Solution 3.1: Diffusion

1. from A to B
2. negative
3. opposite

Solution 3.2: The Nernst Equation

1.

$$E_K = 58\text{mV} \cdot \log_{10}\left(\frac{[\text{K}^+]_{extracellular}}{[\text{K}^+]_{intracellular}}\right) = 58\text{mV} \cdot \log_{10}\left(\frac{5}{148}\right) = 58\text{mV} \cdot (-1.47) = -85.3\text{mV}$$

$$E_{Na} = 58\text{mV} \cdot \log_{10}\left(\frac{[\text{Na}^+]_{extracellular}}{[\text{Na}^+]_{intracellular}}\right) = 58\text{mV} \cdot \log_{10}\left(\frac{142}{10}\right) = 58\text{mV} \cdot 1.15 = 66.8\text{mV}$$

2.

$$E'_{Na} = 58\text{mV} \cdot \log_{10}\left(\frac{142+5}{10}\right) = 58\text{mV} \cdot 1.17 = 67.7\text{mV}$$

$$E'_K = 58\text{mV} \cdot \log_{10}\left(\frac{5+5}{148}\right) = 58\text{mV} \cdot (-1.17) = -67.9\text{mV}$$

$$\frac{E'_{Na} - E_{Na}}{E_{Na}} = +1.3\%$$

$$\frac{E'_K - E_K}{E_K} = -20.5\%$$

The extracellular change of $[\text{K}^+]$ has a more drastic effect. This condition is dangerous because the heart muscle contraction depends on the membrane potential, and this potential results from mechanisms very similar to the ones governing the neuron's potential.

Solution 3.3: The Goldman-Hodgkin-Katz Equation

Qualitatively:

Since $V_{membrane}$ is closer to E_K than to E_{Na}, we can conclude that the membrane must be more permeable to K^+, *i.e.*, P_K is bigger than P_{Na}.

Quantitatively:

$$V_{membrane} = \frac{RT}{F} \ln\left(\frac{P_K \cdot [\text{K}^+]_{out} + P_{Na} \cdot [\text{Na}^+]_{out}}{P_K \cdot [\text{K}^+]_{in} + P_{Na} \cdot [\text{Na}^+]_{in}}\right)$$

$$-77\text{mV} = 58\text{mV} \cdot \log_{10}\left(\frac{P_K \cdot 5 + P_{Na} \cdot 142}{P_K \cdot 148 + P_{Na} \cdot 10}\right)$$

$$10^{\frac{-77}{58}} = 0.0470 = \frac{P_K \cdot 5 + P_{Na} \cdot 142}{P_K \cdot 148 + P_{Na} \cdot 10}$$

$$P_K \cdot 148 \cdot 0.0470 + P_{Na} \cdot 10 \cdot 0.0470 = P_K \cdot 5 + P_{Na} \cdot 142$$

$$P_K \cdot (148 \cdot 0.0470 - 5) = P_{Na} \cdot (142 - 10 \cdot 0.0470)$$

$$\frac{P_K}{P_{Na}} = 72.2$$