Question			Answer	Marks	Guidance
1	(a)		resistivity = resistance x area (of cross-section)/length	B1	**accept** equation with *resistance* as subject **allow** *over* for divide by; do **NOT** allow formula with a word for each symbol
	(b)	(	$R = \rho l/A = 1.7 \times 10^{-8} / 6.4 \times 10^{-3}$ $= 2.7 \times 10^{-6}$ (Ω)	C1 A1	**accept** 2.66×10^{-6} (Ω)
		(ii)	$P = I^2R$ $= 8000^2 \times 2.7 \times 10^{-6}$ = 170 W	C1 C1 A1	select formula**;** can use P = VI & V = IR **ecf b(i)** 173 (2.7), 170 (2.66)
		(iii)	170 x 9.0 = 1530 W **or** 170 x 24 = 4080 W 1.5 x 24 = 36 (kW h) 4.08 x 9 = 36.7 (kWh)	B1 B1	**ecf b(ii)**; 1 mark for X 9 **or** 1 mark for X 24
		(iv)	36 x 15 = 540 p	B1	**ecf b(iii)** 551(36.7), 555 (37)
	(c)		I = nAev $8000 = 8.4 \times 10^{28} \times 6.4 \times 10^{-3} \times 1.6 \times 10^{-19}$ v $v = 9.3 \times 10^{-5}$ (m s^{-1})	C1 C1 A1	select formula correct substitution
			Total	**12**	

Question			Answer	Marks	Guidance
2	(a)	(	**energy transferred from source/changed from some form to electrical energy**; per unit charge (to drive charge round a complete circuit)	**M1** A1	 allow energy <u>divided by</u> charge
		(ii)	any source has an <u>internal resistance</u> where energy is transferred into thermal energy /lost as heat	B1 B1	 there will be 'lost' volts (across the cell when a current is drawn) **or** V = E – Ir explained
	(b)	(	V = IR 1.2 = 0.2 R R = 6.0 Ω	C1 A1	substitution needed to score mark **allow** 6 Ω
		(ii)	1.6 – 1.2 = 0.4 = 0.2 r r = 2.0 Ω	C1 A1	 **allow** 2 Ω
	(c)	(i)	Q = It = 0.20 x 3600 x 1.5 =1100 correct unit,	C1 A1 B1	substitution needed to score mark 1080 **allow** 1 mark max for 0.3 or 18 **allow** C, kC, A s **exception** 0.3 A h or 18 A min scores 3 marks
		(i)	energy = QV = 1100 x 1.2 **or** $I^2Rt = 0.2^2$ x 6 x5400 = 1320 (J)	C1 A1	**ecf (c)(i)1** substitution needed to score mark 1296(1080) **allow** 1 mark for 1728 (using 1.6)
		(ii)	I is constant for about 9 to 10 hours because <u>internal</u> resistance remains constant/cell operates at constant <u>emf</u> I falls <u>rapidly/towards zero</u> over last hour or so because <u>cell</u>'s/<u>chemical</u> <u>energy</u> is used up (so E falls)	B1 B1 B1 B1	QWC must have link between observation and reason to score full marks **accept** r of cell increases causing fall in V or I
			Total	**17**	

Question			Expected Answers	M	Additional Guidance
3	**a**		use of $R = \rho l/A$ $= 2.4 \times 12 \times 10^{-3}/9.0 \times 10^{-6}$ $= 3.2 \times 10^{3}$ (Ω)	C1 M1 A0	
	b		$V^2 = PR$ $= 0.125 \times 3.2 \times 10^{3}$ $V = 20$(V)	C1 M1 A0	**allow** $V = \sqrt{(0.125 \times 3.2 \times 10^{3})}$ **allow** substituting V = 20 to prove P = 0.125 W
	c	**i**	adding resistors in series and then in parallel to show that total resistance is 3.2 kΩ	B1 B1	**do not allow** any reference to values of V or P, etc in answer
		ii	p.d across each resistor is 20 V so power dissipated is 0.125 W	B1 B1	**accept** $P = 40^2/3.2\text{ k} = 0.50$ W so P per resistor = 0.50/4 = 0.125 W **do not accept** $P_{total} = 0.50$ W without proof – scores zero
	d	**i**	using $R_X = \rho l/A$; $A \rightarrow 4A$ and $l \rightarrow 2l$ $R_Y = \rho 2l/4A = \rho l/2A = R_X/2$	M1 A1	**accept** figures 24×10^{-3} m and 36×10^{-6} m^2 to give 1.6×10^{3} Ω
		ii	same current in X and Y (as in series) power dissipated is I^2R **or** IV where $V_X = 2V_Y$ so X has larger P (dissipation)	B1 M1 A1	**allow** $P = V^2/R$; $V_X = 2V_Y$ etc. **allow** 1 mark only for using $P = V^2/R$ or IV and V is larger across X (i.e. not quantitative) so X has larger P
			Total question 1	**13**	