Given the ion distributions inside and outside the cell, distributions that are maintained under steady-state conditions, we must now examine how such ion concentration gradients give rise to diffusion potentials. To do this, let us start with a concentration cell that we can construct in the laboratory, as diagrammed in Figure V-1. The chamber is completely divided into two compartments by a thin membrane made of celloidin, which has negatively charged pores. A solution of any salt at one concentration is placed in one compartment (side 1), and a solution of the same salt but at another concentration is placed in the other compartment (side 2). In the example shown, 0.1 M NaCl is in side 1 and 0.01 M NaCl is in side 2. There is a tendency for Na\(^+\) and Cl\(^-\) ions to diffuse down their concentration gradients from side 1 to side 2. The force for this diffusion process is the random motion of the particles, motion due to thermal energy. The probability is that the side of higher concentration will have more particles moving across the membrane from side 1 to side 2 per unit time than the side of lower concentration has moving across the membrane in the opposite direction.

The negatively charged Cl\(^-\) ions, however, cannot pass across the membrane, because of the negatively charged pores (like charges repel), as shown in the lower portion of Figure V-1. Therefore, the net diffusion of Na\(^+\) from side 1 to side 2 brings a surplus of positive charges to side 2 and leaves a deficiency of positive charges, or excess of negative charges, on side 1. In this manner, a potential difference (PD) is developed across the membrane, the side of higher
FIGURE V-1. Upper diagram: Concentration cell diffusion potential developed across artificial membrane containing negatively charged pores. Thus the membrane is impermeable to Cl\(^{-}\) ions but permeable to cations such as Na\(^{+}\). Concentration gradient for Na\(^{+}\) causes a potential to be generated, the side of higher Na\(^{+}\) concentration becoming negative. Lower diagram: Expanded diagram of a water-filled pore in the membrane, showing the permeability to Na\(^{+}\) ions but lack of penetration of Cl\(^{-}\) ions. Potential difference is generated by charge separation, a slight excess of Na\(^{+}\) ions being held close to the right-hand surface of the membrane; a slight excess of Cl\(^{-}\) ions is plastered up close to the left surface.