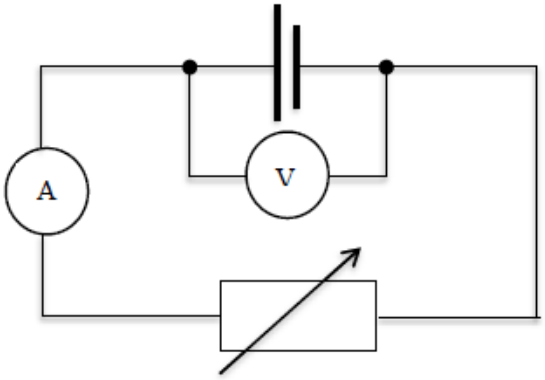
**Potential Dividers, EMF and Internal Resistance - Mark Scheme**

Q1.

| Question Number | Answer | Mark |
|---|---|---|
| a | Energy (supplied) to/per unit charge<br>**Or** Work done (supplied) to/per unit charge<br>**Or** The work done moving unit charge around the whole circuit (1) | **(1)** |
| bi | Use of sum of e.m.f. = sum of p.d.<br>**Or** see $\mathcal{E} = V + Ir$ with correct substitutions (1)<br><br>$r = 1.9 \times 10^{-2}\ \Omega$ (1)<br><br>Example of calculation<br>$\mathcal{E} = V + Ir$, 12.0 V = 11.81 V + (9.83 A) $r$. so $r = 0.0193\ \Omega$ | **(2)** |
| bii | Plot $V$ against $I$ (1)<br>Determine the gradient (1)<br>Gradient is $-r$ (1)<br><br>**OR**<br>Plot $I$ against $V$ (1)<br>Determine the gradient (1)<br>Gradient is $-(1/r)$ (1)<br><br>**OR**<br>Plot $(\mathcal{E} - V)$ against $I$ (1)<br>Determine the gradient (1)<br>Gradient is $r$ (1) | **(3)** |

Q2.

| | | |
|---|---|---|
| c | Calculates circuit current using $I = \varepsilon$ / Total $R$<br>**Or** Calculates p.d. across fixed resistor using potential divider equation (1)<br><br>Use of a power equation (to calculate Power dissipated in fixed resistor) (1)<br><br>Divides final power by initial power<br>**Or** Divides difference in power by initial power<br>**Or** Calculates 70% of initial power (1)<br><br>Calculated value for final power/initial power is greater than 70% of initial power so student incorrect<br>**Or** Calculated value for difference between initial and final power is less than 30% so student incorrect<br>**Or** Calculated value for 70% of initial power is less than the final power so student incorrect (1)<br><br>(Candidates who use incorrect values of I, V or R in either power calculation for MP2 cannot be awarded MP3 or MP4)<br><br><u>Example of calculation</u><br>Initially $I = \varepsilon$ / Total $R$ = 9.0 V / (5.0 + 0.10 Ω) = 1.76 A<br>Power of external resistor = $I^2 R$ = (1.76 A)$^2$ (5.0 Ω) = 15.5 W<br>When $r$ = 0.50 Ω, $I = \varepsilon$ / Total $R$ = 9.0 V / (5.0 + 0.50 Ω) = 1.64 A<br>Power of external resistor = $I^2 R$ = (1.64 A)$^2$ (5.0 Ω) = 13.4 W<br>Percentage of original value = (13.4 W) / (15.5 W) = 0.86 (or 86%) | **(4)** |

| Question Number | Answer | Mark |
|---|---|---|
| a | Ammeter in series with cell, voltmeter in parallel with cell (1)<br>Variable resistor (1)<br><br>  <br><br><br>(Voltmeter can be drawn in parallel with the (variable) resistor for MP1,as long as there are no other components with resistance in the circuit). | 2 |
| b | Line of best fit drawn (1)<br>$\varepsilon$ = 0.28 – 0.29 V (1)<br>(Magnitude of) gradient calculated using a best fit line (1)<br>$r$ = 400 – 430 Ω (1)<br><br>(If no best fit line has been drawn, only MP2 and MP4 are available)<br><br><u>Example of calculation</u><br>Gradient = $\Delta V / \Delta I$ = −0.18 V / (0.44 x 10$^{-3}$ A) = −409 Ω<br>so $r$ = 409 Ω | 4 |

| | | |
|---|---|---|
| c | In series/A there is a greater (combined) resistance than in parallel/B **Or** Resistance in series/A is 2R, resistance in parallel/B is R/2. (1)<br><br>So greater current in parallel/B **Or** so less current in series/A (1)<br><br>As $\varepsilon$ and $r$ the same **Or** since $\varepsilon = V + Ir$ **Or** more lost volts in parallel/B (1)<br><br>Terminal potential difference is greater in series/A (1)<br><br>**OR**<br><br>In series/A there is a greater (combined) resistance than in parallel/B **Or** Resistance in series/A is 2R, resistance in parallel/B is R/2. (1)<br><br>as $\varepsilon$ and $r$ the same (1)<br><br>$V = \frac{\varepsilon R}{R+r}$ (1)<br><br>Terminal potential difference is greater in series/A (1) | **4** |
| | **Total for question** | **10** |

Q3.

| Question Number | Answer | Mark |
|---|---|---|
| | **A is the correct answer as this represents the current in the internal resistance multiplied by the p.d. across the internal resistance.**<br><br>B is not the correct answer as this is the power dissipated by the external resistance<br>C is not the correct answer as this is the power dissipated by the whole circuit.<br>D is not the correct answer as this equation combines the p.d. across the external resistance with the value for the internal resistance – as a result, it does not represent the power of any of the components in the circuit | **(1)** |

Q4.

| Question Number | Answer | Mark |
|---|---|---|
| | **D is the correct answer**<br><br>A is not the correct answer as these are the units of charge<br>B is not the correct answer as these are the units of energy<br>C is not the correct answer as these are the units of force | **(1)** |