17–4 The Electron Volt, a Unit of Energy

The joule is a very large unit for dealing with energies of electrons, atoms, or molecules. For this purpose, the unit **electron volt** (eV) is used. One electron volt is defined as the energy acquired by a particle carrying a charge whose magnitude equals that on the electron ($q = e$) as a result of moving through a potential difference of 1 V. Since the charge on an electron has magnitude 1.6×10^{-19} C, and since the change in potential energy equals qV, 1 eV is equal to $(1.6 \times 10^{-19}\,\text{C})(1.0\,\text{V}) = 1.6 \times 10^{-19}\,\text{J}$:

Electron volt (unit)

$$1\,\text{eV} = 1.6 \times 10^{-19}\,\text{J}.$$

An electron that accelerates through a potential difference of 1000 V will lose 1000 eV of potential energy and will thus gain 1000 eV, or 1 keV (kiloelectron volt) of kinetic energy. On the other hand, if a particle with a charge equal to twice the magnitude of the charge on the electron $(= 2e = 3.2 \times 10^{-19}\,\text{C})$ moves through a potential difference of 1000 V, its energy will change by 2000 eV.

Although the electron volt is handy for *stating* the energies of molecules and elementary particles, it is *not* a proper SI unit. For calculations, electron volts should be converted to joules using the conversion factor just given. In Example 17–2, for example, the electron acquired a kinetic energy of 8.0×10^{-16} J. We normally would quote this energy as 5000 eV $(= 8.0 \times 10^{-16}\,\text{J}/1.6 \times 10^{-19}\,\text{J/eV})$. But when determining the speed of a particle in SI units, we must use the KE in joules (J).

17–5 Electric Potential Due to Point Charges

The electric potential at a distance r from a single point charge Q can be derived from the expression for its electric field (Eq. 16–4) using calculus. The potential in this case is usually taken to be zero at infinity (∞); this is also where the electric field $(E = kQ/r^2)$ is zero. The result is

Electric potential of a point charge ($V = 0$ at $r = \infty$)

$$V = k\frac{Q}{r} = \frac{1}{4\pi\epsilon_0}\frac{Q}{r}, \qquad \text{[single point charge]} \quad \textbf{(17–5)}$$

where $k = 8.99 \times 10^9\,\text{N}\cdot\text{m}^2/\text{C}^2$. We can think of V here as representing the *absolute potential* at a distance r from the charge Q, where $V = 0$ at $r = \infty$, or we can think of V as the potential difference between r and infinity. Notice that the potential V decreases with the first power of the distance, whereas the electric field (Eq. 16–4) decreases as the *square* of the distance. The potential near a positive charge is large and positive, and it decreases toward zero at very large distances. The potential near a negative charge is negative and increases toward zero at large distances (Fig. 17–9).

CAUTION
$V \propto \frac{1}{r}$, $E \propto \frac{1}{r^2}$ for a point charge

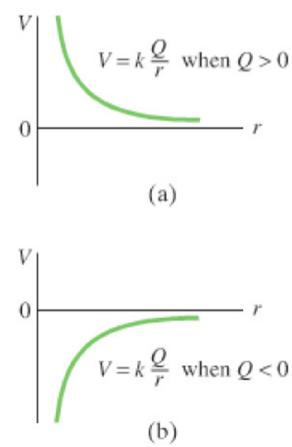

FIGURE 17–9 Potential V as a function of distance r from a single point charge Q when the charge is (*a*) positive, (*b*) negative.