen.

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5 **(a)** $R = \frac{\rho L}{A} = \frac{1.7 \times 10^{-8} \times 1.4}{7.8 \times 10^{-7}}$	1	In this example you have to start off by rearranging the resistivity equation to make R the subject.
$= 3.1 \times 10^{-2}\ \Omega$	1	
(b) since the volume is constant, $L_1 A_1 = L_2 A_2$ for the two wires $\therefore A_2 = \frac{1}{2} A_1$ ($\Theta\ L_2 = 2\ L_1$)	1	If you find it difficult to do this using algebra, you could do it using numbers. L becomes 2.8 m, so A is halved to 3.9×10^{-7} m^2. Substitution of these values gives a resistance of $12.4 \times 10^{-2}\ \Omega$, which is 4 R.
$R_2 = \frac{\rho \times 2L_1}{A_1/2} = \frac{4\rho\ L_1}{A_1} = 4\ R$	1	
6 **(a)** **(i)** *Circuit to show:* • battery, switch, wire, variable resistor and ammeter in series • voltmeter in parallel with wire	2	The variable resistor allows you to take more than one result for each length of wire, but your main need is to take results for different lengths.
(ii) switch on, measure I and V	1	The question tells you that the cross-sectional area of the wire is known. Otherwise you would also have to measure the diameter of the wire.
change length of wire	1	
measure new I and V	1	
measure length of wire each time	1	
(iii) for each length of wire calculate R using $R = (V/I)$ and plot a graph of R against L	1	In this part you must show how you would use your results for I, V and L in order to determine the value of ρ. Graphical methods are preferred because they lead to a more reliable average value.
Since $R = \frac{\rho L}{A}$, the graph is a straight line of gradient (ρ / A)	1	
$\rho = A \times$ gradient, and A is known	1	
(b) $R = \frac{V}{I} = \frac{240}{2.0 \times 10^{-3}} = 1.20 \times 10^5\ \Omega$	1	This part makes you think carefully about the application (it is not a wire this time). You are told that a current is passing through the plastic material. The metal films (which coat the end areas) are where the current enters and leaves the plastic, so A is $(80 \times 10^{-3})^2$.
$\rho = \frac{RA}{L} = \frac{120 \times 10^3 \times (80 \times 10^{-3})^2}{1.5 \times 10^{-3}}$	1	
$= 5.1 \times 10^5\ \Omega$ m	1	
7 **(a)** **(i)** a component (or substance) which has no electrical resistance	1	It is far better to refer to resistance than to say it is an excellent conductor!
(ii) *Sketch graph of R against T to show*: • correct high temperature graph with abrupt discontinuous vertical line indicating that R has become zero at a certain temperature • temperature axis labelled (e.g. $T_{transition}$) at the corresponding temperature	2	At higher temperatures than $T_{transition}$ the resistance increases steadily with temperature. Below $T_{transition}$ the resistance remains zero.

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(b) *Reason*: when resistance is zero there is no energy (heat, or power) lost	**1**	This tests your knowledge of facts. A superconductor used as a power cable is only really useful if less energy is used to maintain the (generally low) transition temperature of the substance than is saved by using the superconductor.
Applications: power cables, electromagnets, generators, motors, transformers, MRI scanners, monorail trains, particle accelerators, fusion reactors	**any 2**	

Nelson Thornes is responsible for the solution(s) given and they may not constitute the only possible solution(s).