Mark Scheme – Resistors & Kirchhoff's Laws

Q	Expanded Answer Guidance	Marks
1a	Kirchhoff’s Current Law (KCL): • Total current entering a node equals total current leaving • Current in = current out • Sum of currents at a junction = 0	1
1b	Kirchhoff’s Voltage Law (KVL): • Sum of voltages around a closed loop = 0 • Total voltage rise equals total voltage drop	1
1c	Ohm’s Law: • V = IR • Voltage = Current × Resistance	1
2a	Relationship: • Series resistors • Same current flows through both	1
2b	Use the series resistance equation to work out the total resistance $R_{total} = R_1 + R_2$ $R_{total} = 2.6k + 1.8k = 4.4k\Omega$ $R_{total} = 2600 + 1800 = 4400\Omega$	1
2c	Use ohms law to work out the current through the circuit $V = IR$ $I = \frac{V}{R}$ $I = \frac{24}{4400} = 0.0054A = 540mA$	1
2d	Use power equation to work out value based on previous answers $P = I^2R$ $P = 0.0054^2 * 4400 = 0.00002916 * 4400 = 0.128304W$	2
3a	Fixed resistor: • Constant resistance value Variable resistor: • Adjustable resistance value Accept: • Potentiometer/rheostat examples	2

3b	Importance of power rating: • Prevents overheating • Avoids damage • Prevents fire risk • Ensures reliability	2
4	Use voltage divider to work out value of R_2 $$V_{out} = V_{in} * \left(\frac{R_2}{R_1 + R_2}\right)$$ $$2 = 10 * \left(\frac{R_2}{1000 + R_2}\right)$$ $$\frac{2}{10} = \frac{R_2}{1000 + R_2}$$ $$\frac{2}{10}(1000 + R_2) = R_2$$ $$200 + \frac{2}{10}R_2 = R_2$$ $$200 = \frac{8}{10}R_2$$ $$R_2 = 250$$	4

5a	a) For the resistors in parallel $$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2}$$ $\frac{1}{R_t} = \frac{1}{1.8} + \frac{1}{1.2} = 1.39$ hence, $R_t = \frac{1}{1.39}$ = 0.72 kΩ [B1, 1, AO2] **<u>Or, alternatively:</u>** $$R_t = \frac{(R_2 \times R_3)}{(R_2 + R_3)}$$ $R_t = \frac{(1.8 \times 1.2)}{(1.8+1.2)}$ = 0.72 kΩ [B1, 1, AO2] $V_o = \frac{R_2}{(R_1+R_2)} \times V$ [M1, 1, AO1a] $V_o = \frac{0.72}{(1.6 + 0.72)} \times 240$ $V_o = 74.483$ V or 74.5 V [B2, 1, AO2]	3

5b	b) Calculate total resistance of the circuit: 1.6 + 0.72 = 2.320 kΩ = 2320 Ω $I = \frac{V}{R}$ $I = \frac{240}{2320}$ $I = 0.103$ A [B1, 1, AO2]	1
6a	Use both parallel and series resistor equations to work out total resistance $$Parallel: R_{tot} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \cdots}$$ $$Series: R_{tot} = R_1 + R_2 + \cdots$$ $$R_{tot} = 350 + \frac{1}{\frac{1}{220} + \frac{1}{120}} = 427.6470588$$ Use ohms law to work out the current from the source $$V = IR$$ $$I_{total} = \frac{V}{R}$$ $$I_{total} = \frac{24}{427.6470588} = 0.0561210453$$ Use the current divider equation to work out the current $$I_1 = I_{total} * \left(\frac{R_2}{R_1 + R_2}\right)$$ $$I_1 = 0.05612104539 * \left(\frac{220}{120 + 220}\right)$$ $$I_1 = 0.05612104539 * 0.6470588235 = 0.03631361761A$$ $$I_1 = 36.3mA$$	3
6b	Calculate the current through 220 ohm resistor $$I_2 = 0.05612104539 * \left(\frac{120}{120 + 220}\right) = 0.01980742778$$ Or $$I_2 = 0.05612104539 - 0.03631361761A = 0.01980742778$$ Use ohms law to work out the voltage drop $$V = IR$$ $$V = 0.01980742778 * 220 = 4.357634112$$	2

7a	a) Using parallel and series formulae: $\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2}$ and $R_T = R_1 + R_2$ Series calculation $R = 5.6k\Omega + 4.7k\Omega = 10.3k\Omega$ [B1, 1, AO2] Parallel calculation $\frac{1}{R} = \frac{1}{10.3k\Omega} + \frac{1}{10k\Omega}$ $R = 5.07k\Omega$ [B2 1, AO2] Total resistance calculation $R_t = 20k\Omega + 5.07k\Omega + 30k\Omega$ [M1, 1, AO2] $R_t = 55.1\,k\Omega$ [A1, 1, AO2]	4
7b	b) I = V / R I = 110 / 55,100 [M1, 1, AO1b] I = 0.002 A [A1, 1, AO1b]	2
8a	LDR: • Resistance changes with light intensity • Used in automatic lighting • Used in sensors	2

8b	Thermistor: • Resistance changes with temperature • Used in temperature monitoring • Used in thermostats	2