Question Number	Answer	Mark
1 (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) <u>Example of calculation</u> 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
1 (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)) <u>Example of calculation</u> power = 1.5×10^{-3} W m^{-2} × 3.9×10^{-4} m^2 = 5.85×10^{-7} W power = IV = 3.8×10^{-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**

Question Number	Answer	Mark
2(a)	The (maximum) length is (directly) proportional to the area **(1)**	**1**
2(b)(i)	Use of $\rho l/A = R$ **(1)** $R = 1.34$ (Ω) **(1)** <u>Example of calculation</u> $R = 1.68 \times 10^{-8}\ \Omega\ \text{m} \times 80\ \text{m} \div 1.0 \times 10^{-6}\ \text{m}^2$ $R = 1.34\ \Omega$	**2**
2(b)(ii)	Use of $P = I^2R$ **(1)** $P = 160$ W allow ecf from (i) **(1)** <u>Example of calculation</u> $P = (11\ \text{A})^2 \times 1.34\ \Omega$ $P = 162$ W (157 W if they use 1.3 Ω)	**2**
2(b)(iii)	Use of $V = IR$ **Or** use of $P = VI$ **Or** use of $P = V^2/R$ **(1)** $V = 15$ V allow ecf from (i) and/or (ii) **(1)** <u>Example of calculation</u> $V = 11\ \text{A} \times 1.34\ \Omega = 14.7$ V (14.3 V if 1.3 Ω is used)	**2**
2(c)	To prevent (use of a cable with) resistance that is too large (Accept answers that refer to maintaining or not exceeding a resistance of about 1.3 Ω) **(1)** Meaning more energy / power / p.d. available for the shredder **(1)**	**2**
	Total for Question	**9**

Question Number	Answer		Mark
3(a)	Use of $W = VIt$ W = 69 000 (J) Use of efficiency = (useful energy / total energy) (x 100%) Efficiency = 0.42 (or 42%) **Or** Use of $P = IV$ Use of $P = W/t$ (to calculate rate of increase of internal energy of water) Use of efficiency = (output power / input power) (x 100%) Efficiency = 0.42 (or 42%) <u>Example of calculation</u> W = 5.0 A × 230 V × 60 s = 69 000 J Efficiency = 29 000 J / 69 000 J = 0.42	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**4**
3(b)	Human body contains water molecules **Or** body has same structure as food So cells/tissues would gain internal energy (Accept cells/tissues would be heated)	 **(1)** **(1)**	**2**
3(c) (i)	Waves spread out After passing through a gap **Or** after passing around an obstacle	**(1)** **(1)**	**2**
3(c)(ii)	Use of $c = f\lambda$ with $c = 3.0 \times 10^8$ m s^{-1} λ = 0.12 m <u>Example of calculation</u> $\lambda = 3.0 \times 10^8$ m s^{-1} ÷ 2.5×10^9 Hz λ = 0.12 m	**(1)** **(1)**	**2**
3(c)(iii)	Diameter = 2mm	**(1)**	**1**
***3(c)(iv)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Diffraction greatest when wavelength is about the same as gap size Diameter of holes much greater than wavelength of light **and** diameter of holes less than microwave wavelength so no/little diffraction of light takes place **Or** so microwave radiation still diffracted through large angle but intensity is very small. MP3 must follow on from relevant part of MP2	 **(1)** **(1)** **(1)**	**3**
	Total for Question		**14**

Question Number	Answer	Mark
4	(high resistance) so very little /negligible/zero current in the voltmeter **Or** because otherwise a current would pass through the voltmeter **Or** so the total resistance of the parallel combination isn't changed **Or** because otherwise total resistance of parallel combination would be reduced **(1)** because that would change /increase the current in the ammeter **Or** because that would mean the current through the ammeter was different to (larger than) the current through the component **(1)** .	**2**
	Total for question	**2**

Question Number	Answer	Mark
5(a)(i)	Use of $P = IV$ **(1)** Power = 2900 W **(1)** <u>Example of calculation</u> Power = 12.5 A × 230 V = 2875 W	**2**
5(a)(ii)	$P = E/t$ **(1)** Energy = 400 000 J (ecf from (i)) **(1)** <u>Example of calculation</u> Energy = 2875 W × 140 s = 402 500 J	**2**
5(a)(iii)	Use of efficiency = useful energy output / total energy input **(1)** = 0.87 or 87% (ecf from (ii)) (do not award if > 100%) **(1)** <u>Example of calculation</u> Efficiency = 351 000 J / 402 500 J = 0.87 or 87%	**2**
5(b)	Some energy transferred by heating the kettle / element / wires / surroundings **Or** Some energy transferred as sound **(1)** So not all of the (input) energy is transferred to (heating) the water **Or** so useful energy output is less than energy input **Or** only the energy heating the water is useful **(1)**	**2**
	Total for question	**8**

Question Number	Answer	Mark
6(a)	Series sketch with two bulbs **(1)** Connected in series: because when one is removed there is a break in the circuit **Or** because when one is removed there is no current **Or** so the bulbs could have different p.d.s **(1)** Not connected in parallel because: if one removed, still complete circuit (for the other) **Or** if one removed, still current (through the other) **Or** full mains voltage would have blown small bulb **(1)**	**3**
6(b) (i)	Use of $P = IV$ **(1)** I = 0.17 (A) (at least 2 sf required) **(1)** <u>Example of calculation</u> 40 W = I × 230 V I = 0.17 A	**2**
6(b) (ii)	Use of appropriate equation **(1)** R = 1300 Ω **(1)** <u>Example of calculation</u> $P = V^2/R$ 40 W = $(230 \text{ V})^2 / R$ R = 1323 Ω	**2**
6(b) (iii)	Use of $R = V/I$ **(1)** R = 13 Ω **(1)** <u>Example of calculation</u> R = 2.5 V / 0.2 A R = 12.5 Ω	**2**
6(c)	Current – both require about the same (not just both have 0.2 A) **(1)** Potential difference – total (required) p.d. is very close to mains supply **Or** (operating) p.d. for mains bulb much greater than (operating) p.d. for torch bulb **(1)**	**2**

6(d)	Lower resistance **(1)** (smaller current, so) lower temperature (so less vibration of lattice ions) **Or** (smaller current, so) smaller drift velocity **(1)** fewer collisions of electrons with lattice ions **Or** less frequent collisions of electrons with lattice ions **(1)** Less energy dissipation (as heat) **Or** less ke lost in collisions **(1)**	**4**
	Total for question	**15**

Question Number	Answer	Mark
7(a)	Use of $P = VI$ **(1)** Current = 0.021 A **(1)** <u>Example of calculation</u> $I = \frac{P}{V} = \frac{4.8}{230} = 0.021$ A	**2**
7(b)(i)	Use of $P = VI$ to justify (numbers or symbols) **(1)** <u>Examples</u> $P = VI$, so W = V A **Or** V = JC^{-1}, A = C s^{-1} so V A = J C^{-1} x C s^{-1} = J s^{-1} = W **Or** 5 V × 0.1 A = 0.5 W	**1**
7(b)(ii)	Efficiency = $\frac{0.5}{4.8}$ (× 100) **(1)** Efficiency = 10% or 0.1 **(1)** <u>Example of calculation</u> Efficiency = $\frac{0.5}{4.8} \times 100$ Efficiency = 10.42 %	**2**
7(b)(iii)	Energy/power converted/wasted/transferred/lost to thermal or heat (energy) **Or** Energy/power lost due to resistance **(1)** (allow internal resistance)	**1**
	Total for question	**6**