1 Electrostatics

We first start with the concept of thermodynamic electrochemical potential. Just like chemical potential $\mu$, at equilibrium the chemical potentials are equal, $\mu_1 = \mu_2$. Since we are discussing electrochemical potential we need to describe how the chemical potential is related to the electrostatic potential. We can do this by writing the electrochemical potential as:

$$\tilde{\mu}_{\text{ion}} = \mu_{\text{ion}} + Ze\psi(x)$$

The chemical potential is given by:

$$\mu^0_{\text{ion}} + RT \ln a_{\text{ion}}(x) + Ze\psi(x)$$

and for dilute solutions $a_{\text{ion}}(x)$ can be replaced by concentration $C_{\text{ion}}(x)$. The bulk behavior is neutral, in that the electric static charges cancel each other out and thus the electrochemical potential of the bulk is simply $\tilde{\mu}_{\text{ion,bulk}} = \mu_{\text{ion,bulk}}$. We now can solve for an explicit formulation of the electrochemical potential:

$$\tilde{\mu}_{\text{ion}} = \tilde{\mu}_{\text{bulk}} = \mu_{\text{bulk}}$$

$$\mu_{\text{bulk}} = \mu^0 + RT \ln C_{\text{ion,bulk}}$$

$$RT \ln C_{\text{ion}}(x) + Ze\psi(x) = RT \ln C_{\text{ion,bulk}}$$
\[
RT \ln C_{\text{ion}}(x) - RT \ln C_{\text{ion, bulk}} + Z e \psi(x)
\]

\[
RT \ln \frac{C_{\text{ion}}(x)}{C_{\text{ion, bulk}}(x)} = -Z e \psi(x)
\]

\[
\frac{C_{\text{ion}}(x)}{C_{\text{ion, bulk}}(x)} = \exp \frac{-Z e \psi(x)}{RT}
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\therefore C_{\text{ion}}(x) = C_{\text{ion, bulk}} \exp \frac{-Z e \psi(x)}{RT}
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Figure 1: Plot of eq. 1