SOHe method of balancing redox equations
*If you balance half reactions using this method, you will always have a balanced overall reaction

Practice using SOHe method
*Know difference between species and element

0           +5                    +2            +4
1.  Cu(s) + NO3^− (aq) → Cu^{2+}(aq) + NO_2(g) in acid

Elements whose oxidation numbers are changing
Cu: 0 → +2  (oxidation)
N:  +5 → +4  (reduction)

<table>
<thead>
<tr>
<th>Species on reactant side</th>
<th>Species on product side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu (s) (oxidized)</td>
<td>Cu^{2+} (aq)</td>
</tr>
<tr>
<td>NO_3^− (reduced)</td>
<td>NO_2 (g)</td>
</tr>
</tbody>
</table>

Oxidation half reaction
Cu → Cu^{2+} + 2e-
*add 2e- to product side to make charge on reactant side = charge on product side

Reduction half reaction
NO_3^− +2H^+ + e- → NO_2 + H_2O

*Add oxygens needed by adding H_2O
*Add H^+ to side that needs hydrogens (do this if the redox reaction is in acid solution)
    if the redox reaction were happening in basic solution, you would add OH^- to one side
    and H_2O to the other side, to balance the hydrogens, because the side that gets H_2O is
    adding one more H
*Add e- to balance net charge

Overall reaction
Oxidation:  Cu → Cu^{2+} + e-
(Reduction:  NO_3^− +2H^+ + e- → NO_2 + H_2O) ×2
Overall rxn:  Cu + 2 NO_3^− + 4H^+ → 2NO_2 + 2 H_2O + Cu^{2+}

*Multiply reduction rxn by 2 to make e- cancel
note that the least common multiple of electrons (which canceled) was 2 electrons
Another Practice using SOHe method

\[
\begin{array}{c|c|c|c|c}
0 & +4 & +2 & +2 \\
\hline
\end{array}
\]

2. \( \text{Cd (s)} + \text{NiO}_2 (s) + \text{H}_2\text{O (l)} \rightarrow \text{Cd(OH)}_2 (s) + \text{Ni(OH)}_2 (s) \)

In acid

Elements whose oxidation numbers are changing
-Cd: \( 0 \rightarrow +2 \) (oxidized)
-Ni: \( +4 \rightarrow +2 \) (reduced)

Species on reactant side
-Cd (s) is getting oxidized, so it is the reducing agent
-NiO2 is getting reduced so it is the oxidizing agent

Oxidation half reaction
-Cd (s) + 2H\text{H}_2\text{O} \rightarrow \text{Cd(OH)}_2 (s) + 2H^+ + 2e^-

-\text{net charge} = 0 \quad \text{net charge} = +2

2e^- added to neutralize charge

*When adding e- check with oxidation numbers (oxidation side) to ensure correct number of e- were added.

Reduction half reaction
-NiO2 (s) + 2H^+ + 2e^- \rightarrow \text{Ni(OH)}_2 (s)

*Check with oxidation numbers (reduction side) that correct number of e- were added

Overall reaction
-Cd(s) + 2H\text{H}_2\text{O} + \text{NiO}_2 (s) \rightarrow \text{Cd(OH)}_2 + \text{Ni(OH)}_2

least common multiple of electrons that canceled when you were adding up the half reactions is \( n = 2 \) (need this for Nernst equation – save for later)
Electrochemical Cell Animation shown in class

Cu $\rightarrow$ Cu$^{2+}$ or Cu$^{2+}$ $\rightarrow$ Cu is happening in the Cu cell
Zn $\rightarrow$ Zn$^{2+}$ or Zn$^{2+}$ $\rightarrow$ Zn is happening in the Zn cell

*Use table of standard reduction potentials to figure out which one of cells is oxidation (anode) and which one is reduction (cathode)

Reduction potentials are:
- Cu$^{2+}$ + 2e$-$ $\rightarrow$ Cu $\quad E^o = +.337$ V
- Zn$^{2+}$ + 2e$-$ $\rightarrow$ Zn $\quad E^o = -.763$ V

Note that both of these half-reactions are written as reductions for a redox reaction, one of the half-reactions stays a reduction, and the other one turns around and becomes an oxidation.

To get $E^o$ for an oxidation, just flip the sign of $E^o$ for the reduction when you turn the reaction backwards to get the oxidation half-reaction

Two possibilities
1. Cu $\rightarrow$ Cu$^{2+}$ + 2e$-$ $\quad E^o = -.337$ V (oxidized)
   Zn$^{2+}$ + 2e$-$ $\rightarrow$ Zn $\quad E^o = -.763$ V (reduced)
   $E^o$ cell = (-.337)+(-.763)
   $E^o$ cell = -1.10 V

2. Zn $\rightarrow$ Zn$^{2+}$ + 2e$-$ $\quad E^o = +.763$ V (oxidized)
   Cu$^{2+}$ + 2e$-$ $\rightarrow$ Cu $\quad E^o = +.337$ V (reduced)
   $E^o$ cell = (+.763)+(+.337)
   $E^o$ cell = +1.10

*This one is spontaneous because $E^o$ cell is positive

Parts of an electrochemical cell and cell notation
*Standard cell notation is not in book….only in class – will be on final exam