1)

(a)	(i)1	360 (Ω)	B1	
	(i)2	Current	B1	**not** symbol only; **not** unit only
	(ii)1	1/10 + 1/20 + 1/40 = 1/R R = 5.7 (Ω)	C1 A1	1/R = 0.175 **accept** 40/7
	(ii)2	potential difference	B1	**accept** p.d. or voltage **not** e.m.f.; **not** symbol only; **not** unit only
(b)	(i)	**p.d./voltage must be proportional to current** as long as temperature and/or (other) physical conditions remain constant **R** line is straight and through the origin	**M1** A1 B1	symbols may be used but must be defined
	(ii)1	(same current so) at 0.6 A have 4.5 V + 4.5 V (=9.0 V)	B1 B1	**accept** resistors in series (so V's add); i.e recognise that at 0.6 A each component has 4.5 V across it.
	(ii)2	add currents so at 3.0 V have 0.2 A + 0.4 A = 0.6 A	B1 B1	**accept** attempt to add currents for 1 mark (i.e. method mark)
	(iii)	thermistor heats up/temperature increases resistance (of thermistor/circuit) decreases (so current rises) temperature/resistance becomes constant (after 2 s) because thermal equilibrium reached	B1 B1 B1 B1	**max** 3 marks **accept** thermal energy frees more charge carriers/AW **accept** energy/power/heat in/generated = energy/power/heat out/lost
		Total	**15**	

2)

Question			Expected Answers	M	Additional Guidance
	a	**i**	V J C^{-1} R V A^{-1} P J s^{-1} I C s^{-1}.	B1 B1 B1	4 correct 3 marks; 2 correct 2 marks 1 correct 1 mark
	b	**i**	using $V_{out} = R_2/(R_1 + R_2)\ V_{in}$: **alt:** 2.4 = I x 560 V_{out} = 3.6 V so I = 4.3 mA 3.6 = $R_2/(560 + R_2)$ 6 3.6 = I R_2 R_2 = 840 (Ω)	C1 C1 A1	 **accept** R_2 = (3.6/2.4) x 560 or .2.4 = 560/(560 + R_2) 6
		ii	I = 4.3 x 10^{-3} (A)	B1	**accept** 4.3 m(A) or 3/700 (A) **ecf (b)(i)** i.e. I = 6/(560 + R_2)
	c	**i**	20 ± 2 (°C)	B1	
		ii	R_{Th} will fall/ resistance will fall giving greater share of supply V across fixed R/AW causing the voltage across (fixed) R/voltmeter reading to rise	B1 B1 B1	 **accept** explanation in terms of potential divider equation **or** current increases **or** current same in both resistors/resistors in series
		iii	ΔR is large for small ΔT at low temperatures/AW in terms of gradient so thermistor is better in circuit to control low temp, refrigerator	M2 A1	**accept** sensitivity greater at low temperature **or** vice versa **or** ΔR is small for small ΔT at high temperatures scores 1 out of 2
			Total question 3	**14**	

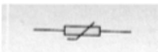
3)

(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)

4)

(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)	**(i)**	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)	**(i)**	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
	(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 — in parallel with LDR ammeter (A) — voltmeter (V) 50 mA — 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**	

5)

a		 for R_1  for R_2	B1 B1	
b	**i**	500 Ω	B1	**accept** ± 20 Ω
	ii	7.0 = I x 500; I 0.014 (A)	B1	**ecf b(i)**
	iii	5.0 = 0.014 x R or 12 = 0.014(500 + R) R = 360 Ω	M1 A1	**ecf b(i)(ii)** **allow** R = 500 x 5/7 = 360 Ω
	iv	(at 200°C) R_{th} = 250 Ω V across thermistor =12 x 250/(250 + 350) = 5.0 V **alt** 5.0 = 12 x R/(R + 350) **or** I = 7.0/350 = 0.02 A; V_{th} = 5.0 = 0.02 x R R = 250 Ω which occurs at 200°C	B1 B1	**allow** R_{th} = 250 ± 10 giving 4.8 to 5.1 V **expect** 350 or 360; **allow** 1 SF where answer is 5.0 **NOT** 250 x 0.02 = 5.0 V; 0.02 A must be justified **allow** 7.0 = 12 x 350/(350 + R)
c		**switch on** 5.0 = 12 x 250/(250 + R) or 7.0 = 12 x R/(250 + R) giving R = 350 Ω which is 190°C **switch off** 7.0 = 12 x 250/(250 + R) or 5.0 = 12 x R/(250 + R) giving R = 180 Ω which is 210°C **or** Switch on, R2 / R1 = 7/5 giving R2 - 250 x 7/5 = 350 ohm Switch off, R2 / R1 = 5/7 giving R2 = 250 x 5/7 = 179 ohm	M1 A1 M1 A1	**accept** solution in 2 stages first calculating currents on I = 0.02 and R = 7/0.02 off I = 0.028 and R = 5/0.028 **allow** ± 5°C in reading from graph **N.B.** zero marks for correct temperatures quoted without some correct working/justification
		Total question 2	**12**	

6)

a		energy per unit area per unit time	B1	**accept** power per unit area; **allow** second for unit time
b		Small changes in R for high light intensities/daylight conditions Large changes in R for low light intensities/dim light/night time conditions to change circuit state need a significant change in R to be useful/reliable	B1 B1 B1	**accept** low R by day, high R by night for 1 mark **NOT** comparison e.g. R by day smaller than R at night **max 2 marks** from 3 marking points
c	**i**	2.5 (kΩ)	A1	**allow** 2.4 to 2.6
	ii	5.0 = I x 2.5 kΩ giving I = 2.0×10^{-3} A	C1 A1	**ecf (c)(i)** **accept** 2.0 mA
	iii	4.0 = 2.0×10^{-3} x R **or** potential divider argument giving R = 2.0×10^{3} Ω	M1 A0	**ecf (c)(ii) or ecf (c)(i)** **accept** 2.0 kΩ
d		R (of LDR) = 1(.0 kΩ) potential divider of 1.0 kΩ and 2.0 kΩ giving 3.0 V across LDR	B1 C1 A1	 **accept** I = 3.0 (mA) so V = 3.0 (mA) x 1.0 (kΩ) = 3.0 V
e		light shining on the LDR will cause it to switch the illumination off causing an ON/OFF oscillation/AW	B1 B1	two suitable qualifying statements for the 2 marks
		Total question 3	**12**	

7)

Question			Expected Answers	M	Additional Guidance
	a	**i**	V J C^{-1} R V A^{-1} P J s^{-1} I C s^{-1}.	B1 B1 B1	4 correct 3 marks; 2 correct 2 marks 1 correct 1 mark
	b	**i**	using $V_{out} = R_2/(R_1 + R_2)\ V_{in}$: **alt:** 2.4 = I x 560 V_{out} = 3.6 V so I = 4.3 mA 3.6 = $R_2/(560 + R_2)$ 6 3.6 = I R_2 R_2 = 840 (Ω)	C1 C1 A1	 **accept** R_2 = (3.6/2.4) x 560 or .2.4 = 560/(560 + R_2) 6
		ii	I = 4.3 x 10^{-3} (A)	B1	**accept** 4.3 m(A) or 3/700 (A) **ecf (b)(i)** i.e. I = 6/(560 + R_2)
	c	**i**	20 ± 2 (°C)	B1	
		ii	R_{Th} will fall/ resistance will fall giving greater share of supply V across fixed R/AW causing the voltage across (fixed) R/voltmeter reading to rise	B1 B1 B1	 **accept** explanation in terms of potential divider equation **or** current increases **or** current same in both resistors/resistors in series
		iii	ΔR is large for small ΔT at low temperatures/AW in terms of gradient so thermistor is better in circuit to control low temp, refrigerator	M2 A1	**accept** sensitivity greater at low temperature **or** vice versa **or** ΔR is small for small ΔT at high temperatures scores 1 out of 2
			Total question 3	**14**	