



Figure 27-7 (a) Point a is directly connected to ground. (b) Point b is directly connected to ground.

Figure 27-7b is the same circuit except that point b is now directly connected to ground. Thus, the potential there is defined to be $V_b = 0$. Equation 27-11 now tells us that the potential at a is $V_a = -8.0$ V.

Power, Potential, and Emf

When a battery or some other type of emf device does work on the charge carriers to establish a current i , the device transfers energy from its source of energy (such as the chemical source in a battery) to the charge carriers. Because a real emf device has an internal resistance r , it also transfers energy to internal thermal energy via resistive dissipation (Module 26-5). Let us relate these transfers.

The net rate P of energy transfer from the emf device to the charge carriers is given by Eq. 26-26:

$$P = iV, \quad (27-14)$$

where V is the potential across the terminals of the emf device. From Eq. 27-13, we can substitute $V = \mathcal{E} - ir$ into Eq. 27-14 to find

$$P = i(\mathcal{E} - ir) = i\mathcal{E} - i^2r. \quad (27-15)$$

From Eq. 26-27, we recognize the term i^2r in Eq. 27-15 as the rate P_r of energy transfer to thermal energy within the emf device:

$$P_r = i^2r \quad (\text{internal dissipation rate}). \quad (27-16)$$

Then the term $i\mathcal{E}$ in Eq. 27-15 must be the rate P_{emf} at which the emf device transfers energy *both* to the charge carriers and to internal thermal energy. Thus,

$$P_{\text{emf}} = i\mathcal{E} \quad (\text{power of emf device}). \quad (27-17)$$

If a battery is being *recharged*, with a “wrong way” current through it, the energy transfer is then *from* the charge carriers *to* the battery—both to the battery’s chemical energy and to the energy dissipated in the internal resistance r . The rate of change of the chemical energy is given by Eq. 27-17, the rate of dissipation is given by Eq. 27-16, and the rate at which the carriers supply energy is given by Eq. 27-14.

✓ Checkpoint 3

A battery has an emf of 12 V and an internal resistance of 2 Ω. Is the terminal-to-terminal potential difference greater than, less than, or equal to 12 V if the current in the battery is (a) from the negative to the positive terminal, (b) from the positive to the negative terminal, and (c) zero?