Serial vs. Parallel Circuits

Everything you ever needed to make a kick *tokhis* chemical car!

Terminology:

- Oxidation: e^- are removed from a species
  - $Ca(s) \rightarrow Ca^{+2}(aq.) + 2e^-$ E: 2.87V (High Voltage Potential)
  - $Sn(s) \rightarrow Sn^{+2}(aq.) + 2e^-$ E: 0.13V (Low Voltage Potential)

- Reduction: e^- are accepted by a species.
  - $F_2(aq) + 2e^- \rightarrow 2\,F^-(aq)$ E: 2.87V (High Voltage Potential)
  - $AgBr(s) + e^- \rightarrow Ag(s) + Br^-(aq)$ E: 0.07V (Low Voltage Potential)

Terminology/Example

- Redox Rxn:
  - Done in solution (typically H_20)
  - Combination of a reduction AND oxidation reactions

Strongly Favorable Reaction

Oxidation: $Ca(s) \rightarrow Ca^{+2}(aq.) + 2e^-$ Voltage Potential: 2.87V

Reduction: $F_2(aq) + 2e^- \rightarrow 2\ F^-(aq)$ Voltage Potential: 2.87V

Redox Rxn: $F_2(aq) + Ca(s) \rightarrow 2\ F^-(aq) + Ca^{+2}(aq)$ ***V. Pot.: 5.74V***

Favorable Reaction #1

Oxidation: $2\ Li\ (s) \rightarrow 2\ Li^{+}\ (aq) + 2\ \cancel{e^{-}}$ Voltage Potential: 3.0 V

Reduction: $Cu^{+2}\ (aq) + 2\ \cancel{e^{-}} \rightarrow Cu(s)$ Voltage Potential: 0.3V

Redox Rxn: $2\ Li\ (s) + Cu^{+2}\ (aq) \rightarrow 2\ Li^{+}(aq) + Cu(s)$ ***Volt. Pot.: 3.3V***

Favorable Reaction #2

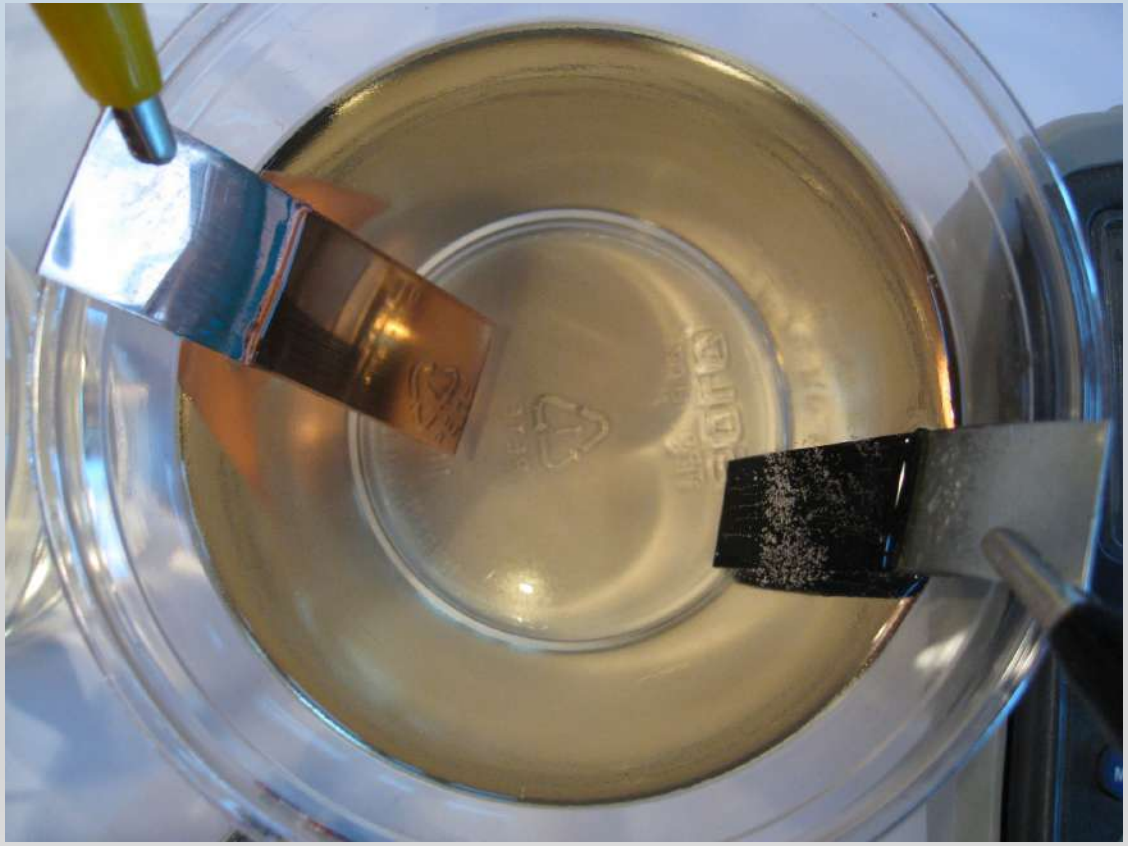
Oxidation: $2\ K\ (s) \rightarrow 2\ K^{+}(aq) + 2\ \cancel{e^{-}}$ Voltage Potential: 2.9 V

Reduction: $Sn^{+2}\ (aq) + 2\ \cancel{e^{-}} \rightarrow Sn(s)$ Voltage Potential: -0.1V

Redox Rxn: $2\ K\ (s) + Sn^{+2}\ (aq) \rightarrow 2K^{+}(aq) + Sn(s)$ ***Volt. Potential: 2.8V***

Coca-Cola Battery

Zn/Cu cell



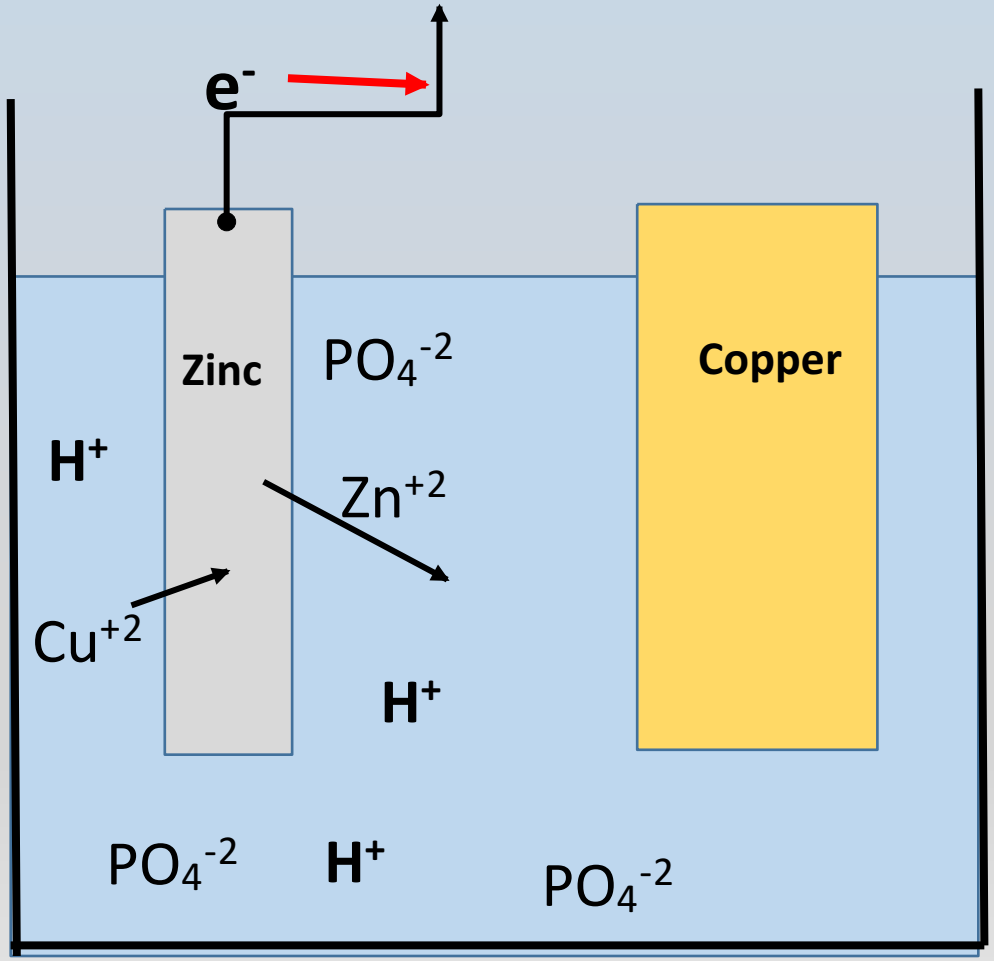
Coca-Cola Battery

- Coke used because it contains an acid (H_3PO_4)
- **Oxidation:** $Zn(s) \rightarrow Zn^{+2}(aq) + 2e^-$ Voltage: 0.76V
- **Reduction:** $Cu^{+2}(aq) + 2e^- \rightarrow Cu(s)$ Voltage: 0.34V

Redox Rxn:

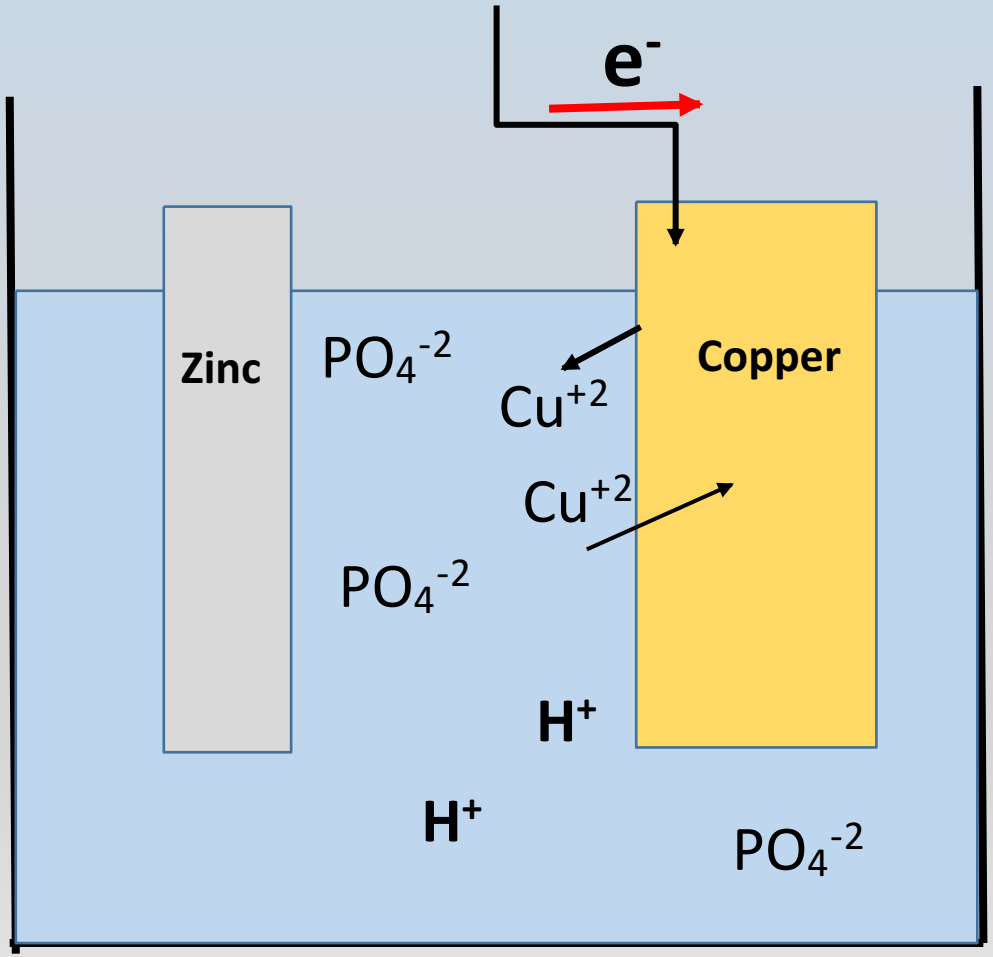
$Zn(s) + Cu^{+2}(aq) \rightarrow Zn^{+2}(aq) + Cu(s)$ Voltage: 1.10V

Coca-Cola Battery-Zn Electrode



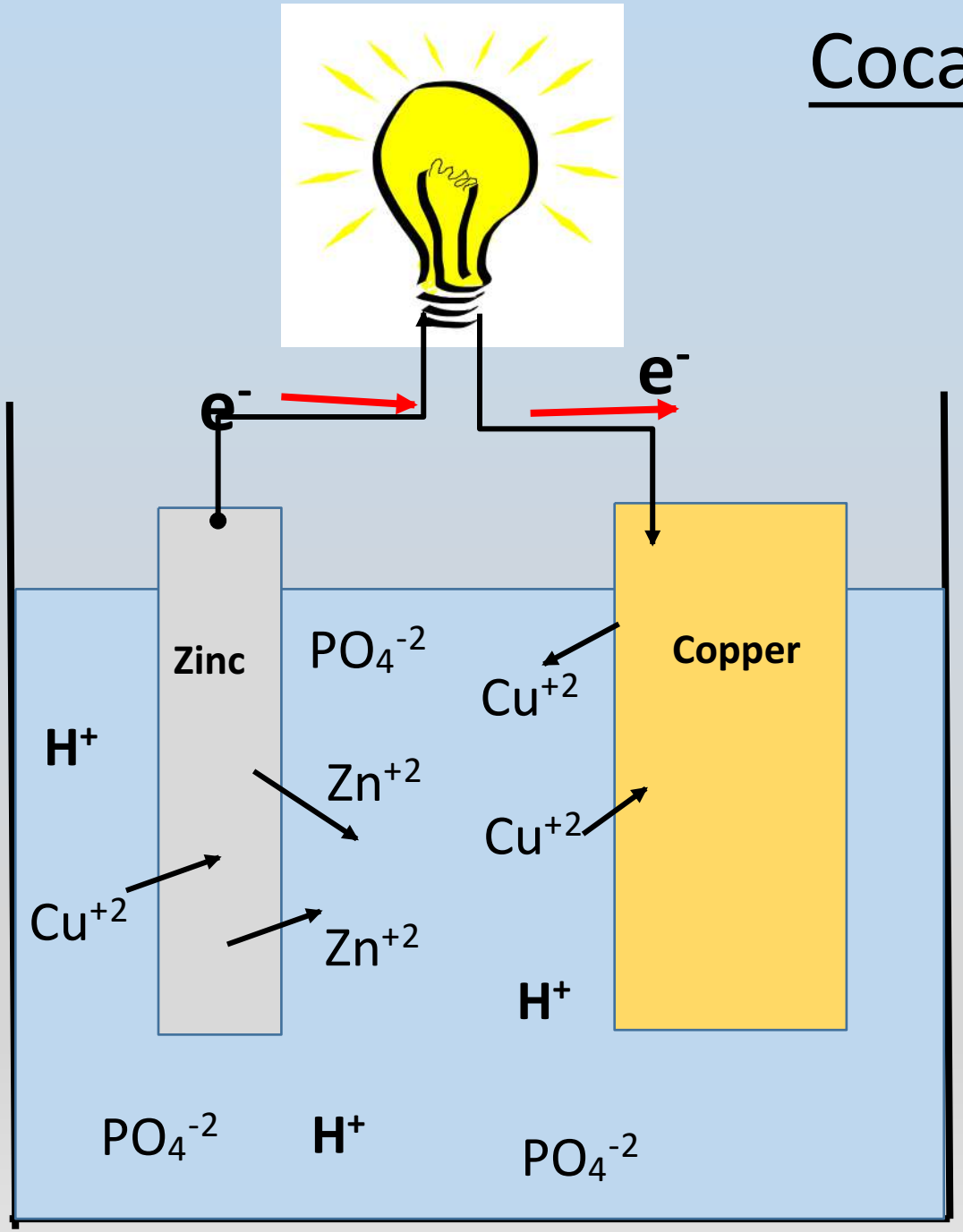
- **The Zn electrode: Oxidation**
  - Zn(s) ➔ Zn^{+2} and 2 e^- migrate to the Cu electrode.
  - Zn^{+2} ions bond to PO_4^{-2}
  - Zn(s) reduces Cu^{+2} on the surface, coating the Zn electrode with Cu.

Coca-Cola Battery: Cu Electrode



- **The Cu electrode**
  - Cu^{+2} ions reduced to Cu(s)
  - Some Cu^{+2} ions make their way to the Zn
  - Cu^{+2} is receiving e^- (reduction)

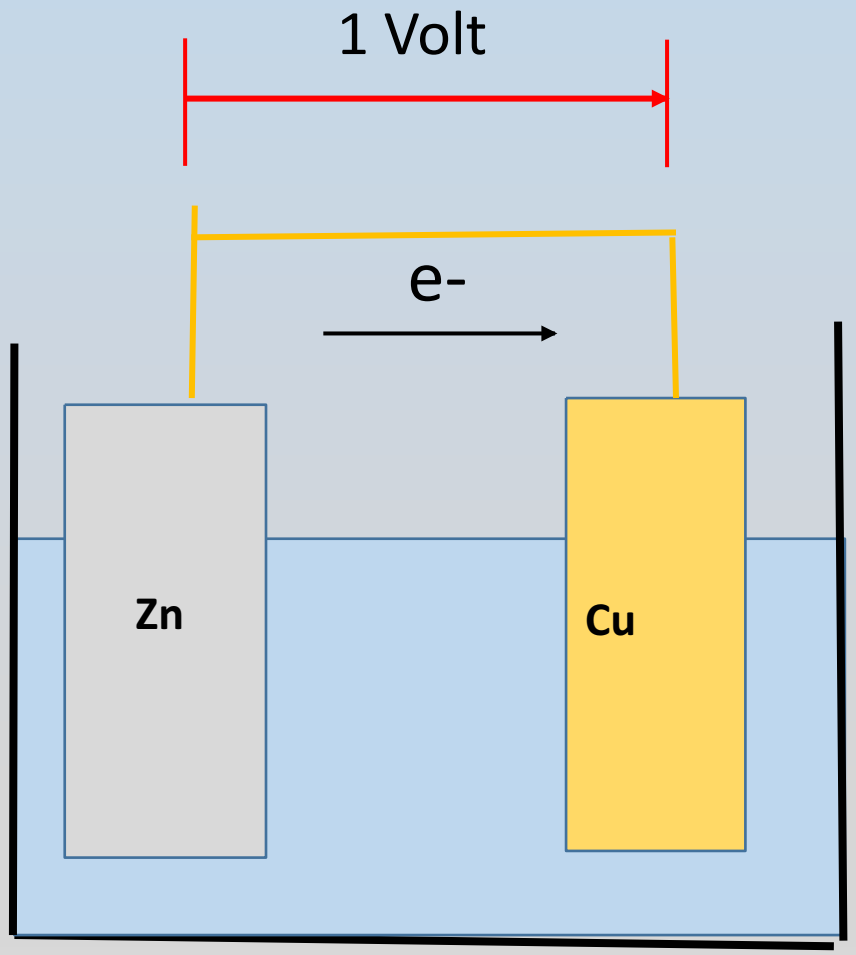
Coca-Cola Battery



- **The Zn electrode**
  - Zn releases e^- to the Cu electrode.
  - Zn^{+2} ions bond to PO_4^{-2}
  - Zn(s) reduces Cu^{+2} on the surf., coating the Zn electrode with Cu.
- **The Cu electrode**
  - Cu^{+2} ions reduced to Cu(s)

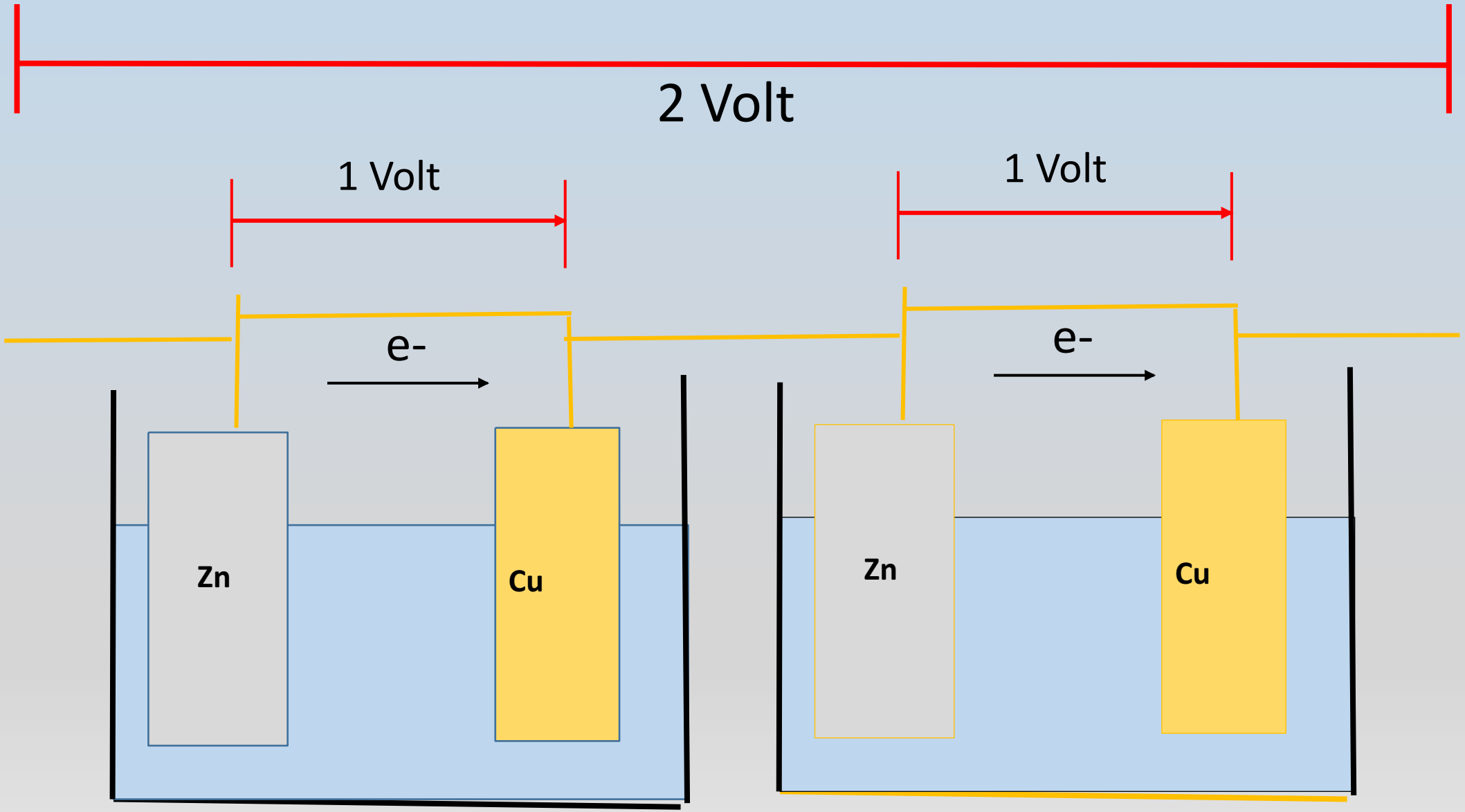
Electrons do NOT move through the solution

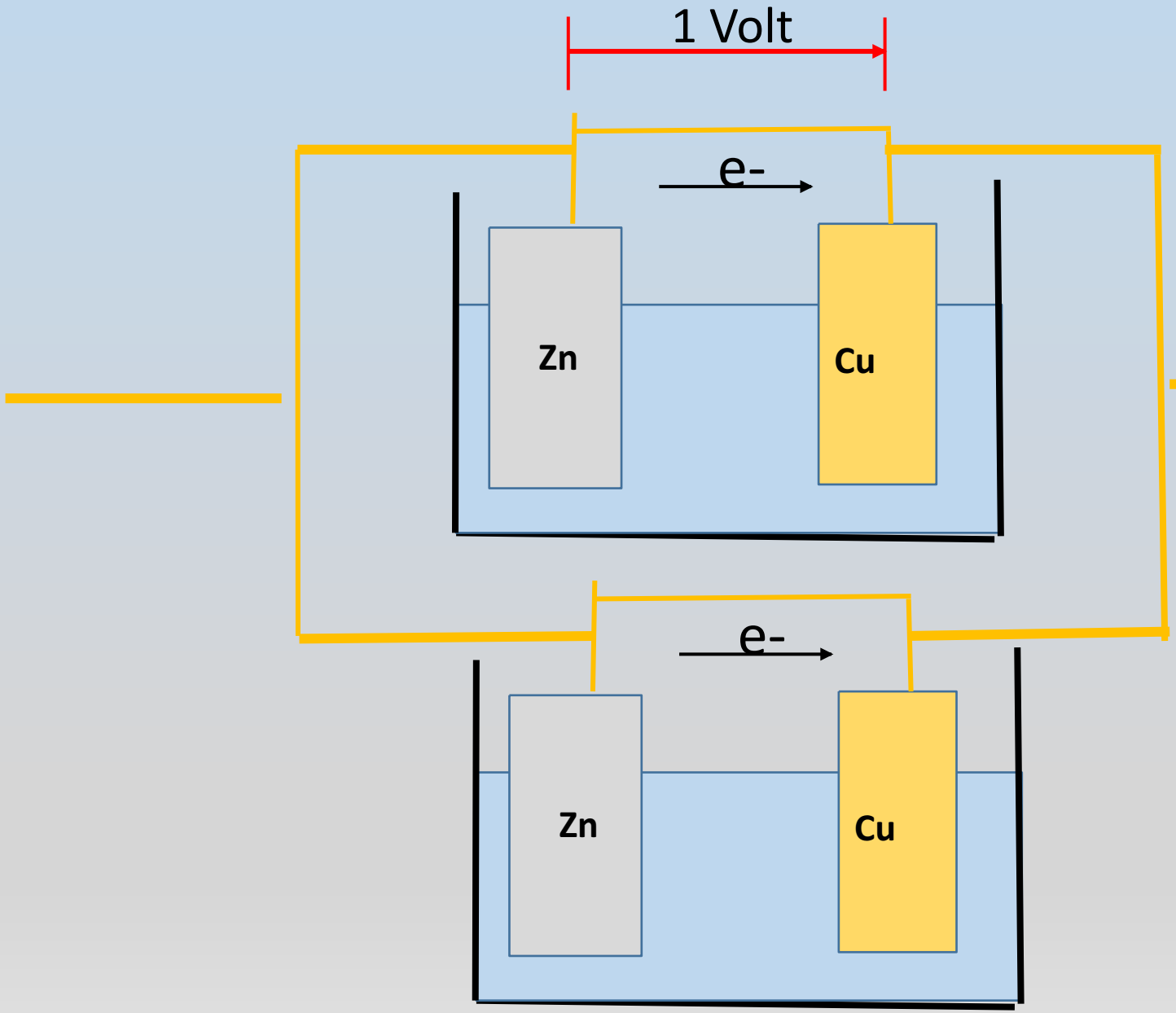
Simplified Cell Drawing



Electrons do NOT move through the solution

Serial Cells: Increase Voltage, No Increase in Amperage
Cu to Zn Connections





Parallel Cells

No Increase in Voltage

Increase in Amperage

Connecting Zn to Zn

Connecting Cu to Cu

Summary

- RedOx Reaction: Combination of 2 Processes
  - Reduction: Chemical reaction in which a species accepts an e^-
  - Oxidation: Chemical reaction in what a species donates an e^-

- Voltage Potential: Energy that would be exchanged in a e^- transfer

- Serial circuits enable increased voltage but no change in amperage

- Parallel circuits enable increased current but no change in voltage

Chemical cars will probably need to use parallel and series circuits