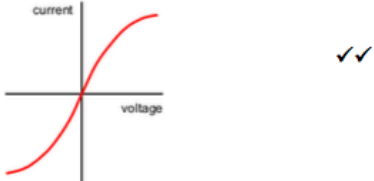


1)

a		<p>first mark for linear at origin and decreasing gradient in either quadrant (linear region can be very small) second mark for symmetry plus no dip at end or extended horizontal section at end</p> <p>straight line scores zero</p>	2
bi	resistance (of filament lamp) increases✓		1
dii	filament lamp is a non-ohmic conductor as current is not (directly) proportional to voltage /resistance is not constant✓	proportionality can be shown using graph	1
c	either circuit/total resistance increases✓ (hence) current decreases and pd/voltage across R decreases✓	implication that current is different in different parts of series circuits scores 0 implication that new total current is greater scores zero	2
	OR resistance of PQ combination increases✓ (hence) greater share of pd/voltage across lamp P✓	voltage flowing loses second mark	
di	(use of $energy = VIt$) (energy converted by X = $60 \times 120 \times 3600 = 2.59 \times 10^7 \text{ J}$ ✓ (energy converted by Y = $11 \times 120 \times 3600 = 4.75 \times 10^6 \text{ J}$ ✓	Accept answers to 1 sig. fig.	2
dii	in lamps energy is wasted as heat/thermal energy✓ specific lamp considered e.g. in lamp, X/ filament lamp more energy is wasted OR in X/filament lamp less energy is converted to light/luminosity✓		2

2)

a		a component with constant resistance OR $V \propto I$ ✓	1	
b	(i)	circuit using correct symbols with means of varying current/voltage✓ correct voltmeter and ammeter✓	2	ignore symbol for component unless it is a variable resistor

b	(ii)	<p>The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.</p> <p>High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.</p> <p><i>Candidate draws an appropriate circuit diagram with correctly positioned ammeter and voltmeters. Candidate has a means of varying the current. Sets current to different values and measures pd. Mentions wide range. Has a sensible way of varying current (e.g. variable resistor/ potential divider). Plots a graph of pd against current. Relates constant gradient to a constant resistance.</i></p> <p>Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.</p> <p><i>Candidate draws an appropriate circuit diagram with correctly positioned ammeter and voltmeters. Candidate has a means of varying the current. Varies current and measures pd. Plots a graph of pd against current. Relates constant gradient to a constant resistance.</i></p> <p>Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate.</p> <p><i>The candidate measures resistance at least twice to see if constant. Has some means of varying current.</i></p> <p>The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case.</p> <p>method for varying current current varied in regular steps pd and current measure resistance calculated graph drawn significance of gradient of the graph discussed</p>	6	<p>Level 1/2 Take several readings of V and I and plot graph or calculate R</p> <p>Level 3/4 Draw best fit line or state R constant Relate straight line on graph to ohmic conductor</p> <p>Level 5/6 meaning of line through origin reverse current readings suitable range with suggested values</p>
c	(i)	a material with zero resistivity/resistance✓	1	not negligible
c	(ii)	material becomes superconducting at/below critical temperature✓	1	accept reverse argument
c	(iii)	any correct usage e.g. powerful magnets, mri, maglev trains/bullet train/(high power) transmission lines/particle accelerators/LHC✓	1	

3)

(a)	superconductivity means a material has zero resistivity/resistance ✓ resistivity decreases with temperature or idea of cooling ✓ becomes superconducting when you reach the critical/certain/transition temperature ✓	3
(b) (i)	(use of $R = \rho l/A$) $0.075 = \rho \times 1/(2.28 \times 10^{-7})$ ✓ (must see working or equation) $R = 1.7 \times 10^{-8}$ ✓ Ωm ✓	6
(ii)	max 3 from the resistance decreases (to zero) ✓ copper still has resistance ✓ but this is in parallel with filaments (which have zero resistance) ✓ hence total resistance is zero ✓ current goes through filaments ✓	
Total		9

4)

(a)	current = 0.40 A ✓	1
(b) (i)	resistance = $12/0.2 = 60 \Omega$ ✓	1
(b) (ii)	power = $12 \times 0.2 = 2.4 W$ ✓	1
(c)	resistance of filament increases or more collisions/scattering ✓ as temperature of filament increase or filament gets hot/heats (until reaches thermal equilibrium) ✓	2
(d) (i)	voltage of supply now shared by lamps or resistance increased ✓ hence current reduced ✓	2
(d) (ii)	current through the lamps unchanged/stays the same ✓ as both connected directly to the supply or correct resistance argument ✓	2
(e)	resistance of lamps will be lower when first switched on ✓ hence initial current will be larger ✓ sudden rapid change in temperature ✓	max 2
Total		11

5)

(a)		a non-ohmic conductor does not have a constant resistance ✓	1
(b)	(i)	curve of decreasing gradient with increasing V ✓ attempt to make graph symmetric in two opposite quadrants ✓	2
(b)	(ii)	resistance increases as pd increases/current increases ✓	1
(c)	(i)	(use of $P = V^2/R$) $36 = 144/R$ ✓ $R = 4.0 (\Omega)$ ✓	2
(c)	(ii)	reference to temperature change ✓ (resulting in) a lower resistance ✓ (hence) power rating would be greater ✓	3
Total			9

6)

a		(use of $\rho = RA/l$) $R = 1.7 \times 10^{-7} \times 0.75 / 1.3 \times 10^{-7}$ ✓ $R = 0.98 \Omega$ ✓	2	First mark for sub. and rearranging of equation. Bald 0.98 gets both marks Final answer correct to 2 or more sig. figs.
b	(i)	(use of $P = VI$) $I = 2.08 \text{ A}$	1	
b	(ii)	$V = 2.08 \times 0.98 = 2.04 \text{ V}$	1	C.E. from (a) and (b)(i)

b	(iii)	$\text{emf} = 12 + 2 \times 2.04 = 16.1 \text{ V}$ ✓	2	C.E. from (b)(ii) If only use one wire then C.E. for second mark
c		lamp would be less bright ✓ as energy/power now wasted in internal resistance/battery OR terminal pd less OR current lower (due to greater resistance) ✓	2	No C.E. from first mark

7)

(a)	(i)	<p>working circuit including power supply and thermistor (correct symbol) ✓ voltmeter and ammeter or ohm meter ✓</p>	<p>2</p>
(a)	(ii)	<p>The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.</p> <p>The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.</p> <p>High Level (Good to excellent): 5 or 6 marks</p> <p>The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.</p> <p>The candidate states that the thermistor is connected in a suitable circuit with voltmeter and ammeter or ohmmeter. The candidate gives details of how the thermistor is heated in a beaker of water or a water bath and a thermometer is used to measure the temperature at small regular intervals. The candidate states that the resistance is found at various temperatures either directly with an ohmmeter or by dividing voltage by current. The candidate may mention that the water must be stirred to ensure that the thermistor is at the temperature measured by the thermometer. The candidate may give some indication of the range of temperatures to be used. The candidate may refer to repetition of whole experiment. The candidate may plot a graph of resistance against temperature. The candidate may use a digital thermometer.</p> <p>Intermediate Level (Modest to adequate): 3 or 4 marks</p> <p>The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.</p> <p>The candidate states that the thermistor is connected in a suitable circuit with voltmeter and ammeter or ohmmeter. The candidate gives details of how the thermistor is heated in a beaker of water and a thermometer is used to measure the temperature. The candidate states that the resistance is found at various temperatures either directly with an ohmmeter or by dividing voltage by current.</p> <p>Low Level (Poor to limited): 1 or 2 marks</p> <p>The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate.</p> <p>The candidate changes temperature at least once and measures V and I or R.</p> <p>The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case.</p>	<p>max 6</p>

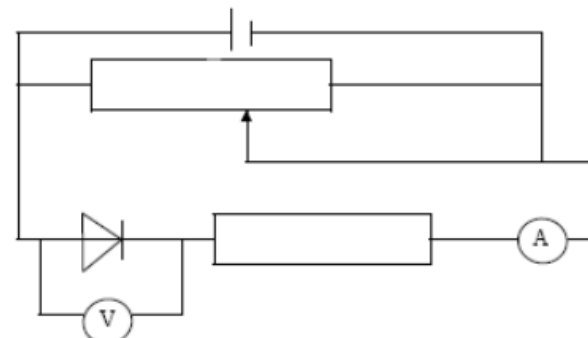
(b)	(i)	pd = 6.0 – 1.6 = 4.4 (V) ✓	1
(b)	(ii)	current = 4.4/1200 = 3.7 × 10 ⁻³ (A) ✓ (not 3.6)	1
(b)	(iii)	resistance = 1.6/3.7 × 10 ⁻³ = 440 or 430 (Ω) ✓ 2 sfs ✓	2
(c)		less current now flows or terminal pd/voltage lower ✓ (or voltage across cell/external circuit is lower) (hence) pd/voltage across resistor will decrease ✓	2
Total			14

8)

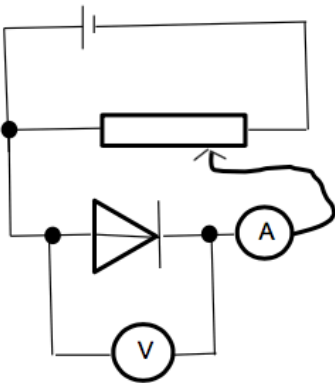

a	<p>The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.</p> <p>High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.</p> <p><i>The candidate measures V and temperature. They have a workable method of varying temperature from 0 °C to 100 °C. They explain why R is necessary and are able to use the thermistor to measure temperature using a graph and calibration curve.</i></p> <p>Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.</p> <p><i>The candidate measures V and temperature. They have a workable method of varying temperature from 0 °C to 100 °C. Give some indication of how an unknown temperature is measured.</i></p> <p>Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and</p>	6		<p>LOWER BAND Measure/record voltage For different temperatures</p> <p>MIDDLE BAND Water bath used Over full range 0 – 100 °C e.g. use ice and Bunsen</p> <p>OR Need for R to form potential divider Use of graph to find</p>
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	<p>may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate.</p> <p><i>The candidate measures V and temperature. They vary the temperature.</i></p> <p>The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case.</p> <p>measurement of V from the voltmeter use of a thermometer use of water bath use of ice importance of stirring explanation of the need for series resistor plotting of a calibration curve use of calibration curve to determine temperature of room</p>			<p>room temperature</p> <p>TOP BAND 3 out the 4 points in middle band 6 marks only if all 4 points in middle band plus reference to thermometer and some additional e.g. stirring, suggested intervals</p>
b	<p>reading changes in opposite way/voltmeter reading would increase as temperature increased ✓ as resistance of thermistor falls/current increases ✓ hence greater share/proportion of pd/voltage across R OR greater current therefore larger pd/voltage across R OR total pd/voltage constant less pd/ voltage across thermistor (at higher temperatures) therefore greater pd/voltage across R ✓</p>	3		

9)

<p>(a) (i)</p>	 <p>suitable variable input (variable power supply or variable resistor) ✓ protective resistor and diode forward biased ✓ correct current and pd measuring devices ✓</p>	<p>3</p>
<p>(ii)</p> <p>QWC</p> <p>good - excellent</p> <p>modest - adequate</p> <p>poor - limited</p> <p>incorrect, inappropriate or no response</p>	<p>the mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication</p> <p>descriptor</p> <p>Uses accurately appropriate grammar, spelling, punctuation and legibility. Uses the most appropriate form and style of writing to give an explanation or to present an argument in a well structured piece of extended writing. [May include bullet points and/or formulae or equations]. Answer refers to at least 5 of the relevant points listed below.</p> <p>Only a few errors. Some structure to answer, style acceptable, arguments or explanations partially supported by evidence or examples. Answer refers to at least 3 or the relevant points listed below.</p> <p>Several significant errors. Answer lacking structure, arguments not supported by evidence and contains limited information. Answer refers to no more than 2 of the relevant points.</p> <p>No answer at all or answer refers to unrelated, incorrect or inappropriate physics.</p> <p>The explanation expected in a competent answer should include a coherent selection of the following physics ideas.</p> <p>connect circuit up ✓ measure current (I) and pd/voltage (V) ✓ vary resistance/voltage ✓ obtain a range of results ✓ reverse connections to power supply (and repeat) ✓ plot a graph (of pd against current) ✓ mention of significance of 0.6 V or disconnect between readings or change range on meters when doing reverse bias ✓</p>	<p>mark range</p> <p>5 - 6</p> <p>3 - 4</p> <p>1 - 2</p> <p>0</p>
<p>(b) (i)</p> <p>(ii)</p>	<p>(use of $I = V/R$)</p> <p>$I = 12/8 \checkmark = 1.5 \text{ A} \checkmark$</p> <p>$I = (12 - 0.65 \checkmark) / 4 = 2.8 \text{ A} \checkmark$ sig figs ✓</p>	<p>5</p>
<p style="text-align: right;">Total</p>		<p>14</p>

10)

<p>(a) (i)</p>	 <p>correct diode bias for variable supply, must have some attempt to vary pd✓</p> <p>correct symbols and positions for voltmeter, ammeter: voltmeter in parallel with diode only ammeter in series with diode✓</p> <p>allow voltmeter across ammeter and diode</p>	<p>Condone variable resistor (condone missing arrow) don't allow thermistor symbol</p> <p>Allow mA symbol instead of A symbol for ammeter</p> <p>Allow symbols for diode without line through triangle and / or with a circle</p> <p>Diode symbol must consist of a triangle and a straight line at nose perpendicular to wiring in circuit.</p> 
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<p>(a) (ii)</p>	<p>The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.</p> <p>The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.</p> <p>High Level (Good to excellent): 5 or 6 marks</p> <p>The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.</p> <p><i>Candidate explains how to obtain sufficient values of I and V. They mention the need to limit the current through the diode and give an indication of the range and frequency of measurements. They discuss an advantage of using a data logger. voltage does not exceed 1.0V, diode is forward biased</i></p> <p>Intermediate Level (Modest to adequate): 3 or 4 marks</p> <p>The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.</p> <p><i>Candidate explains how to obtain sufficient values of I and V. includes mention of diode is forward biased or suitable voltage for switch on mentioned or advantage of data logger</i></p>	<p>Lower band</p> <p>vary pd obtain several readings of I and V</p> <p>or an advantage of using data logger or low level safety and action to minimise risk</p> <p>Middle band</p> <p>vary pd and obtain several readings of I and V, at least 6 different values including an advantage of using data logger or mention of forward bias or mention of switch on voltage (0.6V) or safety</p> <p>Top Band</p> <p>Mention of how to vary pd (seen in viable circuit) obtain several readings of I and V, at least 6 different values (range given where maximum value of pd does not exceed 1.0V)</p> <p>mention of limiting current through diode using protective resistor</p> <p>consider advantage of data logger</p> <p>mention forward bias</p> <p>must include potentiometer for 6 marks</p> <p>must have voltage as independent, no current led arguments in Top band</p>	<p>6</p>
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	<p>Low Level (Poor to limited): 1 or 2 marks</p> <p>The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate.</p> <p>vary pd obtain several readings of I and V</p> <p>or an advantage of using data logger</p> <p>or forward biased</p> <p>low level safety may include switch off / avoid overheating type arguments / don't touch</p> <p>The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case.</p> <p>means of controlling pd across diode indication of range and frequency of measurement mention of limiting current to avoid damage to diode a consideration of the advantages of a datalogger e.g. many readings, computer display of results use of potential divider instead of series resistor</p> <p>All signs of quality that could lift mark</p>	<p>Data logger advantages: Not more accurate Not removes human error</p>	
(a) (iii)	reverse connections to the power supply/battery/cell / reverse diode ✓	not switch wires around (need clear link to reversing connections at supply's terminals)	1
(b) (i)	divide V by I for a reading from graph or uses $R = \frac{V}{I}$ for a reading from graph ✓ repeat for different values of V and I ✓	Treat gradient = $\frac{1}{R}$ as TO Must score 1 st mark to achieve 2 nd	2
(b) (ii)	(Resistance) decreases ✓	Or resistance starts off very high and then becomes much lower	1