Question			Expected Answers	Marks	Additional Guidance
1	(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**	

Question			Answer	Marks	Guidance
2	(a)	(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** chemical
		(ii)	(some) energy is transferred into thermal energy /lost as heat in (driving charge through) the battery. It behaves as if it has an (internal) resistance/AW **or** there is a voltage drop across/decrease in voltage from the battery when a current is drawn from it/AW	B1	**allow** any description which uses E = V + Ir with symbols defined but **not** just the formula alone **or** e.g. statement about 'lost volts'/current
	(b)	(	correct substitution into resistors in parallel formula R = 90 Ω	C1 A1	1/R = 1/90 or 0.011 correct answer
		(ii)	using $V_{out} = R_2/(R_1 + R_2)\ V_{in}$: **alt:** 16 = I x 120 V_{out} = 90/(30 + 90) 16 so I = 0.133 A V_{out} = 12 V V_{out} = 0.13 x 90 = 12 V	C1 C1 A1	**ecf (b)(i)** **accept** V_{out} = (90/120) x 16 = 12 V for full marks **N.B.** beware of false ratios, e.g. 360/(120 + 360) giving correct answer; give first marking point only
A A A		(iii)	resistance (of thermistor) decreases (with temperature increase) current <u>in circuit</u> increases **or** as <u>total</u> resistance is less so current in thermistor increases voltage ratio between 30 Ω and combination changes so voltage across thermistor falls	B1 M1 A1 M1 A1	**max** 4 marks QWC mark is either of the M marks
	(c)	(	Q = It = 1.2 x 8 x 60 x 60 Q = 34560 (C) correct unit,	C1 A1 B1	**accept** 3.5 or 3.46 x 10^4 **allow** 1 mark for answer of 9.6 or 576 **allow** C, kC, A s; **N.B.** 9.6 A h or 576 A min score 3/3
		(ii)	energy = 34560 x 16 = 552960 J **or** I = 1.4/16 = 00875 A time = 552960/1.4 = 394970 s **then** t = 34560/I time = 394970/3600 = (109.7 h) = 110 h	C1 C1 A1	**ecf (c)(i)** **allow** full marks for 1.2 x 8 x 16/1.4 = 110 h **allow** 111 h when using 3.5 x 10^4 C
			Total	**18**	

			Answer	Marks	Guidance
3	(a)		360 (Ω)	B1	
		(i)2	Curr	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)	(	**p.d./voltage must be proportional to curre** as long as temperature and/or (other) physical conditions remain constant **R** line is straight and <u>through the origin</u>	**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**	