We saw in Chapter 6 that the change in potential energy between two points a and b equals the negative of the work done by the conservative force to move an object from a to b: $\Delta\text{PE} = -W$.

Thus we define the change in electric potential energy, $\text{PE}_b - \text{PE}_a$, when a point charge q moves from some point a to another point b, as the negative of the work done by the electric force to move the charge from a to b. For example, consider the electric field between two equally but oppositely charged parallel plates; we assume their separation is small compared to their width and height, so the field $\vec{\mathbf{E}}$ will be uniform over most of the region, Fig. 17–1. Now consider a tiny positive point charge q placed at point a very near the positive plate as shown. This charge q is so small it doesn't affect $\vec{\mathbf{E}}$. If this charge q at point a is released, the electric force will do work on the charge and accelerate it toward the negative plate. The work W done by the electric field E to move the charge a distance d is

$$W = Fd = qEd$$

where we used Eq. 16–5, $F = qE$. The change in electric potential energy equals the negative of the work done by the electric force:

$$\text{PE}_b - \text{PE}_a = -qEd \qquad [\text{uniform } \vec{\mathbf{E}}] \quad \textbf{(17–1)}$$

for this case of uniform electric field $\vec{\mathbf{E}}$. In the case illustrated, the potential energy decreases (ΔPE is negative); and as the charged particle accelerates from point a to point b in Fig. 17–1, the particle's kinetic energy KE increases—by an equal amount. In accord with the conservation of energy, electric potential energy is transformed into kinetic energy, and the total energy is conserved. Note that the positive charge q has its greatest potential energy at point a, near the positive plate.[†] The reverse is true for a negative charge: its potential energy is greatest near the negative plate.

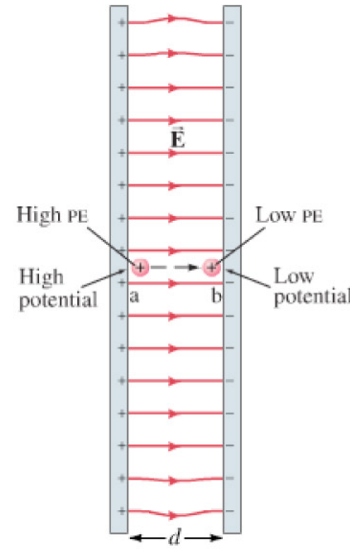

FIGURE 17–1 Work is done by the electric field in moving the positive charge from position a to position b.

Electric Potential and Potential Difference

In Chapter 16, we found it useful to define the electric field as the force per unit charge. Similarly, it is useful to define the **electric potential** (or simply the **potential** when "electric" is understood) as the *electric potential energy per unit charge*. Electric potential is given the symbol V. If a positive test charge q has electric potential energy PE_a at some point a (relative to some zero potential energy), the electric potential V_a at this point is

Potential is potential energy per unit charge

$$V_a = \frac{\text{PE}_a}{q}. \quad \textbf{(17–2a)}$$

As we discussed in Chapter 6, only differences in potential energy are physically meaningful. Hence only the **difference in potential**, or the **potential difference**, between two points a and b (such as between a and b in Fig. 17–1) is measurable. When the electric force does positive work on a charge, the kinetic energy increases and the potential energy decreases. The difference in potential energy, $\text{PE}_b - \text{PE}_a$, is equal to the negative of the work, W_{ba}, done by the electric field to move the charge from a to b; so the potential difference V_{ba} is

Potential difference

$$V_{ba} = V_b - V_a = \frac{\text{PE}_b - \text{PE}_a}{q} = -\frac{W_{ba}}{q}. \quad \textbf{(17–2b)}$$

Note that electric potential, like electric field, does not depend on our test charge q. V depends on the other charges that create the field, not on q; q acquires potential energy by being in the potential V due to the other charges.

We can see from our definition that the positive plate in Fig. 17–1 is at a higher potential than the negative plate. Thus a positively charged object moves naturally from a high potential to a low potential. A negative charge does the reverse.

[†] At this point the charge has its greatest ability to do work (on some other object or system).