Question 7		
(a) (i)	work (done)/energy (supplied) per unit charge (by battery) ✓ (or pd across terminals when no current passing through cell or open circuit)	**1**
(a) (ii)	when switch is closed a **current flows** (through the battery) ✓ hence a pd/lost volts develops across the internal resistance ✓	**2**
(b)	(use of $\varepsilon = V + Ir$) $I = 5.8/10 = 0.58$ (A) ✓ $6.0 = 5.8 + 0.58r$ ✓ $r = 0.2/0.58 = 0.34$ (Ω) ✓	**3**
(c)	need large current/power to start the car ✓ (or current too low) internal resistance limits the current/wastes power(or energy)/reduces terminal pd/increases lost volts ✓	**2**
	Total	**8**

Question 7		
a i	(use of $V = IR$) R_{total} = 1 (ohm) ✓ $V = 1 \times 1 = 1.0\,V$ ✓	**2**
a ii	(use of $V = IR$) $R = 9.0/1.0 = 9.0\,\Omega$ ✓ $r = 9.0 - 1.0 - 6.0 = 2.0\,\Omega$ ✓ **or** use of ($E = I(R + r)$) 9.0 = 1(7 + r) ✓ r = 9.0 – 7.0 = 2.0 Ω ✓	**2**
a iii	(use of $W = VIt$) $W = 9.0 \times 1.0 \times 5 \times 60$ ✓ $W = 2700\,J$ ✓	**2**
a iv	energy dissipated in internal resistance = $1^2 \times 2.0 \times 5 \times 60 = 600\,(J)$ ✓ percentage = 100 × 600/2700 = 22% ✓ CE from part aii	**2**
b	internal resistance limits current ✓ hence can provide higher current ✓ **or** energy wasted in internal resistance/battery ✓ less energy wasted (with lower internal resistance) ✓ **or** charges quicker ✓ as current higher or less energy wasted ✓ **or** (lower internal resistance) means higher terminal pd/voltage ✓ as less pd across internal resistance or mention of lost volts ✓	**max 2**
	Total	**10**

	UMS conversion calculator www.aqa.org.uk/umsconversion	

6	a	i	*(use of P=VI)* I = 36/12 + 6/12 ✓ = 3.5 (A) ✓	2

6	a	ii	*(use of V=IR)* R = 12/3 =4 (Ω) ✓	1

6	a	iii	*R* = 12/0.50 = 24 ✓ (Ω)	1

6	b		terminal pd/voltage across lamp is now less OR current is less ✓ due to lost volts across internal resistance OR due to higher resistance✓ lamps less bright ✓	3

6	c	i	current through lamps is reduced as resistance is increased **or** pd across lamps is reduced as voltage is shared ✓ hence power is less OR lamps dimmer ✓	2

6	c	ii	lamp Q is brighter ✓ lamp Q has the <u>higher resistance</u> hence <u>pd</u>/<u>voltage</u> across is greater ✓ current is the same for both ✓ hence power of Q greater ✓	max 3

Mark schemes

1

(a) power increases to a maximum / (up) to 3.0 (2.8 -3.4) Ω / / (up)to 3.0 W ✓
then decreases ✓

2

(b) (i) (*use of* $P = I^2R$)
when R = 0.8 Ω power = 1.95 W ✓
$1.9 = I^2 \times 0.8$ ✓
$I = \sqrt{2.375} = 1.5(4)$ (A) ✓

Range
1.9 - 2.0 W for power (first mark)
Current 1.5 – 1.6 A

3

(ii) (*use of* $V = IR$)
$V = 1.54 \times 0.8$ ✓
$V = 1.2$ V ✓

CE from part (i)

2

(iii) (*use of* $\varepsilon = V + Ir$)
$6.0 = 1.2 + 1.54 \times r$ ✓
$r = (6.0 – 1.2) / 1.54 = 3.1$ (2.9 – 3.2)(Ω) ✓
use of maximum power theorem (quoted) as alternative method can get both marks i.e. read peak maximum from graph

CE from part (ii)

2

(c) power would decrease (as R increased) ✓
pd / voltage across R is now constant / equal to emf ✓
and so power proportional to 1 / R / inversely proportional to R OR
can quote $P = V^2 / R$ but only if scored second mark ✓

3

[12]

Mark schemes

1 (a) emf is the work done / energy transferred by a voltage source / battery / cell ✓per unit charge✓
OR
electrical energy transferred / converted / delivered / produced✓
per unit charge✓
OR
pd across terminals when no current flowing / open circuit✓✓

not in battery

accept word equation OR symbol equation with symbols defined if done then must explain energy / work in equation for first mark

2

(b) (i) by altering the (variable) resistor✓

1

(ii) reference to correct internal resistance✓

e.g. resistance of potato (cell)

terminal pd = emf – pd across internal resistance / lost volts✓
pd / lost volts increases as current increases OR as (variable) resistance decreases greater proportion / share of emf across internal resistance✓

accept voltage for pd

3

(iii) draws best fit straight line and attempts to use gradient✓
uses triangle with base at least 6 cm✓
value in range 2600 – 2800 (Ω)✓

3

stand-alone last mark

(c) total emf is above 1.6 V✓
but will not work as current not high enough / less than 20 mA✓

2

[11]

Question			Answer	Marks	Guidance
3	(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 energy divided by charge
		(ii)	any source has an internal resistance 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)	(i)	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)1	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)2	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 internal resistance remains constant/cell operates at constant emf I falls rapidly/towards zero over last hour or so because cell's/chemical energy 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			Answer	Marks	Guidance
4	(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**	