Chapter 18

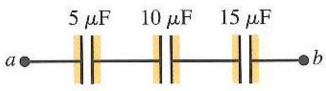
Conceptual Questions

1. *Why* must electric-field lines be perpendicular to equipotential surfaces?

3. If the electric field is zero throughout a certain region of space, is the potential necessarily zero in that region? If not, what *can* be said about the potential?

Multiple-Choice Problems

7. The capacitor network shown in Figure 18.36 is connected across a fixed potential difference of 25 V. Which statements about this network must be true? (There may be more than one correct choice.)
   A. The potential difference is the same across each capacitor.
   B. The charge is the same on each capacitor.
   C. The equivalent capacitance of the network is 30 μF.
   D. The equivalent capacitance of the network is less than 30 μF.

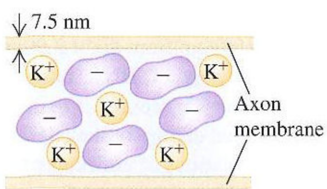


▲ **FIGURE 18.36** Multiple-choice problem 7.

9. If the electrical potential energy of two point charges is U when they are a distance d apart, their potential energy when they are twice as far apart will be
   A. $U/4$. B. $U/2$. C. $2U$. D. $4U$.

Problems

14. • **Axons.** BIO Neurons are the basic units of the nervous system. They contain long tubular structures called *axons* that propagate electrical signals away from the ends of the neurons. The axon contains a solution of potassium ions K^+ and large negative organic ions. The axon membrane prevents the large ions from leaking out, but the smaller K^+ ions are able to penetrate the membrane to some degree. (See Figure 18.39.) This leaves an excess negative charge on the inner surface of the axon membrane and an excess of positive charge on the outer surface, resulting in a potential difference across the membrane that prevents further K^+ ions from leaking out. Measurements show that this potential difference is typically about 70 mV. The thickness of the axon membrane itself varies from about 5 to 10 nm, so we'll use an average of 7.5 nm. We can model the membrane as a large sheet having equal and opposite charge densities on its faces. (a) Find the electric field inside the axon membrane, assuming (not too realistically) that it is filled with air. Which way does it point, into or out of the axon? (b) Which is at a higher potential, the inside surface or the outside surface of the axon membrane?



▲ **FIGURE 18.39** Problem 14.

48. • **Electric eels.** BIO Electric eels and electric fish generate large potential differences that are used to stun enemies and prey. These potentials are produced by cells that each can generate 0.10 V. We can plausibly model such cells as charged capacitors. (a) How should these cells be connected (in series or in parallel) to produce a total potential of more than 0.10 V? (b) Using the connection in part (a), how many cells must be connected together to produce the 500 V surge of the electric eel?