# 6.2.1: Electromotive Force and Internal Resistance

The reader is reminded of the following definition from section 4.1:

*Definition*. The potential difference across the poles of a cell when no current is being taken from it is called the *electromotive force* (EMF) of the cell.

I shall use the symbol $E$ for EMF.

*Question*. A 4 Ω resistance is connected across a cell of EMF 2 V. What current flows?

The immediate answer is 0.5 A – but this is likely to be wrong. The reason is that a cell has a resistance of its own – its *internal resistance*. The internal resistance of a lead-acid cell is typically quite small, but most dry cells have an appreciable internal resistance. If the external resistance is $R$ and the internal resistance is $r$, the total resistance of the circuit is $R+r$, so that the current that flows is $E/(R+r)$.

Whenever a current is taken from a cell (or battery) the potential difference across its poles *drops* to a value less than its EMF. We can think of a cell as an EMF in series with an internal resistance:

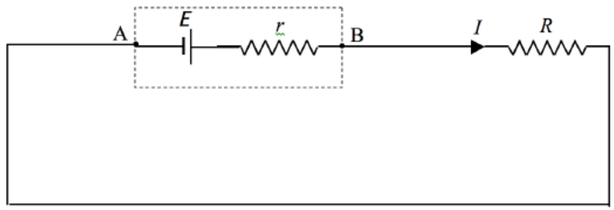


FIGURE IV.4

If we take the point A as having zero potential, we see that the potential of the point B will be $E$ - $Ir$, and this, then, is the potential difference across the poles of the cell when a current $I$ is being taken from it.

? Show that this can also be written as $\frac{ER}{R+r}$.