

Biol635/Math635/Biol432/Math430
Fall 2025

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^+ , $[K^+]_{out} = 5 \text{ mmol/L}$, $[K^+]_{in} = 150 \text{ mmol/L}$.
- (b) Na^+ , $[Na^+]_{out} = 150 \text{ mmol/L}$, $[Na^+]_{in} = 15 \text{ mmol/L}$.
- (c) Cl^- , $[Cl^-]_{out} = 125 \text{ mmol/L}$, $[Cl^-]_{in} = 10 \text{ mmol/L}$.
- (d) Ca^{2+} , $[Ca^{2+}]_{out} = 2 \text{ mmol/L}$, $[Ca^{2+}]_{in} = 0.0002 \text{ mmol/L}$.
- (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 $V = -60 \text{ mV}$?
- (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 $V = -60 \text{ mV}$ as a function of the temperature in the range 10° C to 40° C .

Question 3

Consider the following passive membrane equation

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

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

- (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 $V = -50 \text{ mV}$.
- (d) Calculate, if possible, the time it takes the voltage to reach $V = -30 \text{ mV}$.

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

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

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.**