Electrochemistry Quiz **Name:** Key

May I post your solution? [ ] Yes [ ] No [ ] Yes, but redact my name

Consider a Galvanic/voltaic cell based on the following half reactions under standard conditions.

$$\mathbf{Fe^{2+}\,(aq) + 2\,e^- \rightarrow Fe\,(s)} \qquad E° = -0.440\text{ V}$$

$$\mathbf{Cd^{2+}\,(aq) + 2\,e^- \rightarrow Cd\,(s)} \qquad E° = -0.403\text{ V}$$

What will be the cell potential (E_{cell}) when the cathode solution *changes* by 0.827 M?
<u>You may leave your answer in the form of an expression.</u>

To construct a Galvanic/voltaic cell, the overall reaction must be spontaneous: $\Delta G° < 1$ and $E°_{\text{cell}} > 0\text{ V}$.

This means that the following reactions must take place:

- Anode oxidation $Fe\,(s) \rightarrow Fe^{2+}\,(aq) + 2\,e^-$
- Cathode reduction $Cd^{2+}\,(aq) + 2\,e^- \rightarrow Cd\,(s)$

The overall (net ionic) equation for the cell is: $Fe\,(s) + Cd^{2+}\,(aq) \rightarrow Fe^{2+}\,(aq) + Cd\,(s)$

$$\begin{aligned} E°_{\text{cell}} &= E°_{\text{cathode}} - E°_{\text{anode}} \\ &= -0.403\text{ V} - (-0.440\text{ V}) \\ E°_{\text{cell}} &= +0.037\text{ V} \end{aligned}$$

Now we can set up an IC"E" chart to determine how much of each solution will be left after the cell has operated for some time. Note three things though:

- We are starting at standard conditions initially, so $[Fe^{2+}] = [Cd^{2+}] = 1.000$ M and T = 298.15 K.
- The change value is x = 0.827 M.
- The number of electrons is $n = 2$.

	Fe (s)	+	Cd^{2+} (aq)	→	Fe^{2+} (aq)	+	Cd (s)
I	n/a		1.000 M		1.000 M		n/a
C	n/a		– 0.827		+ 0.827		n/a
"E"	n/a		0.173 M		1.827 M		n/a

Now use the Nernst equation to find the new cell potential at these concentrations:

$$\begin{aligned} E_{\text{cell}} &= E°_{\text{cell}} - \frac{RT}{nF}\ln\left(\frac{[Fe^{2+}]}{[Cd^{2+}]}\right) \\ &= 0.037\text{ V} - \frac{\left(8.314\frac{\text{J}}{\text{mol}\cdot\text{K}}\right)(298.15\text{ K})}{(2\text{ mol }e^-)\left(96500\frac{\text{C}}{\text{mol }e^-}\right)}\cdot\ln\left(\frac{1.827}{0.173}\right) \\ E_{\text{cell}} &= 0.007\text{ V} \end{aligned}$$