

Solutions to practice problems

1. What is the current through a 500 MΩ resistor if a potential of -80 mV is applied?

$$V = IR \rightarrow I = \frac{V}{R}$$

$$\begin{aligned} I &= \frac{V}{R} \\ &= \frac{-80 \times 10^{-3} \text{ V}}{500 \times 10^6 \Omega} \\ &= -1.6 \times 10^{-10} \text{ A} \end{aligned}$$

$$I = -160 \text{ pA}$$

2. There are four different channel types in a particular neuron: Na⁺, K⁺, Ca⁺, and Cl⁻ channels. Channel resistances at rest are, respectively, 1 GΩ, 500 MΩ, 700 MΩ, and 900 MΩ. What is the total membrane resistance?

$$\begin{aligned} \frac{1}{R_T} &= \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} \\ &= 10^{-9} \Omega + 2 \times 10^{-9} \Omega + 1.43 \times 10^{-9} \Omega + 1.11 \times 10^{-9} \Omega \end{aligned}$$

$$R_T = 180 \text{ M}\Omega$$

3. If the resting membrane potential (V_m) of a cell is -82 mV, the equilibrium potential for K⁺ (E_K) is -92 mV, and the total conductance through K⁺ channels (g_K) is 1 nS, how much K⁺ current is flowing?

$$V = IR \rightarrow I_K = g_K (E_m - E_K)$$

$$\begin{aligned} I_K &= g_K (E_m - E_K) \\ &= 1 \times 10^{-9} \text{ S} \left[-82 \times 10^{-3} \text{ V} - (-92 \times 10^{-3} \text{ V}) \right] \\ &= 1 \times 10^{-11} \text{ A} \end{aligned}$$

$$I = 10 \text{ pA} \quad (\text{Note, we would expect a small } I_K \text{ at } \underline{\text{rest}}).$$

4. In the single channel recording from Lecture 4 slide 8, the voltage difference across the membrane patch was -140 mV and every time the channel opened -6.6 pA of current flowed (i.e. negative denotes inward current). What was the resistance of this single channel?

$$V = IR \rightarrow R = \frac{V}{I}$$

$$R = \frac{V}{I}$$

$$= \frac{-140 \times 10^{-3} \text{ V}}{-6.6 \times 10^{-12} \text{ A}}$$

$$R = 21.2 \text{ G}\Omega$$

5. What is the equilibrium potential for Cl^- ions (E_{Cl}) if the molar concentration of extracellular Cl is 120 mM and intracellular Cl is 9 mM?

$$E_{\text{Cl}} = 58 \log \frac{[\text{Cl}]_i}{[\text{Cl}]_o} \quad (\text{at } 20^\circ\text{C})$$

$$= 58 \text{ mV} \log \left(\frac{9 \text{ mM}}{120 \text{ mM}} \right)$$

(Note, for Cl^- it is $\frac{i}{o}$ not $\frac{o}{i}$).

$$E_{\text{Cl}} = -65.2 \text{ mV}$$