Marking Scheme

#1

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	(a)	(i)	Resistance of LDR / circuit increases [as light intensity decreases] (1) [Hence] current decreases (1)	2			2		2
		(ii)	**Either:** Current in LDR $= \frac{4.0}{2.4 \times 10^3}$ = [1.67 × 10^{-3} A] (1) $R = \frac{5.0}{1.67 \times 10^{-3}}$ (1) R = 3.0 kΩ (1) **Alternative:** $4.0 = \frac{2.4 \times 10^3 \times 9.0}{(2.4 \times 10^3 + R)}$ (1) [substitution into potential divider equation] Correct algebra (1) R = 3.0 kΩ (1) **Alternative:** $\frac{4}{5}$ (1) $= \frac{2.4}{R}$ (1) R = 3.0 kΩ (1)	1	1 1		3	2	3
	(b)		Light from lamp will decrease [LDR resistance and hence] V across lamp low so lamp not activated (1) Hence reason for on/off, e.g. lamp off → LDR in dark → V_{out} high → lamp on		2		2		2
			Question 1 total	**3**	**4**	**0**	**7**	**2**	**7**

#2

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	(a)		There are 6 J of energy/work done (converted from electrical to other forms) (1) Per coulomb of charge between X and Y (1)	2			2		
	(b)	(i)	Attempt to use equation to determine resistors in parallel (1) Resistance of parallel combination = 3.7[2] Ω (1) Total circuit resistance = 9.3 Ω ecf on parallel (1) Current = $\frac{V}{R}$ = 0.64 A [accept 0.65 A] answer to 2 d.p. (1)	1	1 1 1		4	3	
		(ii)	Apply ecf from part (b) (i) PD across parallel = 0.65 × 3.7 ecf OR pd across 5.6 Ω = 0.65 × 5.6 = 3.6 V (1) Answer = 2.4 V (1)		2		2	1	
		(iii)	Substitute values into $P = I^2R$ [$P = 0.65^2 \times 3.7$] (1) P = 1.54 W – ecf (1)	1	1		2	2	
			Question 2 total	**4**	**6**	**0**	**10**	**6**	**0**

#3

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	(a)		capacitance = $\frac{\text{charge (on either plate)}}{\text{pd (between the plates)}}$ Accept charge per unit pd / voltage [between plates] (1) Accept $C = \frac{Q}{V}$ if Q and V defined	1			1		
	(b)	(i)	Q = - 75 nC, R = + 75 nC, S = - 75 nC All numerical values stated as 75 [nC] (1) Correct signs and unit, i.e. nC (1) One of: (1) • Capacitors in series carry equal charges when joined to common pd • Conservation of charge applies for series circuit [hence if +75 μC moves from A to plate P, the same moves from Q → R etc] • Opposite charge to P (accept R), since connected to negative potential [Accept: battery transfers electrons from P to Q]	3			3		
		(ii)	Total capacitance = 7.5 nF (1) $V = \frac{75 \times 10^{-9}}{7.5 \times 10^{-9}}$ **(ecf on total C)** V = 10 V (1) **Alternative:** Application and substitution into $\frac{Q}{C_1} + \frac{Q}{C_2}$ i.e. $\frac{75 \times 10^{-9}}{30 \times 10^{-9}} + \frac{75 \times 10^{-9}}{10 \times 10^{-9}}$ (1) V = 10 V (1)		2		2	2	
		(iii)	**Either:** Q same on both capacitors (1) $\frac{1}{2}\frac{Q^2}{C}$ is bigger on smaller capacitor (1) (Award 2 marks for correct numerical analysis) **Or:** $V \propto \frac{1}{C}$ so V bigger across smaller capacitor (1) ½ CV^2 bigger across smaller capacitor (V^2 factor) (1) (Award 2 marks for correct numerical analysis) **Or** Q same on both capacitors and $V \propto \frac{1}{C}$ so V bigger across smaller capacitor (1) ½ QV is bigger on smaller capacitor (1) (Award 2 marks for correct numerical analysis			2	2		
	(c)		New C = 0.47 pF (1) New $d = 3.0 \times 10^{-3}$ m (1) $\Delta d = 5.2 \times 10^{-3} - 3.0 \times 10^{-3} = 2.2 \times 10^{-3}$ m (1) (**ecf** from new d) Application of $F = k\Delta d$ ecf k = 91 N m^{-1} so spring of k = 90 N m^{-1} suitable [conclusion consistent with value of F](1) **Alternative 'Trial and Error' :** Application of $x = \frac{F}{k}$ for each spring constant, showing that for: k = 120 N m^{-1}, $x = 1.67 \times 10^{-3}$ m k = 150 N m^{-1}, $x = 1.33 \times 10^{-3}$ m k = 90 N m^{-1}, $x = 2.22 \times 10^{-3}$ m (All required for1) New C = 0.47 pF (1) Application of $C = \frac{\varepsilon_0 A}{d}$ for each value of x above to show that, for $x = 2.22 \times 10^{-3}$ m, $C = 0.475 \times 10^{-12}$ F, so k = 90 N m^{-1} suitable. (1)			4	4	3	
			Question 6 total	**4**	**2**	**6**	**12**	**5**	**0**

#4

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
	(a)		Electrical energy (or work) transferred [to other forms] per unit [accept coulomb] of charge [passing between the two points]	1			1		
	(b)		**Either:** I in circuit = $\frac{2.4}{160}$ (1) [= 15.0 mA] $R_{\text{Thermistor}} = \frac{(12.0-2.4)(1)}{15.0 \times 10^{-3}}$ **[ecf** on I**]** = 640 [Ω] (1) **Or:** $R_T = \frac{9.6(1)}{2.4} \times 160$ (1) **or** $2.4 = \frac{12 \times 160}{160 + R_T}$ (2) = 640 [Ω] (1)	1	1 1		3	3	
	(c)	(i)	[Resistance of thermistor decreases as temp increases] pd across thermistor decreases (1) So pd across fixed resistor increases **because**: **Either** - ratio of pds across potential divider changes **Or** - total pd must = 12.0 V (or equivalent) (1) **Alternative:** [Resistance of thermistor decreases as temp increases] so circuit current increases (1) So pd across fixed resistor increases **because** $V = IR$ and R is constant or $V \propto I$ (1)		2		2		
		(ii)	At 30 °C, $R_{\text{thermistor}}$ = 480 Ω from graph (1) $V_{\text{cooling system}} = \frac{160}{(480+160)} \times 12.0$ (1) **[ecf** on $R_{\text{Thermistor}}$**]** = 3.0 [V] (1) **Alternative:** $2.8 = \frac{160}{(R_{\text{Thermistor}} + 160)} \times 12.0$ (1) $R_{\text{Thermistor}}$ = 526 [Ω] (1) Corresponds to 25 °C from graph (1) **Alternative:** $I_R = \frac{2.8}{160}$ = 0.0175 [A] (1) $R_T = \frac{9.2}{0.0175}$ = 526 [Ω] (1) Corresponds to 25 °C from graph (1) **Alternative:** $I_R = \frac{2.8}{160}$ = 0.0175 [A] (1) At 30 °C, $R_{\text{thermistor}}$ = 480 Ω from graph (1) $I_T = \frac{9.2}{480}$ = 0.0192 [A] (1) **Alternative:** At 30 °C, $R_{\text{thermistor}}$ = 480 Ω from graph (1) $I = \frac{V}{R} = \frac{12}{(480+160)}$ =0.01875 [A] (1) $V = IR$ = 0.01875 × 160 = 3 [V] (1) **Final mark for all methods - Valid conclusion consistent with answer:** i.e. Claim incorrect - system activated at $\theta < 30$ °C (1)			4	4	3	
	(d)		More effective at 0 °C – 10 °C (no mark) Because: Steeper gradient / larger change in resistance (1) Greater sensitivity in this range / greater [fractional] change in R per °C change in temperature or over the same temperature range) (1)			2	2		2
			Question total	**2**	**4**	**6**	**12**	**6**	**2**

#5

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	(a)		V- Energy (per coulomb or unit charge) used in external resistor/circuit [1] E- Energy (per coulomb/unit charge) transferred by source [or from chemical energy or from other forms] or used in whole circuit [1] Ir – energy (per coulomb/unit charge) wasted/lost in source or due to internal resistance [1] Use of 'per coulomb' or 'unit charge' at least once [1]	4			4		
	(b)	(i)	Circuit current = $\frac{1050 \times 10^{-3}}{2.5}$ = 0.42 [A] [1] Total internal resistance = $\frac{0.5}{0.42}$ = 1.2 [Ω] ecf on I [1] r_{cell} = 0.6 [Ω] [1]		3		3	2	
		(ii)	Substitution into I^2rt i.e. $(0.42)^2 \times 0.6 \times 60$ (ecf on I, r) [1] **Alternative:** Substitution into $\frac{V^2t}{r}$ i.e. $\frac{(0.25)^2 \times 60}{0.6}$ (ecf on V, r) **Alternative:** Substitution into IVt i.e. $0.42 \times 0.25 \times 60$ (ecf on I, V) Energy dissipated = 6.3 [J] [N.B. Alternative → 6.4 J] [1]	1	1		2	1	
	(c)		**Either**: Total resistance of coils in parallel = 2.975 [Ω] [1] and total circuit resistance = 4.175 [Ω] ecf [1] New current in circuit = $\frac{3}{4.175}$ = 0.72 [A] [1] **For the 4th mark:** Rate of energy dissipation in each cell = $(0.72)^2 \times 0.6$ = 0.31 [W] so Kiera correct (or ratio calculated to be approx. 3) **Or** Energy dissipated in each cell in one minute = $(0.72)^2 \times 0.6 \times 60$ = 18.6 [J] so Kiera correct (or ratio calculated to be approx. 3) [1] **Alternative:** Total resistance of coils in parallel = 2.975 [Ω] [1] and total circuit resistance = 4.175 [Ω] **ecf** [1] New current = 0.72 [A] and pd drop across internal resistance = 0.72×1.2 = 0.86 [V] [1] Rate of energy dissipation in each cell **For the 4th mark:** = $\frac{(0.43)^2}{0.6}$ = 0.31 [W] so Kiera correct (or ratio calculated to be approx. 3) **Or** Energy dissipated in each cell in one minute = $\frac{(0.43)^2 \times 60}{0.6}$ = 18.6 [J] so Kiera correct (or ratio calculated to be approx. 3) [1]			4	4		
			Question 1 total	5	4	4	13	3	0

#6

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
				Marks available					
	(a)		Label axis with units and suitable scale (1) Plot all points correctly ± ½ small square division (1) Draw a smooth curve with maximum between 2.3 and 2.6 Ω **no** straight lines present (no requirement to extend back to the origin) (1)	1	1 1		3	3	3
	(b)	(i)	6.0 [J] of [chemical] energy transferred/converted/work done to electrical [potential] energy (1) Per unit charge [or coulomb] [flowing through the cell/battery] (1)	2			2		2
		(ii)	Using $P = I^2R$ (1) Data point from graph when R = 4.5 Ω, P = 3.64 W (1) Need 2 dp and within ± ½ small square Calculation of current correctly i.e. = 0.90 [A] (1)	1	1 1		3	3	3
		(iii)	Using $E = V + Ir$ (1) Substituting correct values 6 = 0.90 × 4.5 + 0.90r **ecf** (1) Internal resistance = 2.2 [Ω] (1)	1	1 1		3	3	3
	(c)		Power is <u>higher/greater/larger</u> (1) Total resistance of circuit is less for <u>all values of R</u> (1) Accept peak of graph shifts to left			2	2		2
			Question total	**5**	**6**	**2**	**13**	**9**	**13**

#7

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*	(i)	Rate of charge flow Accept $I = \frac{\Delta Q}{\Delta t}$ only if ΔQ and Δt defined [accept Q and t]	1			1		
		(ii)	J C^{-1} and C s^{-1} as units of V and I respectively clearly shown (1) Correct division seen i.e. $\frac{\text{JC}^{-1}}{\text{Cs}^{-1}}$ seen (1) Or from alternative correct expression, e.g. $R = \frac{V^2}{P}$ [illegible] Or equivalent in terms of quantities.	1	1		2	1	
	(b)	(i)	I through R_P = 1.2 A and I through R_T = 0.8 A (1) $\frac{V_P}{V_T} = \frac{1.2R_P}{0.8R_T}$ (=1.5) seen (1) Or Parallel combination calculated as $\frac{2}{3}R$ (1) Potential divider: $\frac{R}{R+\frac{2}{3}R} \times 9 = 1.5$ (1)		2		2	1	
		(ii)	$2.5V_T = 9.0$ or $\frac{5V_P}{3} = 9.0$ (1) V_T = 3.6 V or V_P = 5.4 V (1) Award 2 marks for either V_P or V_T calculated correctly. $R_T = \frac{3.6}{0.8}$ = 4.5 Ω or $R_P = \frac{5.4}{1.2}$ = 4.5 Ω or $\frac{1.8}{0.4}$ = 4.5 Ω(1) **Alternative:** Total circuit $R = \frac{9.0}{1.2}$ = 7.5 Ω (1) Parallel and series combination shown to be = $\frac{5R}{3}$ (1) $\frac{5R}{3}$ = 7.5 and R = 4.5 Ω (1) **Alternative:** Understanding that $V_P + V_T = 9$ (1) $1.2R_P + 0.8R_T = 9$ (1) (award 2 marks for this only) $R_P = R_T = R$ and $R = \frac{9}{2}$ = 4.5 Ω clearly shown (1) Accept reverse argument.		3		3	3	
	(c)		P (circuit) = 10.8 W (1) (either $\frac{81}{7.5}$ or $(1.2)^2 \times 7.5$ or 1.2×9) P in $R_Q = (0.4)^2 \times 4.5$ = 0.72 W (1) $\frac{10.8}{0.72}$ = 15 seen (1) **Alternative:** $P_s = P_Q$ since $I_s = I_Q$ $P_T = 4 \times P_Q$ since $I_T = 2 \times I_Q$ $P_P = 9 \times P_Q$ since $I_P = 3 \times I_Q$ Hence total circuit power = $P_Q + P_Q + 4P_Q + 9P_Q$ = $15P_Q$ Award (1) for correct individual power analysis Award (1) for correct reason linked to currents Award (1) for showing correct total P		3		3	2	
	(d)		Circuit resistance increases, leading to total current decreasing. Power dissipated in circuit decreases (1) V across R_Q has increased (from 1.8 V to 3.0 V), so P_Q increases / I through R_Q has increased (from 0.4 A to 0.67 A) so P_Q increases (1) Hence ratio decreases (1) [only award from correct explanation] Accept numerical explanation: e.g. Circuit resistance is now 13.5 Ω and circuit current = 0.67 A (1) circuit power shown to be 6 W and P_Q shown to be 2 W (1) Hence ratio decreases or is now 3 (1) **Alternative:** With T removed, I through all remaining resistors is the same or V across each is the same (1) Use of VI or I^2R or V^2/R or power / energy dissipated in all three resistors equal (1) So total $P = 3 \times P_Q$ or which is less than $15P_Q$ (1)		3		3		
			Question 2 total	**2**	**12**	**0**	**14**	**7**	**0**

#8

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
				Marks available					
5	*(a)*	(i)	All resistors connected in parallel (1) Using $\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$ [or equiv] (1) R_{total} = 1.44 [Ω] (1)	1	1 1		3	2	3
	(b)	(i)	(A4/emf) is the energy generated in the cell (1) per coloumb (1) Loss of energy in circuit in the load resistor (E4) (1) $E-V$ is the energy is lost in internal resistance (1) Energy is conserved (1) Re-arrange gives $r=\frac{E-V}{I}$ (1)	1 1	1 1 1 1		6	1	
		(ii)	Substituting values in $\frac{\text{A7-E7}}{\text{D7}}$ (1) r = 0.15 [Ω] (1)	1	1		2	2	
		(iii)	Using $P=I^2R$ (1) P = 0.45 [W] (1) 0.50 W – has to be greater than the power dissipated (need reason) (1)	1	1 1		3	1	
			Question 5 total	**5**	**9**	**0**	**14**	**6**	**3**

#9

<table>
<tr><th colspan="3" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="4">Marks available</th><th rowspan="2">Maths</th><th rowspan="2">Prac</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th></tr>
<tr><td></td><td>(a)</td><td>(i)</td><td>For Left Hand Combination:
$\frac{1}{R_{parallel}}=\frac{1}{2R}+\frac{1}{R}+\frac{1}{2R}$ (RHS seen in any correct form e.g. $\frac{4}{2R}$)(1)
$=\frac{R}{2}$ (1)
Total $R=\frac{R}{2}+R$ or $\frac{3R}{2}$ seen (1)
Alternative solutions possible e.g.
Sum of top and bottom branch = R (1)
Then parallel branch = $\frac{R}{2}$ (1)
Total $R=\frac{R}{2}+R$ (1)</td><td></td><td>3</td><td></td><td>3</td><td>3</td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Right hand resistor circled (1)
Greatest current / greatest voltage (1)</td><td></td><td>2</td><td></td><td>2</td><td></td><td></td></tr>
<tr><td></td><td>(b)</td><td></td><td>Correct substitution into $l=\frac{RA}{\rho}$
i.e. $\frac{2.0\times10^{3}\times250\times10^{-9}\times0.25\times10^{-3}}{1.20\times10^{-6}}$ (1)
l = 0.10 [m] (1) (ecf on slip in powers of 10)</td><td>1</td><td>1</td><td></td><td>2</td><td>2</td><td></td></tr>
<tr><td></td><td>(c)</td><td>(i)</td><td>n- <u>free</u> electron density. Accept- number of <u>free</u> electrons per unit volume or per m^3 (or equivalent)</td><td>1</td><td></td><td></td><td>1</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td><table><tr><th>Ratio</th><th>Value</th><th>Explanation</th></tr><tr><td>$\frac{n_X}{n_Y}$</td><td>1</td><td>Wires made of the same material</td></tr><tr><td>$\frac{I_X}{I_Y}$</td><td>1</td><td>Wires in series</td></tr><tr><td>$\frac{v_X}{v_Y}$</td><td>0.25</td><td>Correct explanation based on $A_xv_x=A_yv_y$
e.g $(d)^2v_x=\left(\frac{d}{2}\right)^2v_y$</td></tr></table>Award 1 mark for each correct row</td><td>1
1</td><td>1</td><td></td><td>3</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(iii)</td><td>$R=\frac{\rho l}{A}$ substituted into $P=I^2R$ i.e. $P=\frac{I^2\rho l}{A}$ (1)
$P_x=\frac{I^2\rho_x l_x}{A_x}$ and $P_z=\frac{I^2\rho_z l_z}{A_z}$ (or equivalent) - can award 1st mark from one of these expressions
$A_x=4A_z$ and $l_x=\frac{l_z}{2}$ and $\rho_x=2\rho_z$ to show: (1)
$\frac{P_z}{P_x}=4$ (1)</td><td></td><td>3</td><td></td><td>3</td><td>3</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Question total</td><td>4</td><td>10</td><td>0</td><td>14</td><td>8</td><td>0</td></tr>
</table>