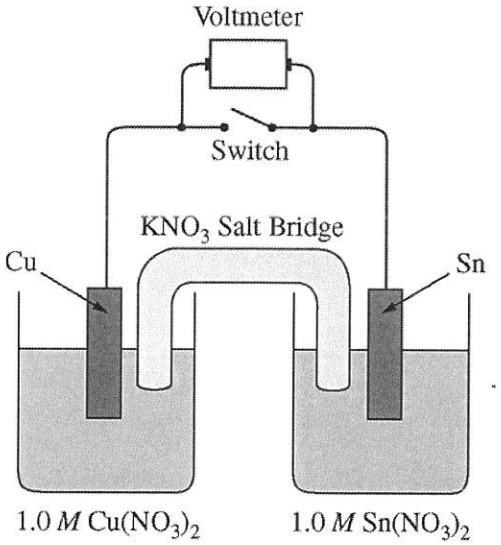
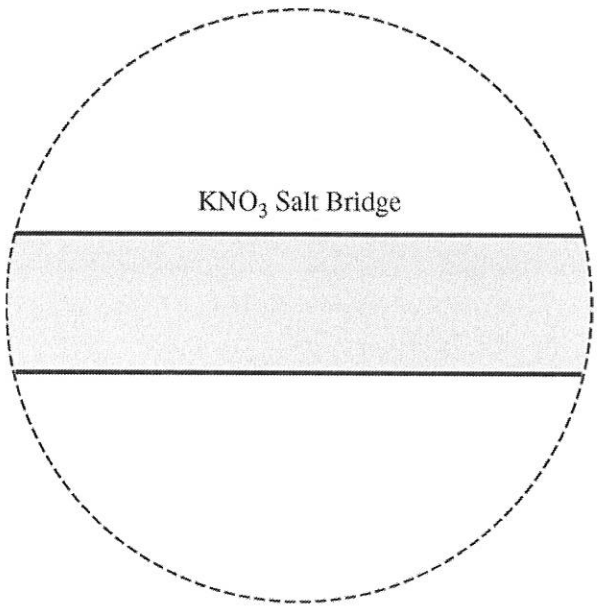



3. A student is given a standard galvanic cell, represented above, that has a Cu electrode and a Sn electrode. As current flows through the cell, the student determines that the Cu electrode increases in mass and the Sn electrode decreases in mass.

   (a) Identify the electrode at which oxidation is occurring. Explain your reasoning based on the student's observations.

   (b) As the mass of the Sn electrode decreases, where does the mass go?

   (c) In the expanded view of the center portion of the salt bridge shown in the diagram below, draw and label a particle view of what occurs in the salt bridge as the cell begins to operate. Omit solvent molecules and use arrows to show the movement of particles.



(d) A nonstandard cell is made by replacing the 1.0 *M* solutions of $Cu(NO_3)_2$ and $Sn(NO_3)_2$ in the standard cell with 0.50 *M* solutions of $Cu(NO_3)_2$ and $Sn(NO_3)_2$. The volumes of solutions in the nonstandard cell are identical to those in the standard cell.

(i) Is the cell potential of the nonstandard cell greater than, less than, or equal to the cell potential of the standard cell? Justify your answer.

(ii) Both the standard and nonstandard cells can be used to power an electronic device. Would the nonstandard cell power the device for the same time, a longer time, or a shorter time as compared with the standard cell? Justify your answer.

(e) In another experiment, the student places a new Sn electrode into a fresh solution of 1.0 *M* $Cu(NO_3)_2$.

| Half-Reaction | $E°$ (V) |
|---|---|
| $Cu^+ + e^- \rightarrow Cu(s)$ | 0.52 |
| $Cu^{2+} + 2\,e^- \rightarrow Cu(s)$ | 0.34 |
| $Sn^{4+} + 2\,e^- \rightarrow Sn^{2+}$ | 0.15 |
| $Sn^{2+} + 2\,e^- \rightarrow Sn(s)$ | –0.14 |

(i) Using information from the table above, write a net-ionic equation for the reaction between the Sn electrode and the $Cu(NO_3)_2$ solution that would be thermodynamically favorable. Justify that the reaction is thermodynamically favorable.

(ii) Calculate the value of $\Delta G°$ for the reaction. Include units with your answer.