2) a.) Given that the value of \( (2.303RT/mF) \) is 0.0592 at \( 25^\circ C \), what would be the voltage reading for the concentration cell 0.01 M \( \text{Cu}^{2+} / \text{Cu} \) and 1.0 M \( \text{Cu}^{2+} / \text{Cu} \).

\[
\text{Cu(s) “input”} \quad \| \quad \text{Cu}^{+2} (1.0 \text{ M}) \quad \| \quad \text{Cu}^{+2} (0.01 \text{ M}) \quad \| \quad \text{Cu(s) “ref”}
\]

For a concentration cell, the Nernst Equation becomes
\[
E = -\left(\frac{RT}{nF}\right) \ln \left(\frac{[X]_1}{[X]_2}\right)
\]
where the subscripts indicate the two concentrations.

The question is: which concentration is in the numerator and which in the denominator?

Remembering that a spontaneous process has a negative \( \Delta G \) and that \( \Delta G = -nF E \), the spontaneous direction of the cell reaction will be that for which \( E \) is positive.

For that to be the case, the quantity in the logarithm must be less than 1 (\( \ln x \) is negative if \( x < 1 \))

So the positive electrode potential will correspond to the smaller concentration being in the numerator. This is equivalent to saying that the reaction proceeds in the direction which will cause a dilution of the more concentrated species.

At the half-cell with the larger concentration, \( [X_2] \), \( X \) is being reduced, so electrons must be flowing into that solution. These electrons have come from the half-cell with the lower concentration. I.e., the electron flow is as shown by the arrows.

Since electrons flow from a point of low potential to higher potential, the electrode in the half cell \( X_2 \) must be the positive electrode (cathode).

b) Will the voltage be positive or negative?

If the voltmeter is connected so the reference lead is connected to the less concentrated half-cell, the voltage will be positive.

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\(^1\) Normal convention writes the cell notation with the anode (at which oxidation occurs) on the left and the cathode on the right. I.e., by convention, the reference electrode is on the left. The representation in this problem labels the anode correctly, but places it on the right. That should not affect the solution of this problem.