

Mark Scheme

Q1.

Question Number	Answer	Mark
	The only correct answer is A - the number of conduction electrons decreases so the ammeter reading decreases. B is not correct because the current would decrease. C is not correct because the number of conduction electrons would decrease. D is not correct because the number of conduction electrons would decrease, and the current would decrease.	1

Q2.

Question Number	Answer	Mark
	D is the correct answer A is not correct because both the resistance and lattice vibrations should increase. B is not correct because the resistance should increase. C is not correct because the lattice vibrations should increase.	1

Q3.

Question Number	Answer	Mark
	A is the correct answer as decreased temperature results in a decrease in lattice vibrations B is not the correct answer as this would only happen if the temperature increased C is not the correct answer as a filament is not a semiconductor D is not the correct answer as a filament is not a semiconductor	(1)

Q4.

Question Number	Answer	Mark
	A is the correct answer as a higher temperature both increases the number of conduction electrons released by a thermistor and increases the amplitude of the lattice vibrations. B is not the correct answer as the number of conduction electrons does not decrease C is not the correct answer as the amplitude of lattice vibrations does not stay the same D is not the correct answer as neither the number of conduction electrons decrease nor the amplitude of lattice vibrations stay the same.	(1)

Q5.

Question Number	Answer	Mark
	C is the correct answer as semiconductors such as LDRs release more electrons when energy is absorbed. A is not the correct answer as the number of conduction electrons increases. B is not the correct answer as the increase in lattice vibrations is not related to the reason why more conduction electrons are released. D is not the correct answer as the number of conduction electrons increases.	(1)

Q6.

Question Number	Answer	Mark
	B is the correct answer A is not correct the resistance of a metal increases with temperature C is not correct because resistance of a thermistor decreases with temperature and resistance of a metal increases with temperature D is not correct because resistance of a thermistor decreases with temperature	1

Q7.

Question Number	Answer	Mark
	B is the correct answer as a thermistor is a semiconductor A is not the correct answer as this would occur when temperature decreases C is not the correct answer as this would occur when temperature decreases D is not the correct answer as this, although it does occur, has a lesser effect than the release of more conduction electrons	(1)

Q8.

Question Number	Answer	Mark
	C is the correct answer as power for the whole circuit = $\mathcal{E} \times I$ and I increases whilst e.m.f. remains the same A is not the correct answer as increased intensity increases the number of conduction electrons released by the LDR B is not the correct answer as the potential difference across the LDR will decrease, causing the potential difference across the resistor to increase D is not the correct answer as the resistance of an LDR decreases as light intensity increases	(1)

Q9.

Question Number	Answer	Mark
	B is the correct answer A is not the correct answer as increasing the temperature of a metal wire causes an increase in the amplitude of lattice vibrations. C is not the correct answer as a change in the number of conduction electrons is normally related to semiconductors. D is not the correct answer as a change in the number of conduction electrons is normally related to semiconductors.	(1)

Q10.

Question Number	Answer
	C is the correct answer A is not correct because the number of conduction electrons should increase B is not correct because the number of conduction electrons should increase and the resistance should decrease D is not correct because the resistance should decrease

Q11.

Question Number	Answer	Mark
	The only correct answer is B (stays the same increase) A is not correct because voltmeter reading stays the same and ammeter reading increases C is not correct because ammeter reading increases D is not correct because voltmeter reading stays the same	1

Q12.

Question Number	Answer	Additional Guidance	Mark
	The (amplitude of) lattice vibrations increase (1) There is an increase in the frequency of collisions (1) of electrons with the lattice So the resistance increases (1) (MP3 dependent on MP2 or MP1)	Allow atoms / ions for lattice	3
	Total for question		3

Q13.

Question Number	Answer	Mark
(a)	The resistance of the LDR increases,(so the current decreases) Or The resistance of the LDR increases, so the LDR has a greater p.d. So the p.d. across the fixed resistor decreases (dependent on MP1)	(1) (1) 2
(b)	Use of $V = IR$ Use of R_{LDR}: $R_{resistor} = 3:2$ $R_{LDR} = 33 \Omega$ OR Use of V_{LDR}: $V_{resistor} = 3:2$ Use of $V = IR$ $R_{LDR} = 33 \Omega$ <u>Example of calculation</u> $R_{resistor} = \frac{0.62 \text{ V}}{28 \times 10^{-3} \text{ A}} = 22.1 \Omega$ $R_{LDR} = 22.1 \Omega \times \frac{3}{2} = 33.2 \Omega$ OR $0.62 \text{ V} \times \frac{3}{2} = 0.93 \text{ V}$ $R_{LDR} = \frac{0.93 \text{ V}}{28 \times 10^{-3} \text{ A}} = 33 \Omega$	(1) (1) (1) (1) (1) (1) (1) 3
Total for question		5

Q14.

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	Indicative content - Resistance of LDR decreases - Due to increase in number of (conduction) electrons - So the resistance of circuit decreases - Or This results in greater current in circuit/LDR/resistor - e.m.f. of the circuit is the same - And due to $P = VI$ Or $P = I^2R$ Or $P = V^2/R$ (for whole circuit) - The power dissipated by the circuit increases (IC2 – allow “number of charge carriers” or “charge carrier density”) (IC4 – allow “total circuit voltage/p.d.” for “e.m.f.”) (IC6 – needs to be related to correct V, I, R for whole circuit)	6
	Total for question	6

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	Indicative content - For filament bulb, resistance increases (as p.d. increases) Or For filament bulb, p.d. increases at a greater rate than current Or rate of increase of current decreases. - Increased temperature leads to increased vibration of ions/atoms/lattice - Increased rate of collision between electrons and ions/atoms/lattice - For a thermistor, resistance decreases (as p.d. increases) Or For a thermistor, current increases at a greater rate than p.d. Or rate of increase of current increases - Increased number of conduction electrons $I = nAqv$, so current increases. (For IC1 & IC4 accept symbols for p.d. and current) (Ignore references to the gradient of the graph as $1/R$)	6
	Total for Question	6

Question Number	Answer	Mark
a	See $V_T = V_1 + V_2$ (1) See $IR_T = IR_1 + IR_2$ (1) (Divides by I to give) $R_T = R_1 + R_2$ (1)	3
b	Use of $V = IR$ with 7.0V and 0.5A (1) Use of $\frac{1}{R_{tot}} = \frac{1}{R_1} + \frac{1}{R_2}$ (1) $R = 12\Omega$ (1) Or Use of $V = IR$ with 6Ω and 0.5A (to get 3V across 6Ω resistor) (1) Second use of $V = IR$ with $V = 4V$ (1) $R = 12\Omega$ (1) <u>Example of calculation</u> R for whole circuit = $(7.0V/0.5A) = 14\Omega$ So R for parallel section = $14 - 6 = 8\Omega$ $1/8 = 1/24 + 1/R_2$ $R_2 = 12\Omega$	3

ci	Use of $V = IR$ to determine circuit current (1) Use of $P = I^2R$ or $P = V^2/R$ or $P = VI$ (1) $P = 1.5 \times 10^{-2} \text{ W}$ (1) Or Ratio of resistances used to calculate p.d. across R (1) Use of $P = V^2/R$ (1) $P = 1.5 \times 10^{-2} \text{ W}$ (1)	3
cii	<u>Example of calculation</u> $I = 12.0 \text{ V} / (8000 + 670 \Omega) = 1.38 \times 10^{-3} \text{ A}$ $P = (1.38 \times 10^{-3} \text{ A})^2 \times 8000 = 0.015 \text{ W}$	
	Decrease in the number of conduction/ free electrons (1) Greater resistance of LDR (1) Less p.d. across the fixed resistor (allow "voltage" for "p.d.") (1) Use of a suitable power equation to conclude that less power dissipated in the fixed resistor. (1) (Converse argument not allowed for MP1 & MP2) (For MP4, do not accept an answer that includes an incorrect statement about one of the variables)	4
Total for question		13

Question Number	Answer	Mark
(a)(i)	Use of $P = VI$ and $V = IR$ Or Use of $P = I^2 R$ and $V = IR$ (1) Appropriate algebra to derive $P = \frac{V^2}{R}$ (1)	2
(a)(ii)	EITHER Their resistance from graph divided by 4 (1) Use of $P = \frac{V^2}{R}$ (1) Use of p.d. across battery = $5 \times$ p.d. across R (1) p.d. across battery = $9.0 - 9.2$ V (1) OR Their resistance from graph divided by 4 (1) Use of $P = I^2 R$ (1) Use of $V = I(R + R_t)$ (1) p.d. across battery = $9.0 - 9.2$ V (1) <u>Example calculation</u> Resistance of $R = \frac{35 \Omega}{4} = 8.75 \Omega$ $0.38 \text{ W} = \frac{V_R^2}{8.75 \Omega}$ $V_R = \sqrt{0.38 \text{ W} \times 8.75 \Omega} = 1.82 \text{ V}$ $V_B = 5 \times 1.82 \text{ V} = 9.1 \text{ V}$	4

(b)(i)	Number of conduction electrons (per unit volume) increases (1) So current increases (for the same potential difference and $R = V/I$) (1)	2
(b)(ii)	(Increased temperature caused) increased lattice/atom/ion vibrations (in the thermistor and the wire resistor) (1) This caused an increase in collisions between electrons and the lattice/ions/atoms (in the thermistor and the wire resistor) (1) So the resistance of the wire resistor increased (1) (Because current decreases) total resistance of the circuit must increase (1) So the increase in the resistance of the wire resistor must be greater than the decrease in the resistance of the thermistor (1)	5
Total for question		13