Biol635/Math635/Biol432/Math430
Fall 2024
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Assignment 1

Answer the following questions.

- **Provide the final answers in the table below (Table 1)**
- **Submit the table as a separate file**
- Provide the necessary calculations in a **clear way** (in a separate file)
- Justify your answers
- Explain your results
- Provide the codes you used
- Mind the units

Question 1

Calculate the equilibrium (reversal) potentials for the following ions at a temperature of 20° C.

(a) K^+, $[K^+]_{out}$= 5 mmol/L, $[K^+]_{in}$= 150 mmol/L.
(b) Na^+, $[Na^+]_{out}$= 150 mmol/L, $[Na^+]_{in}$= 15 mmol/L.
(c) Cl^-, $[Cl^-]_{out}$= 125 mmol/L, $[Cl^-]_{in}$= 10 mmol/L.
(d) Ca^{2+}, $[Ca^{2+}]_{out}$= 2 mmol/L, $[Ca^{2+}]_{in}$= 0.0002 mmol/L.
(e) What is the effect of increasing the temperature to 25° C on these equilibrium potentials.
(f) Plot graphs of E_{Na}, E_K, E_{Ca} and E_{Cl} as a function of temperature in the range 10° C to 40° C.

Note: Mind the units and the signs.

Question 2

(a) Consider an ion X^+ at 20° C. What is the concentration relation $[X^+]_{out}$/ $[X^+]_{in}$ necessary to maintain a resting membrane potential V = -60 mV?
(b) How is this value affected when the temperature is increased to 25° C?

(c) Plot a graph of the concentration relation $[X^+]_{out}/[X^+]_{in}$ necessary to maintain a resting membrane potential V = -60 mV as a function of the temperature in the range 10° C to 40° C.

Question 3

Consider the following passive membrane equation

$$\tau \frac{dV}{dt} = -(V - E_L) + R\, I_{app} \tag{1}$$

with $V(0) = E_L$, $R = 100\, M\Omega$, $C = 100\, pF$, $I_{app} = 0.25\, nA$ and $E_L = -60mV$.

(a) Calculate the value of τ.

(b) Calculate the value of the term $R\, I_{app}$.

(c) Calculate, if possible, the time it takes the voltage to reach $V = -50\, mV$.

(d) Calculate, if possible, the time it takes the voltage to reach $V = -30\, mV$.

Note: Mind the units and the signs.

Question 4

Write a code to solve numerically eq. (1) or adapt the template code provided (see course website).

Simulate eq. (1) for the parameter values provided in Question 3 and

- $I_{app} = 0\, nA$
- $I_{app} = 0.25\, nA$
- $I_{app} = 0.5\, nA$

Plot the solutions in a single graph.

Note: The axis should be labeled correctly and the fonts should be large enough (suggested: “fontsize" = 24).

Question 5 (Graduate level)

Suppose you have the ability to do (wet) experiments and collect membrane potential data by injecting current to the cell (I_{app})

(a) Assuming the cell is a passive cell, how would you determine the membrane capacitance (C), the membrane resistance (R) and the reversal potential (E_L)?

(b) How would you determine that the cell is passive?

Question		Answer
1a	E_K	
1b	E_{Na}	
1c	E_{Cl}	
1d	E_{Ca}	
1e	E_K	
1e	E_{Na}	
1e	E_{Cl}	
1e	E_{Ca}	
1f		Graph
2a	$[X^+]_{out}$ / $[X^+]_{in}$	
2b	$[X^+]_{out}$ / $[X^+]_{in}$	
2c		Graph
3a	τ	
3b	$R\,I_{app}$	
3c	t (time)	
3d	t (time)	
4		Graph

Table 1: **Answers.**