Equilibrium Potential (Nernst equation)

There are two thermodynamic systems in communication

System I System II

Each has a Free energy $\bar{\mu}_i = \underbrace{RT \ln C_i}_{\text{chemical}} + \underbrace{Z_i F \Phi}_{\text{electrical}}$

energies: chemical electrical

i is an ion such as K^+ or Na^+

c is concentration, sometimes denoted in brackets, eg $[K^+]$

Φ is absolute potential, but only potential difference is ever measured

$R = 8.31 \frac{\text{Joules}}{\text{mole } ^\circ K}$ $z =$ "valence", 1 for K^+, 2 for Ca^{2+}

$F = 9.65 \times 10^4 \frac{\text{coul}}{\text{mole}} = 6.02 \times 10^{23} \frac{\text{ions}}{\text{mole}} \times 1.6 \times 10^{-19} \frac{\text{coul}}{\text{ion}}$

↑ charge of a mole of ions ↑ Avagadro's number ↑ charge of electron

<u>Assume</u> equilibrium, $\mu_{K^+}^{I} = \mu_{K^+}^{II}$

(electrical potential is equal and opposite of chemical potential)

$$RT \ln [K^+ I] - RT \ln [K^+ II] = -F(\Phi_I - \Phi_{II})$$

$$E_m = -\frac{RT}{F} \ln \frac{[K^+ in]}{[K^+ out]} = -2.3 \frac{RT}{F} \log_{10} \frac{[K^+_{in}]}{[K^+_{out}]}$$

$$= -58 \log_{10} \frac{[K^+_{in}]}{[K^+_{out}]}$$