1)

Question			Expected Answers	Marks	Additional Guidance
	a		resistors in series add to 20 Ω and current is 0.60 A so p.d. across XY is 0.60 x 12 (= 7.2 V)	B1 B1	**accept** potential divider stated **or** formula gives (12 /20) x 12 V (= 7.2)V
	b	i	the resistance of the LDR decreases (so total resistance in circuit decreases) and current increases	M1 A1	
		ii	resistance of LDR and 12 Ω (in parallel)/across **XY** decreases so has smaller share of supply p.d. (and p.d. across XY falls)	B1 B1	**alternative** I increases so p.d. across 8.0 Ω increases; so p.d. across **XY** falls
			Total question 3	**6**	

2)

(a)	**(i)**	I = V/R = 8.0/200 I = 0.040 (A)	C1 A1	
	(ii)	V = 24 – 8 = 16 (V)	B1	
	(iii)	R = 16/0.04 giving R = 400 (Ω)	C1 A1	**accept** ratio of p.d.s to ratio of Rs **ecf** from **(i)** & **(ii)** ie **(a)(ii)/(a)(i)**
	(iv)	$P = VI = I^2R = V^2/R$ P = 0.640 (W)	C1 A1	**ecf** from **(i)** & **(ii)** **accept** 640 mW
(b)	**(i)**	the thermistor has heated up/ its temperature has increased so its resistance has dropped so the ratio of the voltages across the potential divider changes/AW	B1 M1 A1	 **accept** so the current increases **accept** so IR of fixed resistor increases
	(ii)	voltages are equal so resistances are equal	B1	
(c)	**(ii)**	straight line through origin labelled R passing through 0.06,12	B1 B1	**allow** correct lines with no labels
	(ii)	upward curve below straight line through origin labelled T passing through 0.06,12	B1 B1	
		Total question 3	**15**	

3)

a		resistance decreases with increase in light intensity	B1	**ora**
b	**i**	3.0 (V)	B1	**accept** 3 V, no SF error
	ii	$3.0 = I.1.2 \times 10^3$ giving $I = 2.5 \times 10^{-3}$ A $6.0 / 2.5\ 10^{-3} = R = 2400\ \Omega$ 2.4 kΩ	C1 C1 A1	**accept** 6 = (R/ R + 1.2 k).9 2R + 2.4 k = 3R or similar R = 2.4 k ;**give** 2 with POT error **accept** ratio of resistors 6/3 x 1.2 good candidates can do this by inspection with no working – full marks **allow** 2400 written on answer line rather than 2.4 if 2400 Ω within body of text
	iii	49 **or** 50 ($W\ m^{-2}$)	B1	**ecf (b)(ii)** if on R within graph range
c	**i**	2.2 (kΩ)	B1	**allow** any value from 2.1 to 2.2
	ii	large(r) changes in R at low light intensities relating change in R to change in V	B1 B1	**allow** greater sensitivity of LDR at low light **or** steeper gradient/AW **e.g.** bigger change in I so in V **or** use of $V = R/(R + 1200)\ V_s$ **or** bigger change in V ratio across Rs
d		V across 1.2 kΩ falls so V across LDR rises because ratio of Rs changes in favour of LDR/ potential divider argument **or** total V is constant	B1 B1 B1	**alternative** I increases because total R is less so V across LDR rises do **not** award B marks where there is CON e.g. V across 1.2 k rises so V across LDR rises
e		continuous record for very long time scale of observation can record very short time scale signals (at intervals) automatic recording/remote sensing data can be fed directly to computer (for analysis)	B1 B1	**allow** any two sensible suggestions which fall within the 4 categories listed for 2 marks
		Total question 4	**14**	

4)

(a)		R of thermistor decreases as temperature increases supply V is constant/ total R is smaller current increases as V = IR/AW	**B1** **B1** **B1**	**accept** more free e's as temperature rises using I = nAev current increases as v decrease very small/AW
(b)		R_{th} = 40 Ω at 240 °C (stated or used in calculation) total R in circuit = 240 Ω I = 6/240 = 0.025 A V = 200 x 0.025 = 5.0 V	**B1** **C1** **C1** **A1**	**apply ecf** if wrong value of R read from graph **allow** V = (200/240)6 so V = 5.0 V **accept** 5 V (no SF error)
(c)	**(i)**	correct symbol for LDR	**B1**	no circle required
	(ii)	R of LDR decreases/current in circuit increases so V increases across fixed/200 Ω resistor/AW	**M1** **A1**	 **accept** simple potential divider argument **accept** voltmeter reading increases
		Total	**10**	

5)

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
17	(a)		p.d. across resistor = 1.50 – 0.62 = 0.88 (V) current = 0.88/120 = 7.33... $\times 10^{-3}$ (A) power = VI = 1.50 $\times$ 7.33 $\times 10^{-3}$ = 1.1 $\times 10^{-2}$ (W)	**C1** **C1** **A1**	
	(b)		The voltmeter has large or infinite resistance. Hence the p.d across the lamp or current in the lamp is small or zero (and the lamp is not lit). Refining design: remove voltmeter from the circuit or place the voltmeter across the lamp.	**B1** **B1** **B1**	
	(c)*		**Level 3 (5–6 marks)** Explanation is complete with E1, 2 and 3 For calculation expect C3 At least two limitations mentioned. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Expect two points from E1, 2 and 3 Expect either C1 or C2 for the calculations Expect at least one limitation Limitation identified but calculations are inappropriate. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)**	**B1** **×6**	**Explanation (E)** 1. Total resistance decreases as temperature increases (allow reverse argument) 2. Current in circuit increases as temperature increases or p.d. is in the ratio of the resistance values 3. Therefore, the p.d. across resistor increases or p.d. across thermistor decreases. **Calculations (C)** 1. $I = V/R$ used to show current increases as temperature increases 2. Potential divider equation (or $I = V/R$ and $R = R_1 + R_2$) used to calculate the voltmeter reading at either 200°C or 300°C • V_{300} = 6.0 $\times$ 25/(25+500) = 0.29 V • V_{200} = 6.0 $\times$ 60/(60+500) = 0.64 V) 3. Potential divider equation used to calculate the voltmeter reading at **both** 200°C and 300°C

Question			Answer	Marks	Guidance
			Expect at least one point from explanation Expect C1 and an attempt at C2 Limitations given are inappropriate. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.		**Limitation (L)** 1. The change in resistance is small when resistance of thermistor changes from 200 °C to 300 °C 2. Change in voltmeter reading is too small over this range 3. Non-linear change of resistance with temperature.
			Total	**12**	