Key and guide to exam #2

Chemistry 488, Spring 2013
Physical Chemistry of Biochemical Systems

Use the hints below to get you started on problems you had trouble with on the second exam. You should arrange to meet with me if you still don't understand how to do the problems.

Problem 2 From the table:

$$\text{NADH} \rightarrow \text{NAD+} + \text{H}^+ + 2e^- \qquad \text{E(ox)} = +0.32 \text{ V}$$

$$\text{Q} + 2\text{H}^+ + 2e^- \rightarrow \text{QH}_2 \qquad \text{E(red)} = +0.04 \text{ V}$$

Add the two equations, so that the electrons cancel; add the cell potentials to get +0.36 V. Use the Nernst equation (5.12) to convert to $\Delta_r G^{\oplus}$.

Problem 3 For a first order reaction, $[A](t) = [A](0)\exp(-kt)$. Set [A](0) to 220 mM, [A](t) to 56 mM, t to 3.4 hr, and solve for k.

Problem 4 *(a)* the net rate of formation of [O] is $d[O]/dt = k_a[O_3] - k_{a'}[O][O_2] - k_b[O][O_3]$; make sure you know how to write down expressions like this. *(b)* At steady state $d[O]/dt = 0$; plug this into the equation for part *(a)*, and solve for [O].

Problem 5 The energy to pump protons is $\Delta G = RT\ln Q = RT\ln(1/1000)$, since the ratio of inner and outer concentrations is 1:1000 for a difference of 3 pH units. At equilibrium, this would be balanced by a membrane potential which is $zF\Delta\phi$, where here z=1. Set $zF\Delta\phi = \Delta G$, and solve for $\Delta\phi$. Note that we are dealing with pumping of protons here: redox potentials from the Table (which describe the thermodynamics of the transport of *electrons*) are irrelevant here.

Problem 6 This problem was harder than I intended it to be, and I apologize. It was not graded, since to answer you would have needed to have known (memorized) the units of viscosity. But you should think about problems like this. The numerator (k_BT) has units of J (make sure you know how to derive this!), and J=kg m^2 s^{-2}. Viscosity has units of kg m^{-1} s^{-1}, and the particle diameter has units of m. Dividing the units of the numerator by the units of the denominator yields the units of D, which are m^2 s^{-1}.