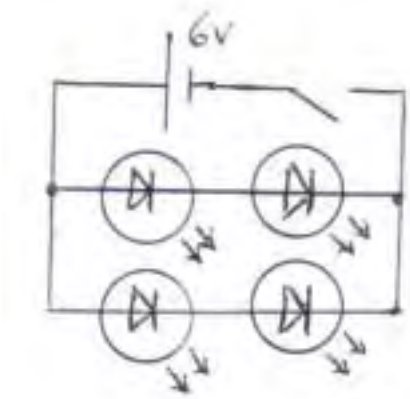
Question			Answer	Marks	Guidance
1	(a)		Work done/energy <u>transfer</u>(red) per unit time	B1	**accept** per second **or** rate of energy transfer / rate of doing work **or** energy transfer / time taken
	(b)	(i)	using P = VI I = 40/230 = 0.17(4) (A)	C1 A1	 accept 4/23
	(b)	(ii)	R = 230/0.17 = 1400 (Ω)	B1	**possible ecf b(i);** expect and **accept** 1322 or 1353 Ω **accept** 40 = 230^2/R giving R = 52900/40 = 1322 Ω
	(c)		l = RA/ρ l = 1.3 x 10^3 x 3.0 x 10^{-8} /7.0 x 10^{-5} l = 0.56 (m)	C1 C1 A1	Choosing R = ρl/A substitution; **ecf b(ii)** evaluation; **allow** 0.57 m (using R = 1322 Ω) and 0.58 m (using 1353 Ω) and 0.6 m (using 1400 Ω)
A A A	(d)		larger power needs larger I so smaller R (for same V) smaller R (but same length) so larger A / thicker	B1 B1 B1	**accept** P = V^2/R **or** calculation I = 0.26 A giving R **=** 880 or 890 Ω NB if R calculated correctly here, give first 2 marks hence smaller R (but same length) so larger A / thicker
	(e)	(i)	Q = It = 0.17 x 8 x 60 x 60 Q = 4900 (C)	C1 A1	**ecf b(i)** **allow** 4896; or 5000 or 5011 if using I = 0.174 A give 1 mark for 1.36 or 81.6
		(ii)1	(a unit of) <u>energy</u> equal to 3.6 MJ **or** 1 kW for 1 h/AW	B1	**eg** 1000 W for 3600 s or similar
		(ii)2	40 x 8 = 320 Wh / 0.32 kWh 0.32 x 22 = 7.0(4) p	C1 A1	 **accept** 7 p (no SF error); allow 7000p (7040) for 1 mark
			Total	15	

Question			Answer	Marks	Guidance
2	(a)	(i)1	infinity	B1	accept symbol
	(a)	(i)2	R = 1.8/10 x 10^{-3} R =180 Ω	C1 A1	0.18 Ω scores 1 mark
A A A	(a)	(ii)	resistance decreases because I increases more than V therefore since R = V/I value decreases/AW	B1 B1 B1	**accept** calculation at second value, e.g. at 2.0 R = 53 Ω, with comparison **OR** at two other values **QWC mark** for second marking point
A A A	(b)		correct symbol and direction for LED R in series with LED across XY ammeter in series voltmeter in parallel with LED only	B1 B1 B1 B1	circle not essential, internal line optional no variable resistor
	(c)		torch; car brake/rear light/ traffic light, etc. torch: draws a lower current / light lasts longer before battery discharged/AW **or** LEDs (much) more efficient (at converting electrical energy into light)/AW **or** if one LED fails remainder still lit/AW	M1 A1	suitable example **accept** any **one** sensible statement, include longer life, more durable contradictory statements score zero
			Total	12	

Question			Expected Answers	M	Additional Guidance
3					
	a	i	read off value of current (at V = 6.0 V) calculate R using V/I	B1 B1	any reference to using gradient scores 0/2 **accept** I = 0.25 (A) or 250 (mA) **accept** R = 24 Ω
		ii	V is not proportional to I	B1	**accept** not a straight line; R is not constant
	b	i ii iii	Q = It = 0.25 x 1 = 0.25 C E = VIt or QV = 6 x 0.25 = 1.5 J E = VIt = 1.5 x 4 x 60 x 60 = 2.16 x10^4 J	B1 B1 C1 A1	 **ecf(b)(i)** **ecf b(ii)** **accept** 2.2 x 10^4 J; **allow** 360 J for 1 mark only
	c	i ii iii	energy transfer per unit charge from electrical to other forms 30 mA Use of P = VI suitable method (may be expressed purely in numerical form) = 0.36 W	B1 B1 A1 M1 A1 A0	**or** energy transfer/charge; work done /charge **or** across LED 3 x 0.030 = 0.090 W per LED so 0.090 x 4 **or** 30 mA in two branches at 6 V **or** total current is 60 mA from 6 V battery
		iv		B1 B1 B1	symbol for LED correct orientation of LED correct circuit
	d		draws a lower current/ light lasts longer (before battery discharged/)AW **or** LEDs more efficient (at converting electrical energy into light) **or** if one LED fails there are still two lit **or** more robust/longer working life	B1	**allow** lower power consumption/AW
			Total question 1	**16**	