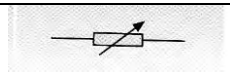
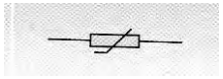
Question			Answer	M	Guidance
1					
	a		 for R_1  for R_2	B1 B1	
	b	i	500 Ω	B1	**accept** ± 20 Ω
		ii	7.0 = I x 500; I 0.014 (A)	B1	**ecf b(i)**
		iii	5.0 = 0.014 x R or 12 = 0.014(500 + R) R = 360 Ω	M1 A1	**ecf b(i)(ii)** **allow** R = 500 x 5/7 = 360 Ω
		iv	(at 200°C) R_{th} = 250 Ω V across thermistor =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**	

Question			Answer	M	Guidance
2					
	a	**i**	Q = It= 0.45 x 4.67 x 60 x 60 = 7600 C or As	C1 A1 B1	 **accept** 7560 or 7570
		ii **1,2**	**1** positive; **2** clockwise energy must be transferred to the cell **or** current in opposite direction transfers energy from the cell to the circuit/AW	M1 A1	positive plus correct direction of arrow for first mark; do not penalise if arrow not labelled I. **allow** (conventional) current is from positive to negative ; **or** electron flow from – to + [but current must be clockwise in **1**]
		3	V_{XY} = 1.5 + 0.45 x 0.90 V_{XY} = 1.9 (V)	C1 A1	 **accept** 1.905 or 1.91
		4	P = VI = 0.45 x 1.5 P = 0.675 (J s^{-1})	C1 A1	**allow** QV/t with **ecf a(i)** if necessary (11340/16800) **allow** 0.7 as final line if 0.675 appears above
	b		**1.**cell across variable resistor R ammeter in series and voltmeter in parallel across R or cell **2.**Take (set of) readings of V and I for different positions/values of the variable resistor **3.**plot a graph of V against I **4.**(find) y-intercept = E **5.**(find) the gradient of the V against I graph which equals the internal resistance in magnitude **or 4 or 5** take one pair of values of V,I and substitute into equation E = V + Ir to find r or E	B1 B1 B1 B1 B1	QWC last marking point needed for full marks **allow** use (digital) voltmeter across unloaded cell to find E; add R and find one value of V and I; then use equation to find r (points 2 to 5) **ignore** sign of gradient in determining r **allow** for no graph plot, using 2 pairs of values of V and I substituted into equation allows r and E to be found.(points 2 to 5)
	c	**i**	4 x 1.5 V cells gives 6.0 V with r of 3.6 Ω so current is 6.0/(3.6 + 18) = 0.28 A requires (2 W/6 V =) 0.33 A to light normally or power delivered = (0.28^2 x 18 or 5.0 x 0.28)= 1.4 W **alt**: use 0.33 A & 6 V to show need emf of 7.2 V (1.8 V per cell)	B1 B1 B1	**allow** AW such as: 6 V but total R now 21.6 Ω; 6 V across 21.6 Ω gives 5 V across 18 Ω; requires 6 V to light normally **allow** P = 1.(6)7 W for 2 marks; only give the third mark if P labelled as power delivered by cell
		ii	1.5 n = 0.33 (18 + 0.9 n) **or** 1.5n = 6 + 0.3n so 3.6 n = 18 **or** 1.2n = 6 giving n = 5	M1 A1	**alt:** lamp needs V = 6V and I = 0.33 A terminal p.d per cell is 1.5 = V + 0.9 x 0.33 giving V = 1.2 V so n = 6/1.2 = 5 **allow** trial and error method but working must be shown to score any marks
			Total question 3	**19**	

Question			Answer	Marks	Guidance
3	a		emf – J C^{-1}, resistance – V A^{-1}, energy – V C, charge – A s	B1 B1	4 correct 2 marks; 2 correct 1 mark
	b	i	energy per unit charge transferred from electrical to other forms	B1 B1	**NOT** coulomb **allow** any other form e.g. heat, light, etc
		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 but not just the formula alone, e.g. 'lost volts' per unit current is just accepable
		iii	p.d. across each branch is the same/branches in parallel resistance in X branch is 6 Ω, in YZ branch is 12 Ω so current in X branch is twice that in YZ branch/ as V = IR	B1 B1 A0	**allow** R in X branch is half that in YZ branch/AW
		iv	V = IR = 0.08 x 6 V = 0.48 (V)	C1 A1	
		v	the p.d. across each 3 Ω resistor is terminal p.d./2 **or** 0.48 V at Z there is 6 Ω either way to the supply/AW so p.d. across each 6 Ω is terminal p.d./2 so p.d. between X and Z is zero	B1 B1 A0	p.d./voltage across 3 Ω and 6 Ω are equal with justification
		vi	terminal p.d. = 0.96 V current in r = 0.16 + 0.08 = 0.24 A use of E = V + Ir 1.2 = 0.96 + 0.24 r giving r = 1.0 (Ω)	C1 C1 C1 A1	**or** V = 0.24 x 4 **or** = 0.08 x 12 **or** 0.16 x 6 **or (iv)** x 2 **alt**: R in parallel gives 4.0 Ω; total R = 1.2/0.24 = 5.0 Ω r = 5.0 - 4.0 = 1.0 (Ω) **allow** 1SF
			Total	15	