Question Number	Answer	Mark
1(a)	**Plot of graph** Check points, 4 correct 2 marks, 3 correct 1 mark Line of best fit to include 0,0.6 and 0.52,0 (1)	**3**
(b)(i)	Use of V = 0.43 V in P = VI (1) ecf values for incorrect best fit line P = 0.17 W (1) **Example of calculation** P = 0.4 A × 0.43 V P = 0.172 W	**2**
(b)(ii)	Value of e.m.f. is when the current is zero (1) No 'lost' volts OR no energy loss (1) **OR** E = V + Ir I = 0, E = V	**2**
(b)(iii)	Identifies current in circuit (1) ecf values for incorrect best fit line Finds 'lost volts' (1) r = 0.24 Ω (1) **Example of calculation** r = (0.52 V – 0.40 V) ÷ 0.50 A r = 0.24 Ω	**3**
(c)	Graph of similar shape as in (a) but initially above the first graph (1) ecf values for incorrect best fit line Finishing at 0.52 V, 0.00 A (1)	**2**
	Total for question	**12**

Question Number	Answer	Mark
2	Use of $V = IR$ **(1)** Use of lost volts = emf − terminal pd **Or** use of total resistance − 6.6Ω **(1)** (quoting $\varepsilon = I(R + r)$ or $\varepsilon = V + Ir$ gets both marks) Internal resistance = 0.54 Ω **(1)** (rounding and different methods all give 0.5 Ω to 1 sig. fig .) Example of calculation V = 0.21 A × 6.6 Ω = 1.39 V Ir = 1.5 V – 1.39 V = 0.11 V r = 0.11 V ÷ 0.21 A = 0.54 Ω	**3**
	Total for question	**3**

Question Number	Answer	Mark
3 (a)	Use of R = V/I (for current) **(1)** Use of sum of e.m.f. = sum of p.d.s Or use of $\mathcal{E} = V + Ir$ **(1)** r = 100 000 Ω or 100 kΩ or 1×10^5 Ω **(1)** (Accept valid alternative methods based on potential divider) Example of calculation I = 0.018 V / 4700 Ω = 3.8×10^{-6} A 0.4 V = 0.018 V + (3.8×10^{-6} A × r) r = 100 000 Ω	**3**
3 (b)	Use of power = radiation flux × area **(1)** Use of an electrical power equation **(1)** Use of efficiency equation **(1)** Efficiency = 12 % **(1)** (Full ecf for current from (a)) Example of calculation power = 1.5×10^{-3} W $m^{-2} \times 3.9 \times 10^{-4}$ $m^2 = 5.85 \times 10^{-7}$ W power = $IV = 3.8 \times 10^{-6}$ A × 0.018 V = 6.84×10^{-8} W Efficiency = 6.84×10^{-8} W / 5.85×10^{-7} W = 0.12 OR 12 %	**4**
	Total for question	**7**

	Answer	Mark
4(a)	<table><tr><td>Switch combination</td><td>Total resistance of circuit</td></tr><tr><td>A open. B closed.</td><td>R</td></tr><tr><td>A open. B open.</td><td>$2R$</td></tr><tr><td>A closed. B closed.</td><td>$R/2$ or 0.5 R</td></tr><tr><td>A closed. B open.</td><td>$2R/3$ or 0.7 R</td></tr></table> **(1)** **(1)** **(1)** Answers must be in simplest form, e.g. not $R + R$	**3**
4(b)	Reference to $P = V^2/R$ **OR** $P = VI$ and $V = IR$ (Accept energy equations.) **(1)** (most power/energy) from the switch combination with the lowest resistance **(1)** [Ignore the table when awarding these method marks.]	**2**
4 (c)	(Internal resistance will) reduce current **Or** reduce V **Or** increase total R **Or** cause lost volts **Or** energy transferred to internal resistance **(1)** less energy/power output (in all combinations) **(1)**	**2**
	Total for question	**7**