

Emf, internal resistance and kirchhoff's laws

Physics grades 11-12 (A Level · IB · Class 11-12) · Lab answers

The sample readings follow $V = \varepsilon - Ir$ with an emf near 1.5 V and an internal resistance near 0.56Ω . The answers below use those readings, so your own results will differ slightly but should show the same straight line.

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Question 1 Graph

The points lie close to a straight line with a negative gradient, so **V decreases linearly as the current increases**, as $V = \varepsilon - Ir$ predicts.

Question 2 Emf

The line extrapolated to $I = 0$ meets the V axis at about **1.52 V $\approx$ 1.52 V**. This is the emf, because with no current there are no lost volts.

Question 3 Internal resistance

Gradient = $(1.18 - 1.46) / (0.60 - 0.10) = -0.28 / 0.50 = -\mathbf{0.56 \text{ V/A}}$. The internal resistance is the size of the gradient: **$r = 0.56 \Omega$** . (A least-squares fit of all six points gives $r = 0.56 \Omega$ and $\varepsilon = 1.52 \text{ V}$.)

Question 4 Power in the cell

$P = I^2 r = 0.60^2 \times 0.56 = \mathbf{0.20 \text{ W}}$, which warms the cell.

Question 5 Short-circuit current

$I_{sc} = \varepsilon / r = 1.52 / 0.56 = \mathbf{2.7 \text{ A}}$. Testing it would heat the cell and leads, risk damaging them, and use up the cell quickly.

Question 6 Switching off between readings

The current heats the cell and changes its chemistry, which alters r and ε . Switching off lets it recover, so **each reading is taken under the same conditions**.

Question 7 Uncertainty

Percentage uncertainty = $(0.01 / 1.18) \times 100 = \mathbf{0.8 \%}$. The uncertainty in the p.d. is small compared with the change of 0.28 V over the range.

Question 8 Reliability of r

Any two of: take more readings and repeat each; use a datalogger with a faster response; use a fresh cell for every run; use a smaller current range to reduce heating; add a fixed protective resistor. **Any two sensible changes.**