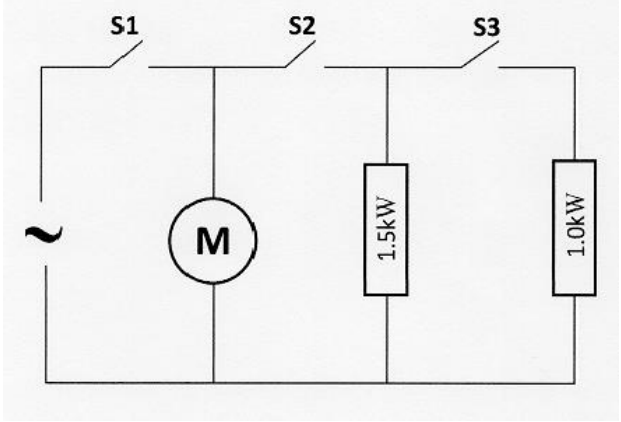
Question			Answer	M	Guidance
1					
	a	i	$P = V^2/R = 230^2/R = 1500$ $R = 35.3\ \Omega$	C1 A1	**accept** $I = P/V = 6.52$ A and $R = 230/6.52$ **allow** $52900/1500 = 35\ \Omega$, i.e. some working shown
		ii	use of $\rho = RA/l$ or $R = \rho l/A$ $l = 35 \times 7.8 \times 10^{-8}/1.1 \times 10^{-6}$ $l = 2.5$ (m)	C1 C1 A1	formula correct substitution answer (2.48)
	b		resistors and motor wired in parallel to supply switches correctly placed (open or closed) any suitably labelled symbols; components in correct order	B1 M1 A1	 do not expect switches to be labelled
	c	i	power is inversely proportional resistance (for same V) resistance of wire is inversely proportional to c-s area/diameter squared (as l and ρ are fixed/same)	B1 B1	**accept**: (same V so for) larger/smaller power need (larger/smaller I and so) smaller/larger resistance **accept** smaller c-s area/diameter (of wire) causes larger resistance or vice versa
		ii	$P \propto A$ (because $P = V^2/R = V^2A/\rho l$) **or** $P \propto d^2$ (because $A = \pi d^2/4$) $1.0/1.5 = (d/D)^2 = 2/3$ so $d = 0.82\ D$	B1 M1 A1	**accept** $R_{1000} = 52.9\ \Omega$ and $R \propto 1/A$ [where $A_d = 5.2 \times 10^{-8}$ & $A_D = 7.8 \times 10^{-8}$] so $35.3 / 52.9 = [(d/D)^2$ or $A_d/A_D] = 2/3$ [where $d = 2.57 \times 10^{-4}$ & $D = 3.15 \times 10^{-4}$]

Question			Answer	M	Guidance
	d		total current in circuit = 2600/230 = 11.3 A so 13 A fuse required	M1 A1	**accept** I = 2500/230 = 10.9 A
	e	**i**	(a unit of) <u>energy</u> equal to 3.6 MJ **or** 1 kW for 1 h/AW	B1	**e.g.** 1000 W for 3600 s or similar; **NOT** 1 kW **per** hour
		ii	1.6 x 4 x 18 115 (p)	C1 A1	**allow** 1 mark for 108 p; i.e. using 1.5 x 4 x 18 **or** 1 mark for 79 p; i.e. using 1.1 x 4 x 18 **NOT** 72 p
			Total question 1	**18**	

Question			Answer	Marks	Guidance
2	a	i	V is not proportional to I	B1	**accept** not a straight line; R is not constant
		ii	R (approximately) constant up to V = 0.5 V and I = 50 mA so R = 0.5/0.05 = 10 (Ω)	B1 B1	**allow** graph is (almost) linear/straight (to V = 0.5 V) or constant gradient **allow** any correct calculation, e.g. 0.2/0.02
		iii	the resistivity/resistance of the (metal) filament increases with temperature the larger the current in the filament the hotter it becomes/AW	B1 B1	larger current heats filament so resistance increases **or** electron-ion collisions increase/AW; **allow** atom for ion
	b		Any potential divider argument or calculation *In the light* parallel combination less than or about 1 Ω/AW so V across lamp less than 0.5 V (so lamp out)/ small compared to V across 25 Ω	B1 B1 B1	**QWC** the arguments must be clear for full marks **allow** R_{lamp} = 10 to 25 Ω for any calculation **or** comparison of voltage across 25 Ω to 1 Ω **N.B.** answers given in terms of current are likely to score zero
			In the dark parallel combination about 25 Ω/AW so V across lamp approximately 6.0 V so lamp on	B1 B1	
			Total	**10**	

Question			Answer	Marks	Guidance
3	a	i	ammeter in series voltmeter in parallel with LED	B1	both correct to score 1 mark
		ii	(at 20 mA) V_{led} = 4.0 V V_R = 0.020 x 100 = 2.0 V so p.d. = 6.0 V	B1 C1 A1	**allow** R_{led} = (4.0/ 0.02) = 200 Ω p.d. = 0.020 (200 + 100) **allow** answer to 1 SF
	b	i	energy in eV = $4.1 \times 10^{-19}/1.6 \times 10^{-19}$ = 2.6 (eV)	B1	**expect** 2.56 eV
		ii	LED strikes at 2.6 V/ only conducts above 2.6 V an electron must pass through a p.d. of 2.6 V to lose energy as a photon of blue light/AW.	M1 A1	
	c	i	n = I/e = $0.02/1.6 \times 10^{-19}$ = 1.3×10^{17}	C1 A1	**expect** 1.25×10^{17}
		ii	energy/s = $1.25 \times 10^{17} \times 4.1 \times 10^{-19}$ or 2.6 V x 0.020 A = 0.051 to 0.053 (J s^{-1})	C1 A1	**ecf (c)(i); NOT** 4.0 x 0.020 answer is 0.053 using 1.3×10^{17}
		iii	efficiency = $0.052/(4.0 \times 20 \times 10^{-3})$ = 0.64	C1 A1	**ecf (c)(ii)** **accept** $V_{strike}/V_{operate}$ = 2.6/4.0 or any other correct (P or W out)/ (P or W in) calculation **accept** 64 %
	d		shape similar to the curve drawn leaving x-axis at close to 2.0 V and passing through (3.4, 20)	B1 B1	Within half a square
			Total	15	