April 15, 2002

- **Exam #3**
  - ✓1999 Exam #3 Questions - answers posted
  - ✓Exam Info Page - updated!
  - ✓**Monday, 4/15 Review/Problem Session: 3 - 4 pm, A531 Cook**

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Example

$$2Al\ (s) + 3Cu^{2+}\ (aq) \rightarrow 3Cu\ (s) + 2Al^{3+}\ (aq)$$

E^o_{cell}? DG^o? K?

E^o_{cell}:

$2 \times [Al(s) \rightarrow Al^{3+}\ (aq) + 3e^-]$	-(-1.66 v)
$3 \times [Cu^{2+}\ (aq) + 2e^- \rightarrow Cu\ (s)]$	+0.337 v
$2Al\ (s) + 3Cu^{2+}\ (aq) \rightarrow 3Cu\ (s) + 2Al^{3+}\ (aq)$	***+2.00 v***

reaction is *spontaneous*

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Now for ΔG^o

$$\Delta G^o = -n\ FE^o_{cell}$$

$\Delta G^o = -(6 \text{ mol e-/mol})(9.6487 \times 10^4 \text{ C/mol e}^-)(2.00 \text{ v})$

$\Delta G^o = -1.158 \times 10^6$ C-v/mol

Joules

$\Delta G^o =$ *-1.16×10^3 kJ/mol*

Equilibrium at last

- Two paths:
  - From ΔG^o (= -RTLnK)
  - From $E^o_{cell} = (0.0592/n)\text{LogK}$

$$\text{LogK} = \frac{(E^o_{cell})n}{0.0592}$$

$$\text{Log K} = \frac{(2.00 \text{ v})(6 \text{ mol e}^-)}{0.0592} = 202.703$$

$$K = 10^{202.703} = 5.043 \times 10^{203} = \mathbf{10^{203}}$$

Non-Standard States?

Recall: $DG = DG^o + RTLnQ$

Since: $\Delta G = -n\,FE_{cell}$

Substituting:

$$\boxed{E_{cell} = E^o_{cell} - \frac{RT}{n\,F} LnQ}$$

The Nernst Equation

At 298.15 K: $$\boxed{E_{cell} = E^o_{cell} - (0.0592/n)LogQ}$$

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Nernst Example

Pt (s)|Fe^{2+} (0.10 *M*), Fe^{3+} (0.20 *M*)||Ag^+ (1.0 *M*)|Ag (s)

Calculate E_{cell}

First, determine E^o_{cell}:

Ox	$Fe^{2+} \rightarrow Fe^{3+} + e^-$	-(0.771 v)
Red	$Ag^+ + e^- \rightarrow Ag\ (s)$	+0.800 v
	$Ag^+ + Fe^{2+} \rightarrow Ag\ (s) + Fe^{3+}$	*+0.029 v*

E^o_{cell}

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Example Continues

Next, find value of ***Q:***

$$Q = \frac{[Fe^{3+}]}{[Ag^{+}][Fe^{2+}]} = \frac{(0.20)}{(1.0)(0.10)} = \boldsymbol{2.0}$$

Lastly, into the *Nernst Equation:*

$$\mathbf{E_{cell} = E^{o}_{cell} - (0.0592/n)LogQ}$$

$$\mathbf{E_{cell}} = 0.029 - (0.0592/1)Log(2.0)$$

$$\mathbf{E_{cell}} = 0.029 - 0.01782 = \mathit{0.01179\ volts}$$

$$\mathbf{E_{cell}} = \underline{\boldsymbol{0.012\ volts}}$$

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Nernst (huh!) . . . What is it good for?

- Concentration Determinations

$$\boxed{\text{Pt, } H_2 \text{ (1 atm)}|H^+ (x\ M)||H^+ (1\ M)|H_2 \text{ (1 atm), Pt}}$$

Unknown $[H^+]$ (Anode)

Std Hydrogen Electrode (Cathode)

Ox $\quad H_2 (g) \rightarrow 2H^+ (aq) + 2e^-$

Red $\quad 2H^+ (aq) + 2e^- \rightarrow H_2 (g)$

concentration cell

$$\underset{(1\ M)}{2H^+ (aq)} \rightarrow \underset{(x\ M)}{2H^+ (aq)}$$

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Using Nernst

$$E_{cell} = E^o_{cell} - (0.0592/n)\text{Log}Q$$

$$Q = \frac{[H^+]^2_{anode}}{[H^+]^2_{cathode}} = \frac{[H^+]^2_{anode}}{1\ M}$$

$$E_{cell} = 0.000 - (0.0592/2)\text{Log}[H^+]^2_{anode}$$

$$E_{cell} = \frac{-2(0.0592)}{2}\ \text{Log}[H^+]_{anode}$$

$$E_{cell} = -0.0592\ \text{Log}\ [H^+]_{anode}$$

$$\boxed{E_{cell} = 0.0592\ pH}$$

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