Unit of potential difference: the volt (1 V = 1 J/C)

The unit of electric potential, and of potential difference, is joules/coulomb and is given a special name, the **volt**, in honor of Alessandro Volta (1745–1827) who is best known for inventing the electric battery. The volt is abbreviated V, so 1 V = 1 J/C. Potential difference, since it is measured in volts, is often referred to as **voltage**.

Voltage = potential difference

If we wish to speak of the potential V_a at some point a, we must be aware that V_a depends on where the potential is chosen to be zero. The zero for electric potential in a given situation can be chosen arbitrarily, just as for potential energy, because only differences in potential energy can be measured. Often the ground, or a conductor connected directly to the ground (the Earth), is taken as zero potential, and other potentials are given with respect to ground. (Thus, a point where the voltage is 50 V is one where the difference of potential between it and ground is 50 V.) In other cases, as we shall see, we may choose the potential to be zero at an infinite distance ($r = \infty$).

$V = 0$ chosen arbitrarily

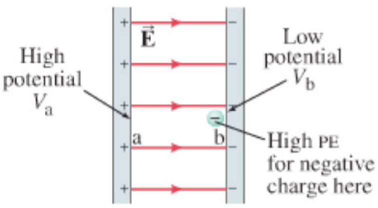

FIGURE 17–2 Central part of Fig. 17–1, showing a negative point charge near the negative plate. Conceptual Example 17–1.

CAUTION
A negative charge has high PE when potential V is low

CONCEPTUAL EXAMPLE 17–1 **A negative charge.** Suppose a negative charge, such as an electron, is placed near the negative plate in Fig. 17–1, at point b, shown here in Fig. 17–2. If the electron is free to move, will its electric potential energy increase or decrease? How will the electric potential change?

RESPONSE An electron released at point b will move toward the positive plate. As the electron moves toward the positive plate, its potential energy *decreases* as its kinetic energy gets larger. But note that the electron moves from point b at low potential to point a at higher potential: $\Delta V = V_a - V_b > 0$. (The potentials V_a and V_b are due to the charges on the plates, not due to the electron.)

NOTE A positive charge placed near the negative plate at b would not be accelerated. A positive charge tends to move from high potential to low.

Because the electric potential difference is defined as the potential energy difference per unit charge, then the change in potential energy of a charge q when moved between two points a and b is

Electric potential and potential energy

$$\text{PE}_b - \text{PE}_a = q(V_b - V_a) = qV_{ba}. \qquad \textbf{(17–3)}$$

That is, if an object with charge q moves through a potential difference V_{ba}, its potential energy changes by an amount qV_{ba}. For example, if the potential difference between the two plates in Fig. 17–1 is 6 V, then a +1 C charge moved (say by an external force) from b to a will gain (1 C)(6 V) = 6 J of electric potential energy. (And it will lose 6 J of electric potential energy if it moves from a to b.) Similarly, a +2 C charge will gain 12 J, and so on. Thus, electric potential difference is a measure of how much energy an electric charge can acquire in a given situation. And, since energy is the ability to do work, the electric potential difference is also a measure of how much work a given charge can do. The exact amount depends both on the potential difference and on the charge.

Potential likened to height of a cliff

To better understand electric potential, let's make a comparison to the gravitational case when a rock falls from the top of a cliff. The greater the height, h, of a cliff, the more potential energy ($= mgh$) the rock has at the top of the cliff, relative to the bottom, and the more kinetic energy it will have when it reaches the bottom. The actual amount of kinetic energy it will acquire, and the amount of work it can do, depends both on the height of the cliff and the mass m of the rock. A large rock and a small rock can be at the same height h (Fig. 17–3a) and thus have the same "gravitational potential," but the larger rock has the greater potential energy (it has more mass). The electrical case is similar (Fig. 17–3b): the potential energy change, or the work that can be done, depends both on the potential difference (corresponding to the height of the cliff) and on the charge (corresponding to mass), Eq. 17–3. But note a significant difference: electric charge comes in two types, + and −, whereas gravitational mass is always +.