Butler Volmer Equation as per F. Fuller

For a chemical reaction at an electrode:

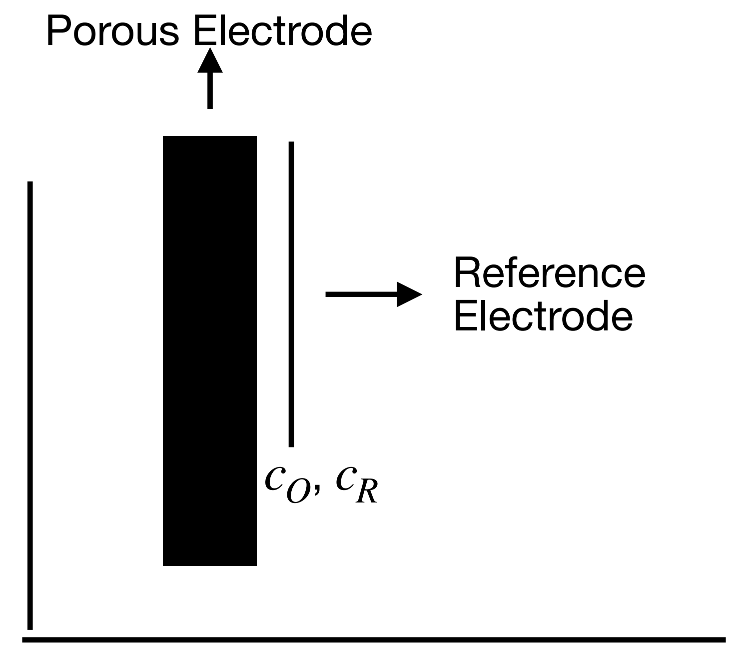
$\boxed{O + e^- \leftrightarrow R}$

$$i = i_0 \left[\exp\left(\frac{\alpha_a F \eta_s}{RT}\right) - \exp\left(\frac{-\alpha_c F \eta_s}{RT}\right) \right]$$

i : Current Density (A/m^2)

i_0 : Exchange Current Density (A/m^2)

η_s : Overpotential (V)



Here, reference electrode is kept at just outside the electrode and U_{eq} is measured from concentrations at that point (c_O and c_R)

$$\eta_s = \left[(\phi_1 - \phi_2) - U_{eq} \right]$$

ϕ_1 : Absolute Potential of Electrode (with respect to reference electrode)

ϕ_2 : Absolute Potential of Electrolyte just outside the double-layer (with respect to reference electrode)

U_{eq} : Equilibrium potential of the reaction (at actual concentrations c_O and c_R)

$$U_{eq} = U_0 - \frac{RT}{nF} \ln\left(\frac{c_R/c_R^0}{c_O/c_O^0}\right)$$

$$\frac{i_0}{F} = k_a^{\beta} k_c^{1-\beta} c_R^{\beta} c_O^{1-\beta}$$

Butler Volmer Equation as per J.Bard

For a chemical reaction at an electrode:

$\boxed{O + e^- \leftrightarrow R}$

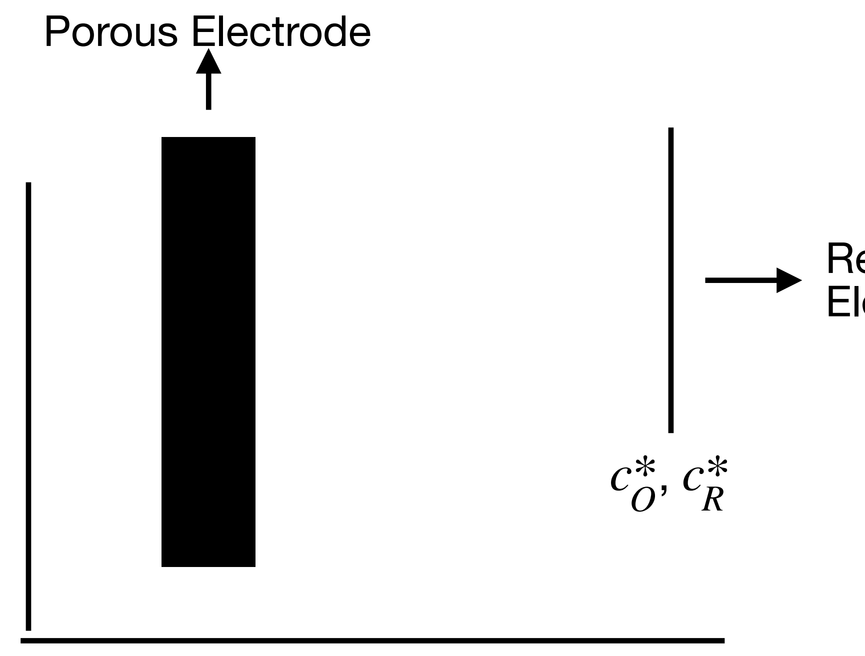
$$i = i_0^* \left[\left(\frac{c_R}{c_R^*}\right) \exp\left(\frac{\alpha_a F \eta_s^*}{RT}\right) - \left(\frac{c_O}{c_O^*}\right) \exp\left(\frac{-\alpha_c F \eta_s^*}{RT}\right) \right]$$

$$\eta_s^* = \left[(\phi_1 - \phi_2) - U_{eq}^* \right]$$

U_{eq}^* : Equilibrium potential of the reaction (at bulk concentrations c_O^* and c_R^*)

$$U_{eq}^* = U_0 - \frac{RT}{nF} \ln\left(\frac{c_R^*/c_R^0}{c_O^*/c_O^0}\right)$$

$$\frac{i_0^*}{F} = k_a^{\beta} k_c^{1-\beta} c_R^{*\beta} c_O^{*1-\beta}$$



Here, reference electrode is kept at the bulk of the electrolyte and U_{eq} is measured from concentrations at that point (c_O^* and c_R^*)