Aghh-My Iphone Battery Is Dead!!!!

Everything you ever needed to make Chemical
Car Battery

What Do We Already Know?

- Atoms and molecule can have positive or negative charge
- Periodic Table Trends:
  1. Columns 1 and 2: Atoms try to lose electrons
  2. Columns 6 and 7: Atoms try to gain electrons

New Terms For This Week

- Oxidation
- Reduction
- RedOx Rxn
- Voltage Potential

What Do We Need To Know For Making A Battery Car?

- How do the chemical reactions work within a cell?
- How do cells relate to batteries?
- Best battery approach for the chemical cars?

2016 Corvette 650 HP: 0-60 mph: 3.3 sec
¼ mile time: 11.3 sec (max speed 128 mph)

2016 Tesla (Insane mode): 0-60 mph: 3.1 sec
¼ mile time: 11.6 sec (max speed 115 mph)

KillaCycle: 0-60 mph: ***less than 1 sec***
¼ mile time: 7.9 sec (max speed of 168 mph)

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.**
  - $F_2(aq) + 2e^- \rightarrow 2F^-(aq)$ 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: $Ca(s) \rightarrow Ca^{+2}\ (aq.) + \cancel{2e^-}$ Voltage Potential: 2.87V

Reduction: $F_2\ (aq) + \cancel{2e^-} \rightarrow 2\ F^-\ (aq)$ 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: $Cu^{+2}\ (aq) + \cancel{2\ e^{-}} \rightarrow Cu(s)$ 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: $2\ K\ (s) \rightarrow 2\ K^{+}(aq) + \cancel{2\ e^{-}}$ 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***

Example

Unfavorable Reaction

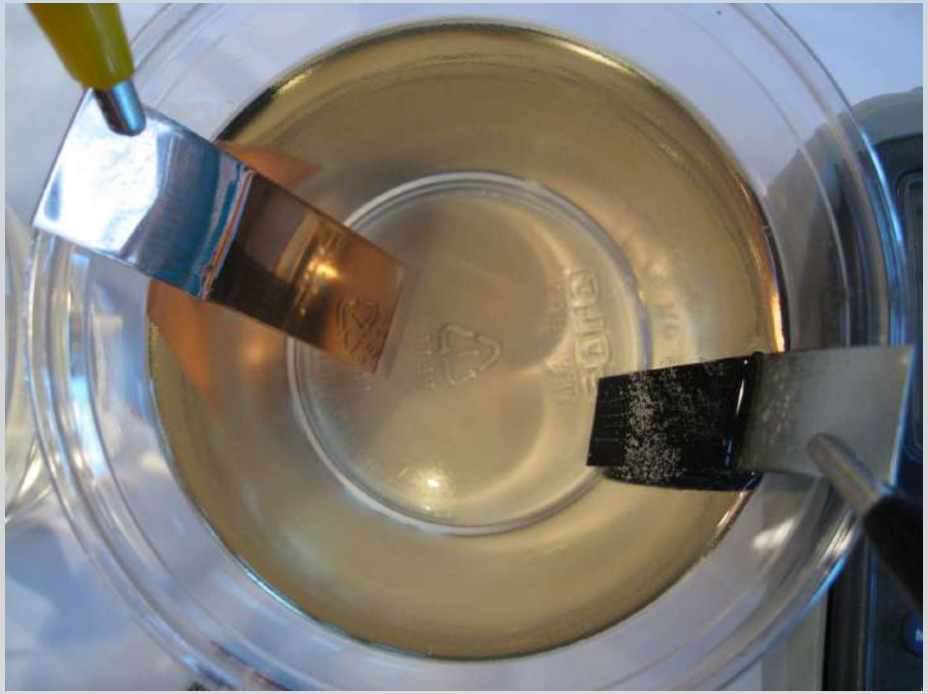
Oxidation: $2\ F^- (aq) \rightarrow F_2(aq) + \cancel{2}\ e^-$ Voltage Potential: -2.87V

Reduction: $2\ Na^+ (aq) + \cancel{2}\ e^- \rightarrow 2\ Na(s)$ Voltage Potential: 2.71V

Redox Rxn: $2\ F^- (aq) + 2\ Na^+ (aq) \rightarrow F_2(aq) + 2\ Na(s)$ ***Volt. Pot.: -0.16V***

Coca-Cola Battery

- Won’t work with just deionized water?
- Only certain metals will work?



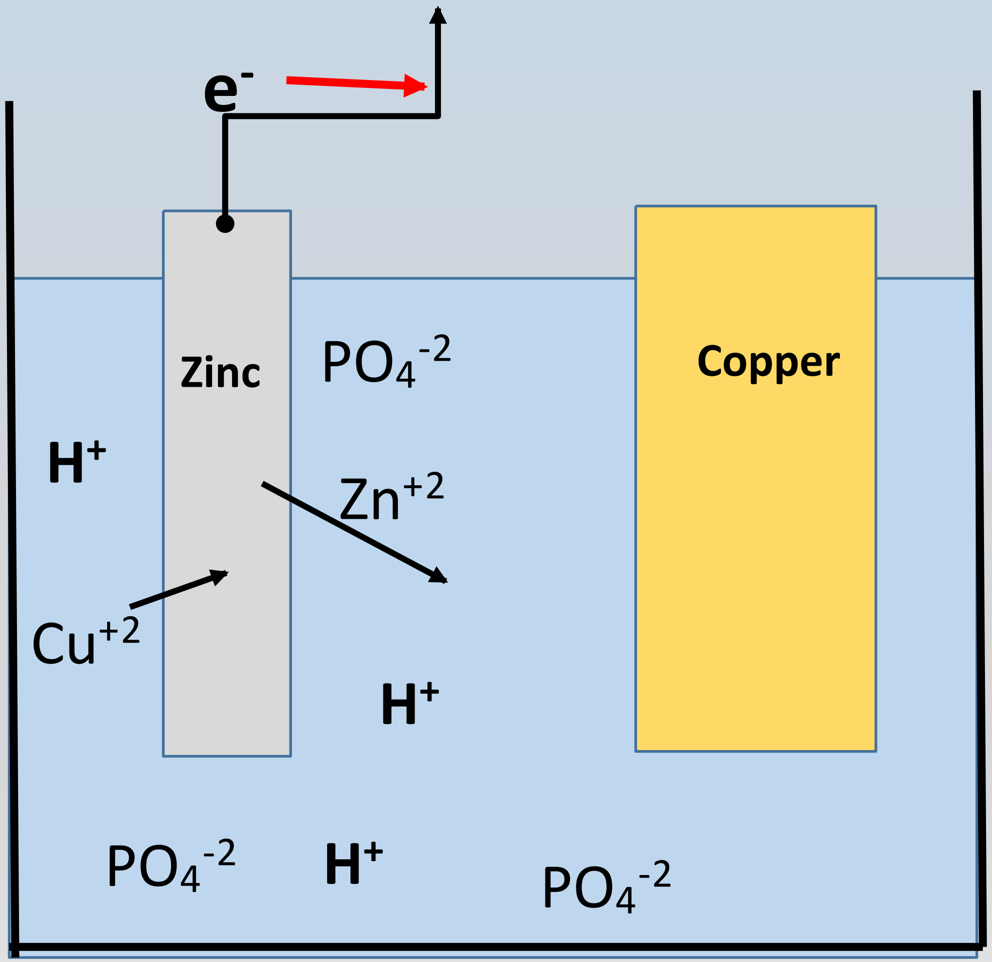
Coca-Cola Battery

- 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:

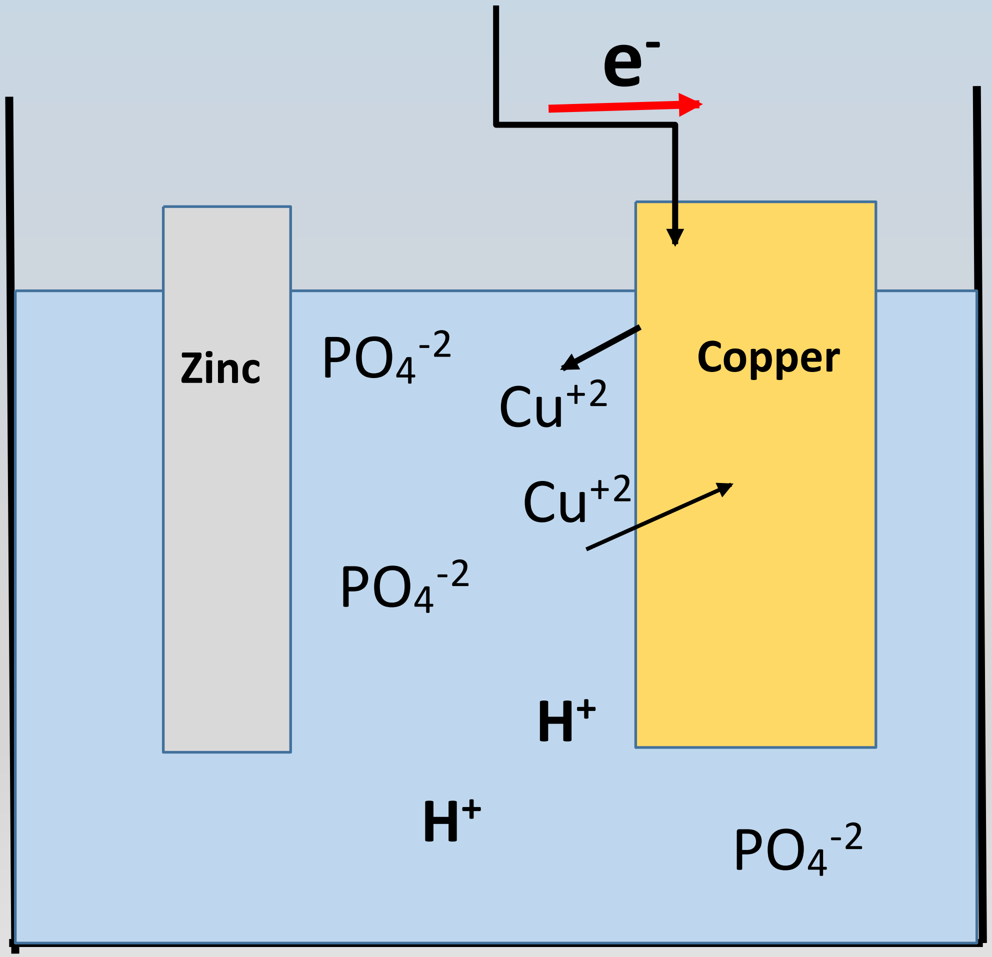
$Zn(s) + Cu^{+2}(aq) \rightarrow Zn^{+2}(aq) + Cu(s)$ Voltage: 1.10V

Coca-Cola Battery-Zn Electrode

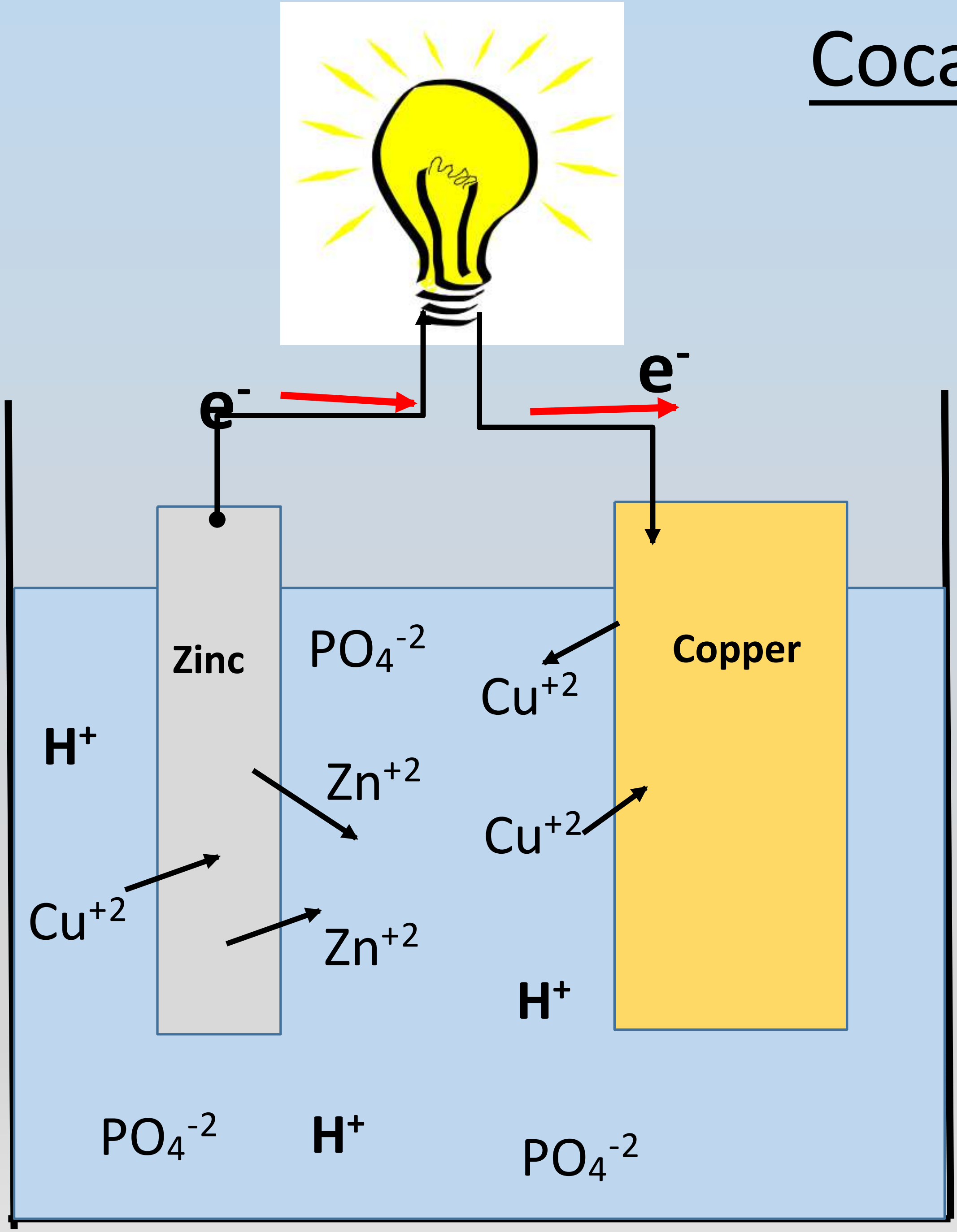


- **The Zn electrode: Oxidation**
  - Zn(s) ➔ Zn^{+2} and 2 e^- migrate to the Cu electrode.
  - Zn^{+2} ions bond to PO_4^{-2}
  - Zn(s) reduces Cu^{+2} on the surface, coating the Zn electrode with Cu.

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

Why Won't My Chemical Car Move?

- Voltage loss across any resistor: $V = I \times R$ Volts = Amps x Ohms
  - Bad wiring on chemical car → Very low current to your motor!
- Power loss to any resistor: $W = V \times I = V^2 \times I$ Watts = $(\text{Volts})^2$ x Amps
  - Very low current to motor → Very little power for the motor to use!

?

- Voltage loss across any resistor: $V = I \times R$ Volts = Amps x Ohms
- Power loss to any resistor: $W = V \times I = V^2 \times I$ Watts = $(\text{Volts})^2$ x Amps

- Car Battery/Wire Demo: V= 12V, Resistance of wire: 1 ohm
  1. Amps through the wire: 12V = I (amps) x (1 Ohm) → I=12 A
  2. Power loss to the wire: $W = (12V)^2 \times 12\ A$ → ***1700 Watts***

Car Battery/Mr. Powers Demo: V =12V, Mr. Powers R: ***1×10^6 ohms***

1. Amps through Mr. P.: 12V = I (amps) x (1×10^6 Ohms) → $I = 1.2 \times 10^{-5}$ A
2. Power loss to Mr. Powers: W = ***1.7×10^{-3} Watts***

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

- What's Next?
  - Cells vs. Batteries
  - Series vs. Parallel Cells

Chemical cars will probably need to use parallel and series circuits