Question			Expected Answers	Marks	Additional Guidance
1					
	a	**i**	no current/no light/does not conduct until V is greater than 1.5 V brightness/intensity of LED increases with current/voltage above 1.5 V above 1.8 V current rises almost linearly with increase in p.d./AW the LED does not obey Ohm's law as I is not proportional to V/AW below 1.5 V, LED acts as an infinite R/ very high R/acts as open switch above 1.5 V, LED resistance decreases (with increasing current/voltage)	B1 B1 B1 M1 A1 B1 B1	**allow** 1.4 to 1.6 V (QWC mark) (alternative QWC mark) **max 5 marks** which must include at least one of the first 2 marking points
		ii 1 **2**	infinite resistance I = 23.0 ± 1.0 (mA) R = 1.9 x 10^3/(23 ± 1) = 83 ± 4 Ω	B1 C1 A1	 **apply** POT error for 0.083 Ω
	b		LED symbol with correct orientation resistor (need not be labelled) and ammeter in series with it voltmeter in parallel across LED only	B1 B1 B1	diode symbol + circle + at least one arrow pointing away
	c		the resistor limits the <u>current</u> in the circuit (when the LED conducts) otherwise it could overheat/burn out/be damaged/AW	B1 B1	
	d		in fig 4.3 the <u>voltage</u> range is from zero to maximum possible in fig. 4.2 the resistance variation is small/AW (so) in fig. 4.2 voltage variation across LED is small	B1 B1 B1	**allow** 6.0 V **accept** the LED is part of a potential divider **accept** only at the top end of the range/AW
			Total question 4	**16**	

Question			Answer	Marks	Guidance
2	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	

Question			Answer	Marks	Guidance
3	(a)	(i)	sum of/total current into a junction equals the sum of/total current out conservation of charge	B1 B1	total vector sum of currents is zero **allow** 'point in a circuit' for 'junction'
		(ii)	(sum of) e.m.f.s = sum /total of p.d.s/sum of voltages in/around a (closed) loop (in a circuit) energy is conserved	B1 B1	**allow** 'in a (closed) circuit' in place of 'loop'
	(b)	(	current in 750 Ω = 0.020 A	A1	**allow** 20 mA **or** 0.02 A
		(ii)	V across 750 Ω = 0.02 x 750 = 15 V	A1	**ecf b(i)**
		(iii)	R_1 = (45 – 15)/0.03 = 1000 Ω R_2 = 15/0.01 = 1500 Ω	A1 A1	**ecf b(ii)**
	(c)	(	correct symbol connected in circuit	B1	2 arrows pointing towards the resistor at about 45^0 with or without a circle; arrows outside circle if drawn
A A A		(ii)	total R falls so I in circuit/in R_1 increases so V across R_1 increases and V across 750 Ω falls	B1 M1 A1	**accept** sum of R's in parallel falls R_1 is fixed so V across R_1 increases so V across R's in parallel falls (so V across 750 Ω falls) **or** correct potential divider argument
		(iii)	in series with LDR ammeter (A) 50 mA in parallel with LDR voltmeter (V) 20 V	M1 A1 B1	**allow** voltmeter in parallel with R_1 (30 – 50 V) **allow** multimeter connected as A (series) or V (parallel) and a correct unit for range given **allow** 20 to 100 mA; or 15 to 50 V
			Total	**15**	