EMF and internal resistance

*(m)* define e.m.f. in terms of the energy transferred by a source in driving

unit charge round a complete circuit

*(n)* distinguish between e.m.f. and p.d. in terms of energy considerations

***(o)* show an understanding of the effects of the internal resistance of a**

**source of e.m.f. on the terminal potential difference and output power.**

Internal resistance of a source of emf

Some of the energy given to charges by a cell (or other source of emf) is dissipated inside the cell itself, as the charges move through the cell (or other source of emf). What is left is available as a potential difference (energy per unit charge) across a circuit connected to the cell. If the emf of the source is *E*, and its internal resistance is *r,* then when a current *I* flows the potential difference *V* is *V = E – I r.*

Internal resistance of a C cell

Apparatus required:

C cell (possibly modified by the addition of a series resistor)

Two multimeters (or an ammeter and voltmeter)

Rheostat (approx. 10 Ω)

Leads

Circuit:

**V**

**A**

Procedure

Start with the rheostat on its maximum resistance. Record *V* and *I*. Gradually reduce the rheostat to its lowest resistance (zero) measuring *V* and *I* a minimum of 7 times over the range. Don’t leave the circuit connected for long when the resistance is low (current high) because this will run the cell down quickly.

Plot a graph of *V* against *I*. *E* is the intercept on the *V* axis. The gradient is –*r*.

Internal resistance of power supplies

Answer the following questions for practice in making calculations about the internal resistance of power supplies.

Torch batteries, car batteries, EHT supplies and solar cells

1. A typical hand-held torch runs off two 1.5 V cells, yet has a lamp rated at 2.5 V, 0.5 A. Explain how the potential difference across the lamp can actually be 2.5 V as rated. What is the internal resistance of each cell, supposing them to be identical?

2. A typical car battery has an emf of 12 V, and must provide a current of 80 A to the starter motor. Why must the car battery have a very low internal resistance? If the internal resistance is 0.05 , find the potential difference across this internal resistance when the starter motor is running. Why is starting the car with the headlights on likely to affect their brightness?

3. Some school laboratories have EHT (Extra High Tension) power packs giving up to

3000 V. For safety, they are provided with a 50 M resistor in series with the supply. What is the maximum current able to be drawn from the supply? Approximately what potential difference would there be across a torch bulb connected across such a supply?

4. A student experimenting with a solar cell connects a 1000  voltmeter across it and observes a potential difference of 1.0 V. Using a different, extremely high resistance digital voltmeter, the reading is larger, 1.2 V. Why the difference? What is the internal resistance of the solar cell?

**Practical Advice**

It is helpful to remember that the internal resistance of a cell is not likely to remain constant as the cell is used, and that other effects such as polarization of the cell also affect the pd obtained from it.

Social and Human Context

Dry cells power all sorts of portable equipment besides torches. Some, such as television or video control handsets, can run for years on one set of batteries. Others, such as palm-top computers and 'organizers', use up batteries very quickly.