4.1 Potential Difference and Power

Energy and p.d.

When electrons flow through a cell or battery, (from the positive terminal to the negative terminal), they gain electrical potential energy. We say there is a **potential difference** (or p.d.) across the battery.

The p.d., V is defined as the work done (or energy transferred) W per unit charge:

$$V = \frac{W}{Q}$$

Where V is in volts; W is in joules; Q is in coulombs.

- If electrons flow through a circuit component, (lamp, resistor, etc), they deliver energy to it. The p.d. across the component is the energy delivered per unit charge.

- The emf (electromotive force) of a cell is defined as the *electrical energy given per unit of charge*. Emf is not a force; this is an old name. The units of emf are volts and it is easiest to think of it as the p.d. across a cell when it is *not* driving a current. (More about this later).

Power and Current

When electrons flow through a device, the work they do (or the energy they transfer) is given by $W = QV$ (see above).

Since $Q = I\Delta t$, we can write

$$W = IV\Delta t$$

The power (P) delivered, which is the energy per second, is therefore

$$P = \frac{W}{\Delta t} = IV$$

*[Note: we can define a volt as a **joule per coulomb** or as a **watt per ampere**]*

Energy delivered to a device

- When electrons deliver energy to an appliance, it can be transferred in a variety of ways. If the appliance has resistance, the electrons lose energy because of collisions with atoms as they flow through it and this is transformed into thermal energy. The device warms up.
- In motors or loudspeakers, the electrons must do work against the force on them due to the magnets in these devices. Their energy is transferred via work into kinetic energy in the motor and sound energy in the loudspeaker.