

CHEMISTRY 133**Quiz 3 – 10 points**

Name _____

Calculate E° for the half-reaction $\text{Pd}(\text{OH})_2(\text{s}) + 2\text{e}^- \leftrightarrow \text{Pd}(\text{s}) + 2\text{OH}^-$ given that K_{sp} for $\text{Pd}(\text{OH})_2$ is 3×10^{-28} and $E^\circ = 0.915 \text{ V}$ for the reaction $\text{Pd}^{2+} + 2\text{e}^- \leftrightarrow \text{Pd}(\text{s})$. Assume $T = 298 \text{ K}$

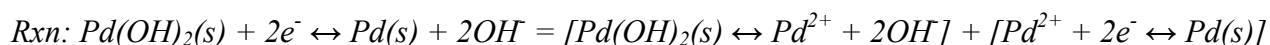
Information you may want to use:

Nernst Equation:

$$E = E^\circ - \frac{RT}{nF} \ln Q = E^\circ - \frac{2.303RT}{nF} \log Q = E^\circ - \frac{0.05916}{n} \log Q \quad (T = 298 \text{ K})$$

$R = \text{Universal Gas Constant} = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$; $F = \text{the faraday} = 96,500 \text{ C/mol e}^-$; $n = \text{moles e}^-$

$$\Delta G^\circ = -RT \ln K$$



For 1 mol of $\text{Pd}^{2+} + 2\text{e}^- \leftrightarrow \text{Pd}(\text{s})$, $\Delta G^\circ = -nFE^\circ = -(2)(96,490 \text{ C/mol e}^-)(0.915 \text{ V}) = -176.6 \text{ kJ/mol}$

For 1 mol of $\text{Pd}(\text{OH})_2(\text{s}) \leftrightarrow \text{Pd}^{2+} + 2\text{OH}^-$, $\Delta G^\circ = -RT \ln K = -8.314(298) \ln(3 \times 10^{-28}) = 157.0 \text{ kJ/mol}$

For 1 mol of $\text{Pd}(\text{OH})_2(\text{s}) + 2\text{e}^- \leftrightarrow \text{Pd}(\text{s}) + 2\text{OH}^-$, $\Delta G^\circ = -176.6 + 157.0 \text{ kJ/mol} = -19.6 \text{ kJ/mol}$

$$E^\circ = -\Delta G^\circ/nF = 19.6/(2 \cdot 96490 \text{ C/mol e}^-) = \mathbf{0.101 \text{ V}}$$

Alternatively, can solve by using the Nernst equation for the half- reaction $\text{Pd}^{2+} + 2\text{e}^- \leftrightarrow \text{Pd}(\text{s})$ under standard conditions for the half-reaction $\text{Pd}(\text{OH})_2(\text{s}) + 2\text{e}^- \leftrightarrow \text{Pd}(\text{s}) + 2\text{OH}^-$. Standard conditions means $[\text{OH}^-] = 1 \text{ M}$ and Pd will be present at the equilibrium concentration in the presence of $\text{Pd}(\text{OH})_2(\text{s})$ and 1 M OH^- .

$$E^\circ(\text{Pd}(\text{OH})_2(\text{s}) \text{ reduction}) = E^\circ - 0.05916/2 \log\{1/[\text{Pd}^{2+}]\} = 0.915 \text{ V} + 0.05916/2 \log[\text{Pd}^{2+}]$$

$$[\text{Pd}^{2+}] = K_{\text{sp}}/[\text{OH}^-]^2 = 3 \times 10^{-28} \text{ so } E^\circ(\text{Pd}(\text{OH})_2(\text{s}) \text{ reduction}) = 0.915 - 0.814 \text{ V} = \mathbf{1.01 \text{ V}}$$