Nernst Equation

Consider the half reaction:

$$NO_3^- + 10H^+ + 8e^- \leftrightarrow NH_4^+ + 3H_2O(l)$$

We can calculate the Eh if the activities of H^+, NO_3^-, and NH_4^+ are known. The general Nernst equation is

$$Eh = E^0 - \frac{2.303RT}{n\Im}\log Q$$

The Nernst equation for this reaction at 25°C is

$$Eh = E^0 - \frac{0.0592}{8}\log\left(\frac{a_{NH_4^+}}{a_{NO_3^-}a_{H^+}^{10}}\right)$$

Let's assume that the concentrations of NO_3^- and NH_4^+ have been measured to be 10^{-5} M and 3×10^{-7} M, respectively, and pH = 5. What are the Eh and pe of this water?

First, we must make use of the relationship

$$E^0 = \frac{-\Delta G_r^o}{n\Im}$$

For the reaction of interest

$$\Delta_r G^\circ = 3(-237.1) + (-79.4) - (-110.8)$$

$$= -679.9 \text{ kJ mol}^{-1}$$

$$E^0 = \frac{679.9}{(8)(96.42)} = 0.88 \text{ volts}$$

The Nernst equation now becomes

$$Eh = 0.88 - \frac{0.0592}{8}\log\left[\frac{a_{NH_4^+}}{a_{NO_3^-}a_{H^+}^{10}}\right]$$

substituting the known concentrations (neglecting activity coefficients)

$$Eh = 0.88 - \frac{0.0592}{8}\log\left[\frac{3\times10^{-7}}{\left(10^{-5}\right)\left(10^{-5}\right)^{10}}\right] = 0.521\,\text{volts}$$

and

$$pe = 16.9Eh = 16.9(0.521) = 8.81$$