Quiz 19.3 – The Nernst Equation

Name: Key

A cell is constructed which reduces Pb^{2+} to Pb and oxidizes Al to Al^{3+} and operated at $25.00\ ^\circ C$

Question 1

Find E°_{cell} for this cell

$E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode} = -0.13 - (-1.66) = 1.53\ V$

Question 2

Based on E°_{cell}, find ΔG° for the reaction in this cell

$\Delta G^\circ = -nFE^\circ$ n for this reaction is 6 $3Pb^{2+} + 2Al \rightarrow 3Pb + 2Al^{3+}$

$\Delta G^\circ = -6 \cdot 96,485\ C/mol \cdot 1.53V = -885,735\ J/mol = -886\ kJ/mol$

Question 3

Based on E°_{cell}, find K for the reaction in this cell

$E^\circ = \frac{RT}{nF} \ln K \rightarrow K = e^{\frac{E^\circ nF}{RT}} = e^{\frac{1.53V \cdot 6 \cdot 96,485\ C/mol}{8.314\ J/mol\cdot K \cdot 298\ K}} = 1.82 \cdot 10^{155}$

Question 4

Find E for this cell if the actual concentrations are: $[Pb^{2+}] = 0.250\ M$ and $[Al^{3+}] = 0.125\ M$

$E = E^\circ - \frac{RT}{nF} \ln Q \qquad Q = \frac{(0.125)^2}{(0.250)^3} = 1.0$ ← This is an accidental coincidence!

$E = 1.53V - \frac{8.314\ J/mol\cdot K \cdot 298\ K}{6 \cdot 96,485\ C/mol} \cdot \ln(1.0) = 1.53\ V$

Question 5

Will the voltage increase or decrease if the cell is placed in the refrigerator?

It's complicated... $\Delta G^\circ = -RT\ln K \rightarrow \Delta H^\circ - T\Delta S^\circ = -RT\ln K \rightarrow \frac{d\ln K}{dT} = \frac{\Delta H^\circ}{RT^2}$

$E^\circ = \frac{RT}{nF} \ln K \qquad \frac{dE^\circ}{dT} = \frac{R}{nF} \ln K + \frac{RT}{nF} \cdot \frac{\Delta H^\circ}{RT^2} \rightarrow \frac{dE^\circ}{dT} = \frac{R}{nF}\left(\ln K + \frac{\Delta H^\circ}{RT}\right)$