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71210 Bioelektroniikka - Bioelectromagnetism
Laskuharjoitus 3 – Exercise 3, 29.9.2004

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1. Why should RT/zF have the unit of "volts" in the Nernst equation? Show it!

2. The Nernst potential for magnesium ions (Mg^{++}) is -50 mV. The extracellular concentration of magnesium is 0.6 mmol/dm^3. What is the intracellular concentration of magnesium (in mmol/dm^3)? T= 37°C. Is it:
   a. 1.4
   b. 2.2
   c. 3.1
   d. 25
   e. 42

3. With regard to movement of ions and the Nernst equation:
(True/False?)
   (a) Ions always move across a membrane down their concentration gradient
   (b) The Nernst equation relates forces owing to concentration and electrical gradients
   (c) It is the voltage at which an ion is in equilibrium.
   (d) Nernst potentials are always positive values
   (e) If the measured membrane potential equals the value calculated using the Nernst equation then there will be no net movement of that ion.

4. The permeabilities of potassium, sodium and chloride ions in the giant axon of a squid at 36 °C are $P_K:P_{Na}:P_{Cl}$ = 1:0.04:0.45. The concentrations of the ions in intracellular and extracellular fluids are (10^{-3} mol/cm^3):

$[K^+]_i = 3.45$	$[K^+]_o = 0.10$
$[Na^+]_i = 0.72$	$[Na^+]_o = 4.55$
$[Cl^-]_i = 0.61$	$[Cl^-]_o = 5.40$

Determine the resting membrane potential. (*Answer = -62mV*)

5. What should be the breakdown tolerance of the cell membrane in the previous example when the thickness of the cell membrane is 100 Å? (*Answer = 6200 kV/m*)

6. A special single cell organism that lives in a natural mineral water spring has permeabilities of 0.09, 1.00 and 0.04 for the Cl^-, K^+ and Na^+, respectively, and the following concentrations

$[Cl^-]_i = 178$	$[Cl^-]_o = 0.47$
$[K^+]_i = 135$	$[K^+]_o = 83$
$[Na^+]_i = 0.05$	$[Na^+]_o = 118$

To *maintain* the chloride gradient, this cell has a special chloride pump. Which direction does the pump have to move chloride in order to maintain the status? T = 25°C.

7. Show that the resting potential of the cell membrane can be expressed as

$$V = \frac{g_K V_K + g_{Na} V_{Na} + g_{Cl} V_{Cl}}{g_K + g_{Na} + g_{Cl}}$$

where

g_i = membrane conductance for ions *i*,
Vi = equilibrium voltage for ions *i*.

8. Review the definitions for cell and membrane resistance, resistivity and capacitance as a function of length/area. (these are needed in next week's exercises…)