<u>EMF and Internal Resistance</u>

To know what EMF and internal resistance are
To know how to measure internal resistance
TO be able to sketch and interpret a V-I graph, labelling the gradient and y-intercept

Energy in Circuits

In circuits there are two fundamental types of component: energy *givers* and energy *takers*.

Electromotive Force (emf), ε

Energy givers provide an electromotive force, they force electrons around the circuit which transfer energy.

The size of the emf can be calculate using: $$\varepsilon = \frac{E}{Q}$$

This is similar to the equation we use to find voltage/potential difference and means the energy given to each unit of charge. We can think of this as the energy given to each electron.
The emf of a supply is the p.d. across its terminals when no current flows

EMF is measured in Joules per Coulomb, JC^{-1} or Volts, V

Energy takers have a potential difference across them, transferring energy from the circuit to the component.

emf = energy giver   p.d. = energy taker

Energy is conserved in a circuit so energy in = energy out, or:

The total of the emfs = The total of the potential differences around the whole circuit

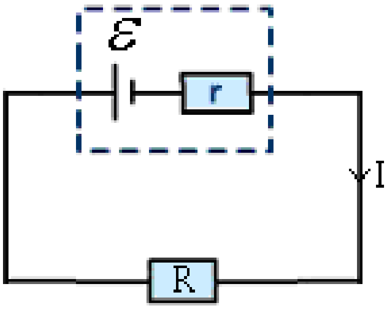
Internal Resistance, r

The chemicals inside a cell offer a resistance to the flow of current, this is the internal resistance on the cell.

Internal Resistance is measured in Ohms, Ω

Linking emf and r

If we look at the statement in the box above and apply it to the circuit below, we can reach an equation that links emf and *r*.



Total emfs = total potential differences
ε = (p.d. across r) + (p.d. across R)   {Remember that V=IR}
ε = (I x r) + (I x R)
ε = Ir + IR

$$\varepsilon = I(r+R)$$

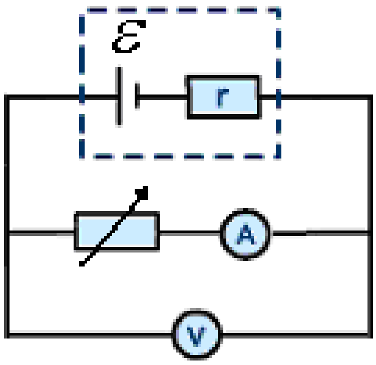
The terminal p.d. is the p.d. across the terminals of the cell when a current is flowing

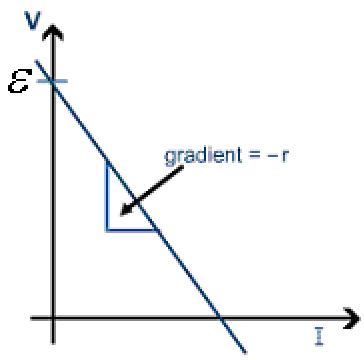
ε = internal p.d + terminal p.d.

So the above equation can be written as $\varepsilon = Ir + V$ where V is the terminal p.d.

Measuring emf and r

We can measure the emf and internal resistance of a cell by measuring the current and voltage as shown on the right, the variable resistor allows us to get a range of values. If we plot the results onto a graph of voltmeter reading against ammeter reading we get a graph that looks like the one below.





Graphs have the general equation of y = mx+c, where y is the vertical (upwards) axis, x is the horizontal (across) axis, m is the gradient of the line and c is where the line intercepts (cuts) the y axis.
If we take $\varepsilon = Ir + V$ and arrange it into y= mx + c

y axis = V and x axis = I

$\varepsilon = Ir + V \rightarrow V = -Ir + \varepsilon \rightarrow V = -r\,I + \varepsilon$

y =m x +c

So we can see that the:

y-intercept represents the emf

and

gradient represents (–)internal resistance