Appendix 3 Essential concepts of physics

A3

Energy

The central concept of all explanations in physical chemistry, as in so many other branches of physical science, is that of **energy**, the capacity to do work. We make use of the apparently universal law of nature that *energy is conserved*, that is, energy can neither be created nor destroyed. Although energy can be transferred from one location to another, the total energy is constant.

A3.1 Kinetic and potential energy

The **kinetic energy**, E_K, of a body is the energy the body possesses as a result of its motion. For a body of mass m travelling at a speed v,

$$E_K = \tfrac{1}{2}mv^2 \qquad \text{(A3.1)}$$

The **potential energy**, E_P or V, of a body is the energy it possesses as a result of its position. The zero of potential energy is arbitrary. For example, the gravitational potential energy of a body is often set to zero at the surface of the Earth; the electrical potential energy of two charged particles is set to zero when their separation is infinite. No universal expression for the potential energy can be given because it depends on the type of interaction the body experiences. One example that gives rise to a simple expression is the potential energy of a body of mass m in the gravitational field close to the surface of the Earth (a gravitational field acts on the mass of a body). If the body is at a height h above the surface of the Earth, then its potential energy is mgh, where g is a constant called the **acceleration of free fall**, $g = 9.81\ \text{m s}^{-2}$, and $V = 0$ at $h = 0$ (the arbitrary zero mentioned previously).

The total energy is the sum of the kinetic and potential energies of a particle:

$$E = E_K + E_P \qquad \text{(A3.2)}$$

A3.2 Energy units

The SI unit of energy is the *joule* (J), which is defined as

$$1\ \text{J} = 1\ \text{kg m}^2\ \text{s}^{-2} \qquad \text{(A3.3)}$$

Calories (cal) and kilocalories (kcal) are still encountered in the chemical literature: by definition, 1 cal = 4.184 J. An energy of 1 cal is enough to raise the temperature of 1 g of water by 1°C.

The rate of change of energy is called the **power**, P, expressed as joules per second, or *watt*, W:

$$1\ \text{W} = 1\ \text{J s}^{-1} \qquad \text{(A3.4)}$$