CHEM 361A - Lecture 14 Activity
Electrochemistry

In Class

1. The conversion of NADH to NAD^+ releases two electrons which are eventually used to reduce molecular oxygen to water in the terminal respiratory chain:

$$\begin{aligned} NAD^+ + H^+ + 2\,e^- &\longrightarrow NADH \; E^{\ominus\prime} = -0.32 \text{ V} \\ \tfrac{1}{2}\,O_2 + 2\,H^+ + 2\,e^- &\longrightarrow H_2O \; E^{\ominus\prime} = 0.816 \text{ V} \end{aligned}$$

   What is the change in the standard biochemical Gibbs Free Energy as a pair of electrons pass through the terminal respiratory chain?

2. One way to prevent a buried iron pipe from rusting is to connect it with a piece of wire to a magnesium or zinc rod. What is the electrochemical principle for this action?

3. For the reaction

$$NAD^+\,(aq) + H_3O^+\,(aq) + 2\,e^- \longrightarrow NADH\,(aq)$$

   $E^{\ominus\prime} = -0.320$ V at 25°C. Calculate the value of E' at pH = 1 and $[NAD^+]$=[NADH]=1. Recall that the prime means that we are using the biochemical standard state meaning that $m^\ominus$ for H_3O^+ is 1×10^{-7}. Assume $\gamma_\pm = 1$.

4. A sodium ion channel which transports Na^+-ions across a cell membrane can be described by the following reaction:

$$Na^+_{\text{outside}} \rightleftharpoons Na^+_{\text{inside}} \qquad\qquad E^{\ominus\prime} = -0.062 \text{ V}$$

   At equilibrium, if the $[Na^+_{\text{outside}}]$=0.143 M, what is $[Na^+_{\text{inside}}]$ at 37°C?

Homework

5. You have a electrochemical cell setup with the following Daniell Cell

$$Sn\,(s)|Sn^{2+}(aq)||Pb^{2+}(aq)|Pb\,(s)$$

   At 25°C, determine

   (a) $E^\ominus$ (0.0113 V)

   (b) $\Delta G^\ominus$ (-2180.9 J mol^{-1})

(c) K (2.4)

(d) The ratio of $[Sn^{2+}]/[Pb^{2+}]$ at equilibrium. Assume $\gamma_{\pm} = 1$ Recall that when writing a chemical reaction for redox chemistry that the anode half-cell reaction is the forward reaction, and the cathode half-cell reaction is the reverse reaction. Assume $\gamma_{\pm}$ is the same for all ionic species. (2.4)

6. Calculate the EMF of the Daniell Cell below at 25°C. Assume $\gamma_{\pm} = 1$. (0.010 V)

$$\mathrm{Mg\,(s)|Mg^{2+}(aq)\,(0.24\,M)||Mg^{2+}(aq)\,(0.53\,M)|Mg\,(s)}$$

7. Flavin Adenine Dinucleotide (FAD) participates in several biological redox reactions according to the half-reaction

$$\mathrm{FAD + 2\,H^+ + 2\,e^- \longrightarrow FADH_2}$$

If the value of $E^{\ominus\prime}$ of thie reaction is -0.219 V at 25°C, and pH 7, calculate its reduction potential at this temperature and pH when the solution contains

(a) 85% of the oxidized form (-0.197 V)

(b) 15% of the oxidized form (-0.241 V)

For both cases, assume $\gamma_{\pm} = 1$.