Question			Answer	Marks	Guidance
1 **A** **A** **A**	**(a)**		R <u>of thermistor</u> decreases as temperature increases supply V is constant/ <u>total</u> R is smaller current increases <u>as V = IR</u>/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 ^{o}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 <u>of LDR</u> decreases/current in circuit increases so V increases <u>across fixed</u>/<u>200 Ω resistor</u>/AW	**M1** **A1**	 **accept** simple potential divider argument **accept** voltmeter reading increases
			Total	**10**	

Question			Answer	Marks	Guidance
2	(a)		R's in parallel have same V/AW so 4.0 x 0.30 = 6.0 x 0.20	**M1** **A1**	**allow** I splits in inverse ratio to R **or** AW; hence I in 6 ohm = 4 / 6 x 0.3 = 0.2 A
	(b)	(i)	sum of/total current into a junction equals the sum of/total current out **or** total algebraic sum of currents is zero	**B1**	**allow** Kirchhoff's first law
		(ii)	0.50 (A)	**A1**	**accept** 0.5 (A) (no SF error)
	(c)		correct formula for R_p and substitution R_p = 2.4 Ω R_s = 8.0 (Ω)	**C1** **C1** **A1**	 **apply ecf** to R_p for second mark **accept** 8 (Ω) (no SF error)
	(d)	(i)	energy transferred from source/changed from some form to electrical energy; per unit charge (to drive charge round a complete circuit)	**M1** **A1**	**allow** form as e.g. light/chemical/heat **allow** energy divided by charge
		(ii)	V = IR = 0.50 x 8.0 =4.0 (V)	**A1**	**ecf b(ii),c** i.e. answer = b(ii) x c **accept** 4 (V) (no SF error)
		(iii)	E – V = Ir giving 5.0 – 4.0 = 0.50 r r = 2.0 (Ω)	**C1** **A1**	**ecf b(ii)** **accept** 2 (Ω) (no SF error); give max of 1 mark for r = 3.3 Ω , i.e. using I = 0.3 A
			Total	**12**	

Question			Expected Answers	M	Additional Guidance
3					
	a	**i**	correct symbols (variable) R in series with ammeter and cell voltmeter correctly in parallel with variable R	B1 B1 B1	variable R and voltmeter needed **ecf** variable resistor symbol **accept** voltmeter in parallel with cell
		ii1	V decreases as I increases caused by R decreasing V is large when R is large **or** V is small when R is small V = e.m.f. when R is infinite/open circuit **or** V = 0 when R = 0 3.14 Ω at A; 0.88 Ω at B and 0.19 Ω at C any correct reference to internal resistance of cell	B1 B1 B1	**max 3 marks** with 2 marks for first two or second two marking points or three numbers and 1 mark for reference to r **allow** as R increases (decreases) V increases (decreases) for 1 mark but **not** as V increases R increases; **award 0/2** if reason given as V α R or I is constant
		ii2	at A I is small or V is much bigger than I/AW at C V is small or I is much bigger than V/AW product of V. and I is largest when the values of both quantities are about equal/half of the maximum value	B1 B1 B1	**accept** numerical answers, e.g. 0.39 W at A, 0.33 W at C 0.56 W at B for 2 marks comment on values for third mark
		ii3	1.4 (V)	B1	
		ii4	appreciating V against I is a straight line graph with gradient –r; giving r = 0.88 ± 0.02 Ω	C1 A1	**accept** using V = E – Ir **not** just quoting formula **allow** 0.8 ± 0.02 for calculation using any point on line N.B. can also have **ecf(ii)3**
	b	**i**	intensity is the (incident) energy <u>per</u> unit area <u>per</u> second	B1	**accept** power per unit area or power per m^2 or (total) power/(surface) area
		ii	efficiency = power out/power in = 0.25/(800 x 2.5 x 10^{-3}) = 0.125 or 12.5%	C1 C1 A1	**not** energy out/energy in **accept** 13%
			Total question 3	**16**	

Question			Expected Answers	M	Additional Guidance
4					
	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 $6.0 / 2.5\ 10^{-3} = R = 2400\ \Omega \quad 2.4\ k\Omega$	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**	