

## Study Guide to Electrochemistry

1. Term to know:

- Faraday Constant: The charge (in Coulombs) of one mole of electrons:

$$F = 96485 \text{ C / mol e}^-$$

2. The relationship between  $\Delta G$  and  $E_{\text{cell}}$ :

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

- Where:

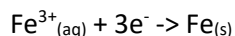
- $\Delta G$ : Change in Gibbs Free Energy
- $n$ : number of moles of electrons exchanged in the redox reaction
- $F$ : Faraday's constant
- $E_{\text{cell}}$ : The general cell potential (not necessarily under standard conditions)

3. How to tell if a reaction is spontaneous from the value of  $E_{\text{cell}}$ :

- If  $E_{\text{cell}}$  is positive ( $E_{\text{cell}} > 0$ ), then the reaction is spontaneous
- If  $E_{\text{cell}}$  is negative ( $E_{\text{cell}} < 0$ ), then the reaction is not spontaneous

4. How to combine known  $E^\circ$  values to find an unknown  $E^\circ$  value

Consider the following reaction:



This reaction (and its  $E^\circ$  value) are not found in the standard reduction potentials table. Instead, we find the following:

1.  $\text{Fe}^{2+}_{(\text{aq})} + 2\text{e}^- \rightarrow \text{Fe}_{(\text{s})}$  ( $E^\circ = -0.440 \text{ V}$ )
2.  $\text{Fe}^{3+}_{(\text{aq})} + \text{e}^- \rightarrow \text{Fe}^{2+}_{(\text{aq})}$  ( $E^\circ = 0.771 \text{ V}$ )
3.  $\text{Fe}^{3+}_{(\text{aq})} + 3\text{e}^- \rightarrow \text{Fe}_{(\text{s})}$  ( $E^\circ = ?$ )

We cannot just add the  $E^\circ$  values because the number of electrons transferred is different for both equations. Instead, we calculate the  $\Delta G$  values, which we can then add:

$$\Delta G = -nFE^\circ_{\text{cell}}$$

1.  $\Delta G = -(2 \text{ mol e}^-)(96485 \text{ C/mol e}^-)(-0.440 \text{ V}) = 0.880F \text{ V}$
2.  $\Delta G = -(1 \text{ mol e}^-)(96485 \text{ C/mol e}^-)(0.771 \text{ V}) = -0.771F \text{ V}$

$$\Delta G_{\text{total}} = 0.880F \text{ V} - 0.771F \text{ V} = 0.109F \text{ V}$$

We can then use  $\Delta G_{\text{total}}$  to calculate  $E^\circ$ :

$$\Delta G_{\text{total}} = 0.109F \text{ V}$$

$$-nFE^{\circ} = 0.109F V$$

$$-3FE^{\circ} = 0.109F V$$

$$E^{\circ} = -0.0363 V$$