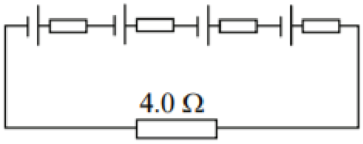
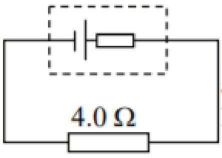
Internal Resistance of Cells Answers WJEC Physics A Level

1.

	(a)		‘per unit charge’ [**or** ‘per coulomb’] used correctly at least once. (1) V = energy delivered [per unit charge] to [external] circuit (1) E = energy supplied [per unit charge] from chemical energy of cell (1) Ir = energy wasted / lost / dissipated [per coulomb] in the internal resistance (1)	4
	(b)	(i)	 or  [with appropriate labelling] [or equivalent]	1
		(ii)	R_{Total} = 4.8 Ω [or by impl.] (1) I = 1.25 A (1) [Accept 1.3 A] no e.c.f.	2
		(iii)	P.d. across 4 Ω resistor = 5.0 V [e.c.f. 4.0 × *(b)*(i) ans]	1
	(c)		5.7V and R_{tot} = 5.0Ω (with) **or** 4.5V and R_{tot} = 4.6Ω (without cell)(1) *With run-down cell*: I = 1.14 A (1) *Without run-down cell*: I = 0.98 A (1) *Conclusion*: better not to remove (e.c.f.): strategy + conclusion (1)	4 **[12]**

2.

uestion			Marking details	Marks Available
	(a)		The electrical (potential) energy transferred [or work done] *per coulomb / unit charge* passing through the cell [Underlined (1); *italic* (1)]	2
	(b)		Voltmeter shown in parallel with cell [outside the dotted line – accept inside the line if outside the cell/i.r combination] [Accept equivalent, e.g. connected in parallel with resistor]	1
	(c)		All points correctly plotted (2) [–1 per mistake, min 0] Line correctly drawn [with extrapolation just to V axis] (1)	3
	(d)	(i)	[e.m.f. =] 1.6 V	1
		(ii)	gradient attempted [or by impl.](1); r = 0.33 Ω / 0.3 Ω / $^1/_3$Ω (1)	2 **[10]**

3.

Question			Marking details	Marks Available
'	*(a)*		*V*- energy (per coulomb) used in [external] resistor / circuit. (1) *E*- energy (per coulomb) transferred / supplied by source / in the whole circuit (1) *Ir*- energy (per coulomb) wasted / lost in source / cell / internal resistance (1) Use of 'per coulomb / unit charge' once. (1)	[4]
	(b)	(i)	4 [Ω]	[1]
		(ii)	Gradient attempted e.g. 60/10 (1) (or use of equation **ecf** from *(b)* (i)) emf = 6 [V] (1)	[2]
		(iii)	$1/I = 4\,[\text{A}^{-1}]$ or by implication (1) $R = 20\,[\Omega]$ (1) Use of I^2R i.e. $(0.25)^2 \times 20$ (**ecf**) (1) or correct substitution into both $V = IR$ and $P = IV$ or V^2/R $P = 1.25$[W] (1)	[4]
	(c)	(i)	emf = 12.0 [V] (**ecf**) **<u>and</u>** $r = 8.0\,[\Omega]$ (**ecf**)	[1]
		(ii)	$R = 52.0\,[\Omega]$ (**ecf**)	[1]
		(iii)	y intercept ($r \rightarrow 8.0\,\Omega$ (**ecf**)) (1) Precise gradient e.g. through (5,52) (**ecf**) (1)	[2]
			Question 7 Total	**[15]**

4.

Question			Marking details	Marks Available
	(a)	(i)	*V* is the terminal p.d. – or clear explanation in energy terms: energy per coulomb delivered to external circuit / [NB "per coulomb" / "per unit charge" required on one of (i) and (ii) if energy explanation given]	1
		(ii)	P.D. across the internal resistance [accept lost volts – "bod"] / energy per coulomb lost / dissipated in the internal resistance / cell	1
	(b)	(i)	2.4 V	1
		(ii)	0.4 Ω [allow e.c.f. from *(b)*(i)]	1
		(iii)	e.g. "Drains" the cell quickly, Cell gets hot	1
	(c)		Correct use of $I = \frac{E}{R_{\text{Tot}}}$ $I = 1.0$ A	2
	(d)		Trial and error acceptable: Use of 1 ×, 2 ×, 3 × … (1); corresponding total resistance (1); use of $\frac{V}{R}$ (1) leading to 5 cells (1) Nice answer: Subst in $I = \frac{E}{R+r}$: $3.0 = \frac{2.4n}{2.0+0.4n}$ [ecf on $n \times 2$](1) Re-arrangement: $6.0 + 1.2n = 2.4n \rightarrow n = 5$ Marking points with analytical answer: $n \times 2.4$ (1) Use of total resistance = $2.0 + 0.4\,n$ (1) Application of $I = \frac{V}{R}$ (1); $n = 5$ (1)	4
				[11]

5.

uestion			Marking details	Marks Available
	(a)	(i)	12 Joules per coulomb (1)	
			Supplied from cell / source / battery / chemical to electrical (1)	2
		(ii)	Energy lost in the resistance of cell	1
	(b)		$\left\{\frac{3.6(1)}{120}\right\}$ = 0.03 [Ω] (1)	2
	(c)		$I = \frac{12}{0.03} = 400$ [A] ecf from (b)	1
	(d)	(i)	$Q = 3 \times [(16 \times 60^2)$ or 57 600 (1)]	
			= 172800 [C] (1)	2
		(ii)	$t = \frac{172,800}{120}$ = 1440 seconds / 24 mins **UNIT mark**	1
			Allow ecf from (d) (i)	
			Question 3 Total	**[9]**

6.

uestion			**Marking details**	**Marks Available**
	(a)		[Electrical] energy [or work done] transferred to whole of circuit [or through cell] (1) per coulomb [or unit charge] (1)	[2]
	(b)		Sensible scale and axes labelled with units (1) All points correct ± ½ small square division (1) Line of best fit (1) (no requirement → y axis)	[3]
	(c)	(i)	$E = 1.48$ [V] (± 0.01 V) **ecf** from graph	[1]
		(ii)	Gradient attempted or $r = \frac{E - V}{I}$ (by implication) (1) $r = 0.83$ [Ω] (1) **ecf** from graph	[2]
	(d)		$I = \frac{E}{R + r}\left\{\frac{1.48}{6 + 0.83}\right\}$ (1) (**ecf** on E and r) $I = 0.22$ A (1) $t = 20 \times 60$ [1 200 s] (1) $Q = 0.22$ **(ecf)** x 1 200 **(ecf)** = 264 [C] (1)	[4]
			Question 3 Total	**[12]**

7.

Question		Marking details	Marks Available
(a)	(i)	Diagram A: Current through X less than current through Y (or vice-versa) *pd* across X same as than *pd* across Y [Both statements correct for 1 mark]	[1]
	(ii)	Diagram B: Current through X same as current through Y *pd* across X greater than *pd* across Y [Both statements correct for 1 mark]	[1]
(b)	(i)	Resistance has decreased by factor 1.5 (or reduced to 2/3 original value) or other correct quantitative comparison. Do not accept reduced by 4 Ω (1) Therefore current increases by same factor (or × 1.5) etc. (1) Accept answers based on calculation: V across 12.0 Ω = 2.4 [V] (1) I through 8.0 Ω = $\frac{2.4}{8.0}$ (= 0.3 A) (1)	[2]
	(ii)	Current = 0.5 [A] (1) Total resistance = 10.8 [Ω] (1) 0.5 × 10.8 seen (1) **Alternative –** pd across parallel combination = 0.2 × 12 = 2.4 [V] (1) pd across 6.0 Ω = (0.2 + 0.3) × 6 = 3.0 [V] (1) Total pd = 2.4 + 3.0 (1) = [5.4 V]	[3]
	(iii)	Some voltage (accept energy) is lost/ given out as heat (1) .... in the internal resistance of the cell (1)	[2]
	(iv)	Substitution into $E = V + Ir$ (e.g. $r = \frac{6-5.4}{0.5}$) (1) r = 1.2 [Ω] (1) deduct 1 mark for incorrect sign	[2]
		Question 5 Total	**[11]**