The chemist's toolkit 5 Electrical charge, current, power, and energy

Electrical charge, Q, is measured in *coulombs*, C. The elementary charge, e, the magnitude of charge carried by a single electron or proton, is 1.602×10^{-19} C. The flow of electrons gives rise to an **electric current**, I, measured in coulombs per second, or *amperes*, A, where $1\text{ A} = 1\text{ C s}^{-1}$. Thus, a current of 1 A represents the flow of 6×10^{18} electrons (10 μmol e^-) per second.

When a current I flows through a potential difference $\Delta\phi$ (measured in volts, V, with $1\text{ V} = 1\text{ J C}^{-1}$), for a time Δt the energy delivered (in joules) is

$$E = I\Delta\phi\Delta t$$

That energy may be supplied either as work (to drive a motor) or as heat (through a 'heater'). In the latter case

$$q = I\Delta\phi\Delta t$$

The **power**, P, is the rate at which energy is supplied and is expressed as joules per second, or *watts*, with $1\text{ W} = 1\text{ J s}^{-1}$. Because $1\text{ J} = 1\text{ A V s}$, in terms of electrical units $1\text{ W} = 1\text{ A V}$. Electrical power is therefore $P = (\text{energy supplied for a time } \Delta t)/\Delta t = It\Delta\phi/\Delta t$; so

$$P = I\Delta\phi$$