Question	Expected Answers	Marks
1		
(a)	10^{-3} to 10^{-1} (m) (Allow range: 0.0005 m to 0.15 m)	B1
(b)	Any <u>one</u> from: 1. Travels at the speed of light / 3×10^8 (ms^{-1} in vacuum) 2. Travel in vacuum (Allow 'free space' but not just 'space') 3. Transverse (wave) / can be polarised 4. Consists of oscillating electric and magnetic fields 5. Can be reflected / refracted / diffracted / shows interference 6. (Behave as) photon(s) 7. Warms food	B1
(c)	(e.m.f. =) $\frac{W}{Q}$ / (e.m.f. =) $\frac{78}{24}$	C1
	(e.m.f. =) $3.25 \approx 3.3$ (V)	A1
		[Total: 4]
2		
(a)	<u>Energy</u> (transformed by a device working) at 1 kW for 1 hour	B1
(b)	$E = Pt$ / $5.8 = 0.12 \times$ time / (time =) 48.3 (hr)	C1
	(time =) $1.74 \times 10^5 \approx 1.7 \times 10^5$ (s)	A1
		[Total: 3]

Question	Expected Answers	Marks
3		
(a)	Line crosses 'y-axis' at 1.4 (V) / $V = E$ or 1.4(V) when $I = 0$ $V = E - Ir$, since $I = 0$ (Hence $V = E$ or 1.4(V))	B1
(b)(i)	(Graph extrapolated to give) current = 2.0 (A) (Allow tolerance ± 0.1A)	B1
(b)(ii)	$E = I_{(max)} r$ $(r = \frac{1.4}{2.0})$ $r = 0.7(0)$ (Ω) gradient = r (Ignore sign) (Attempt made to find gradient) $r = 0.7(0)$ (Ω) (Possible ecf)	C1 A1
(b)(iii)	(excessive) heating of <u>cell</u> / energy wasted <u>internally</u> / cell might 'explode' / <u>cell</u> goes 'flat' (quickly)	B1 **[Total: 5]**

Question	Expected Answers	Marks
4		
(a)	Correct circuit for both lamps in parallel (ignore ammeter here)	B1
	Ammeter placed correctly in <u>series</u> with **P**	B1
(b)(i)		
	The resistance of LDR/circuit changes (as light intensity changes)	B1
	When blade blocks light, resistance of LDR/circuit is large(r) (ora)	B1
	Correct statement about p.d (Possible ecf)	B1
(b)(ii)1.		
	(V = 5.0 – 3.0) 2.0 (V) (Allow 1 sf answer)	B1
(b)(ii)2.		
	$V = \frac{R_2}{R_1 + R_2} \times V_0$ | I = 2.0/2200 / 9.1× 10^{-4} (A)	C1
	$(3.0 = \frac{R}{R + 2200} \times 5.0)$ | (R = 3.0 / 9.1× 10^{-4}) R = 3300 (Ω) | R = 3300 (Ω) Possible ecf	A1
	(For V_{LDR} = 2.0 V, R = 1.47 kΩ. This scores 1/2) (If 3.5 V given in **(b)(ii)1.**, then R = 940 Ω. This scores 2/2)	
		[Total: 8]

Question	Expected Answers	Marks
5		
(a)	(resistance =) p.d./current (Allow use of 'voltage') ((resistance =) ratio of p.d. to current 2/2) ((resistance =) voltage per (unit) current 2/2) ((*R* =) *V*/*I* scores 1/2) ((resistance =) voltage per (unit) ampere scores 1/2)	B2
(b)(i)	Parallel	B1
(b)(ii)1.	$\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}+\ldots$ / $\frac{1}{R}=\frac{3}{18}$	C1
	(*R* =) 6.0 (Ω) (Allow 1 sf answer)	A1
(b)(ii)2.	$P=\frac{V^2}{R}$ (Allow $P = VI$ or $P = I^2R$)	C1
	$(P=\frac{12^2}{6})$	A1
	P = 24 (W) (Possible ecf from **(b)(ii)1.**) (If 18 Ω used, *P* = 8 (W). Allow 1/2)	
(b)(ii)3.	$R=\frac{\rho L}{A}$ (Allow other subject)	C1
	$18=\frac{6.9\times10^{-6}\times0.85}{A}$	C1
	$A = 3.26 \times 10^{-7} \approx 3.3 \times 10^{-7}$ (m^2)	A1
	(3.3×10^{-5} (m^2) scores 2/3) (If *R* = 6.0 Ω then $A = 9.8 \times 10^{-7}$ (m^2). This scores 2/3)	**[Total: 10]**

Question	Expected Answers	Marks
6		
(a)	Arrow towards the cloud	B1
(b)	Into the page (No ecf from **(a)**)	B1
(c)(i)1.	$I = \frac{\Delta Q}{\Delta t}$ (Allow other subject, with or without Δ) (charge =) 7800×0.23 $1.794 \times 10^3 \approx 1.8 \times 10^3$ (C) (Ignore minus sign) (1.8×10^6 (C) scores 2/3)	C1 C1 A1
(c)(i)2.	(number =) $\frac{1.79 \times 10^3}{e}$ (Possible ecf) (number =) $1.12 \times 10^{22} \approx 1.1 \times 10^{22}$	C1 A1
(c)(ii)	$F = BIL$ (F =) $42 \times 10^{-6} \times 7800 \times 250$ (F =) $81.9 \approx 82$ (8.2×10^7 scores 2/3) newton / N / TAm / Jm^{-1}	C1 C1 A1 B1
		[Total: 11]

Question	Expected Answers	Marks
7 (a)	Any five from: 1. Photoelectric (effect) mentioned 2. Photon(s) mentioned in correct context / $E = hf$ 3. One-to-one 'interaction' between photon & electron 4. Surface electrons are involved 5. Electron released / photoelectric (effect) when photon energy > / = work function (energy) 6. Electrons emitted / photoelectric (effect) when frequency > / = threshold frequency 7. Energy is conserved (in the 'interaction' between photon and electron) 8. Reference to Einstein's equation: $hf = \phi + KE_{(max)}$	B1 × 5
	[QWC: Spelling and Grammar]	B1
(b)(i)1.	(energy of photon = 2.2 + 0.3) 2.5 (eV)	B1
(b)(i)2.	(energy =) $2.5 \times \frac{1.6 \times 10^{-19}}{}$ (Possible ecf from **(b)(i)1.**) 4.0×10^{-19} (J) (Allow 1 sf answer)	C1 A1
(b)(ii)	$(f =) \frac{4.0 \times 10^{-19}}{h}$ (Possible ecf) $(f = \frac{4.0 \times 10^{-19}}{6.63 \times 10^{-34}})$ $(f =) 6.03 \times 10^{14} \approx 6.0 \times 10^{14}$ (Hz) (Allow 6×10^{14})	C1 A1
(c)	Each photon has more energy / There are fewer photons (in a given time because intensity is the same) Smaller current	B1 B1
		[Total: 13]

Question	Expected Answers	Marks
8	Any <u>five</u> from: 1. Electrons travel / move as a wave 2. Electrons show diffraction / interference (effects) 3. Diffraction (is noticeable) when λ comparable to 'gap' size 4. Mention of de Broglie equation: $\lambda = \frac{h}{mv}$ 5. λ, h, m and v correctly identified in 4. above 6. Graphite / matter / atoms / nuclei / small gap(s) needed to diffract electrons 7. Experimental evidence: '(diffraction) rings' / 'fringes' (Can score on a diagram) [QWC: Organisation]	B1 × 5 B1 **[Total: 6]**