

## Overall electrochemical reaction inside a fuel cell system



General electrical work

$$W = EI\Delta t \quad \text{E2}$$

The electrical work done in the fuel cell system

$$W = -nFE_{\text{cell}} \quad \text{E3}$$

The Gibbs free energy is the maximum amount of work done on the system.

$$W_{\text{el}} = \Delta G \quad \text{E4}$$

$$\Delta G = -nFE_{\text{cell}} \quad \text{E5}$$

The maximum cell potential or the reversible cell potential becomes

$$E_{\text{rev}} = \frac{\Delta G}{-nF} \quad \text{E6}$$

If all the potential chemical energy for a reaction went into electrical work and there was no heat transfer, there would be no entropy change;  $dG = dH$ . In this case, we can show that:

$$E_{\text{rev}} = \frac{\Delta H}{-nF} \quad \text{E7}$$

For a generic reaction or process



$$\Delta G_f = \Delta G_f^0 + RT \ln \left[ \frac{aC^c aD^d}{aA^a aB^b} \right] \quad \text{E9}$$

To convert to voltage

$$E(T,P) = E^{\circ} - \frac{RT \ln \left( \frac{aC^c aD^d}{aA^a aB^b} \right)}{nF} \quad \text{E10}$$