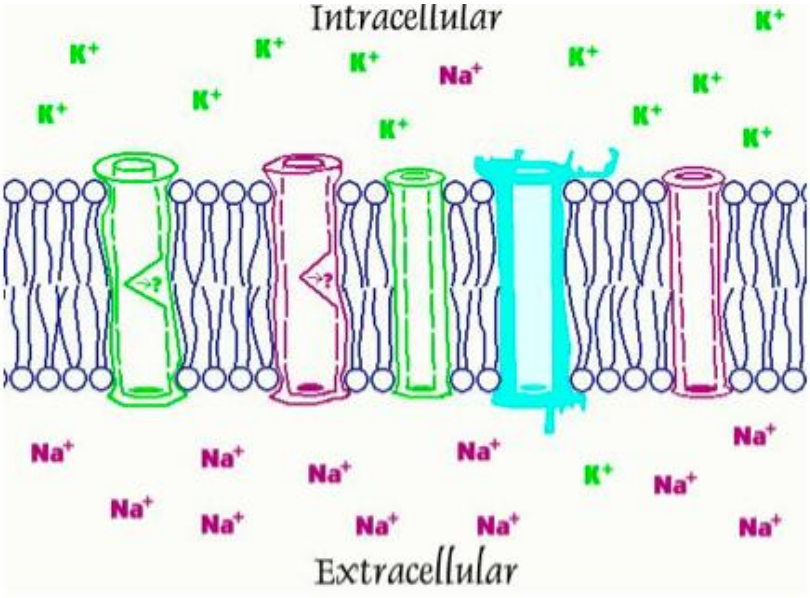
Solution

Physics 213 **Problem 3** **Week 7**

Membrane potentials

Cell membranes in living organisms are not completely in thermal equilibrium. Active pumps use chemical free energy to move some ions from inside a cell to outside and others the other way.



Suppose that the pumps maintain a voltage difference of 73meV between the inside and outside of the membrane in your average cell. (Inside is more negative.) In a slightly simplified picture, K^+ is able to move freely through special channels in the membrane, reaching equilibrium concentrations. What is the equilibrium ratio of K^+ concentration inside to that outside? (Assume K^+ forms an ideal solute. Also assume that the cell is at typical body temperature.)

$[K^+]_{in}/[K^+]_{out}$ =

$\mu_{in} = kT \ln\left(\frac{n_{in}}{n_T}\right)$ setting $U_{in} = 0.$

$\mu_{out} = kT \ln\left(\frac{n_{out}}{n_T}\right) + U_{out}$

Requiring $\mu_{in} = \mu_{out}$, one obtains $\frac{n_{in}}{n_{out}} = e^{U_{out}/kT} = e^{0.073ev/\left(8.6\times10^{-5}\,eV/K\cdot 300K\right)} = 16.8$