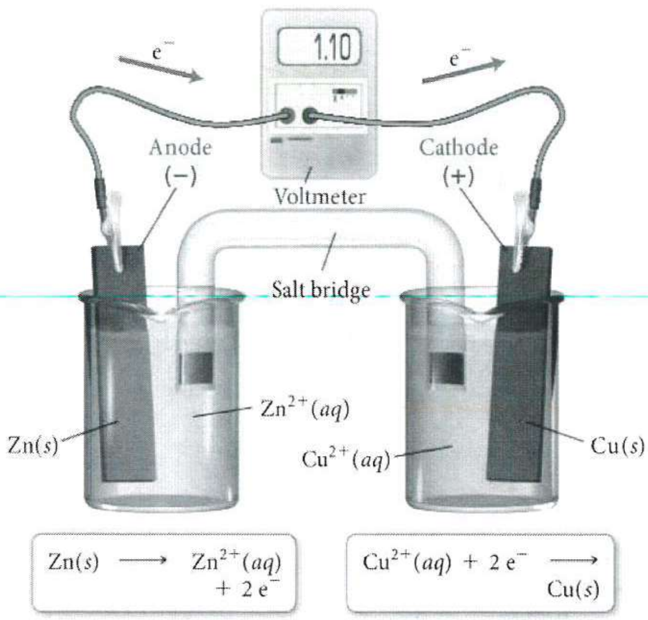
Electrolytic Cells: You have the *power*!

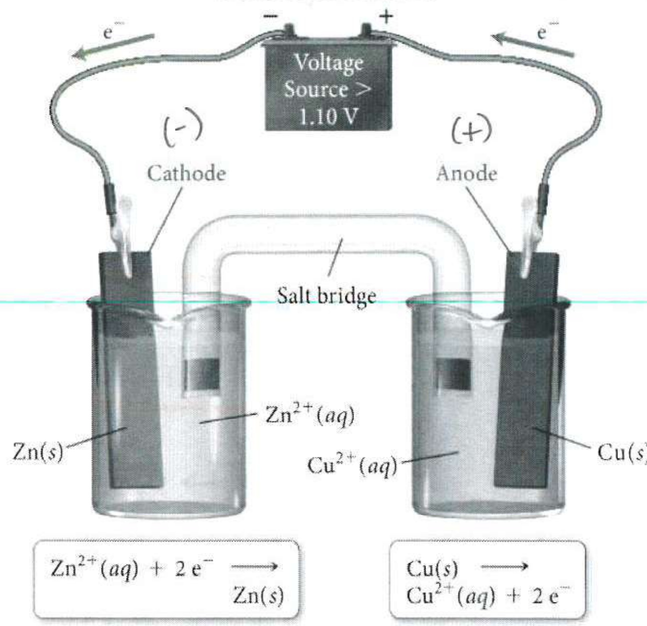
Electrolytic cells: thermodynamically unfavorable, therefore __+__ **ΔG^0** and __−__ **ΔE^0**

- Since an electrolytic cell is NOT spontaneous, it will undergo a redox reaction only if __Current__ is applied!

Voltaic Cell



Electrolytic Cell ← usually in 1 container!



Note: In electrolytic cells, **An Ox** and **Red Cat** still work (yay!)

Differences between Galvanic/Voltaic Cells and Electrolytic Cells

Galvanic/ Voltaic Cells	Electrolytic Cells
__−__ ΔG, __+__ E^o_{cell}, K __>__ 1	__+__ ΔG, __−__ E^o_{cell}, K __<__ 1
Thermodynamically favorable	Thermodynamically Unfavorable
spontaneous in the __forward__ direction	spontaneous in the __reverse__ direction
Separated into two half cells to generate electricity	Usually occurs in a __Single__ container (but can be set up in two containers)
__Is__ a battery (turns chemical energy into electrical energy)	__Needs__ a battery (turns electrical energy into chemical energy)
Often electrodes made of metal used in half-reactions	Usually use __inert__ electrodes (such as Pt or graphite)
Electrons supplied by species being oxidized	Electrons supplied by external battery at cathode
Cathode __+__, Anode __−__	Anode __+__, Cathode __−__

"EPA": Electrolytic = Positive Anode

Electrolysis: the process of using electrical energy to break apart a compound.

→ Can be used to separate compounds into their component elements.

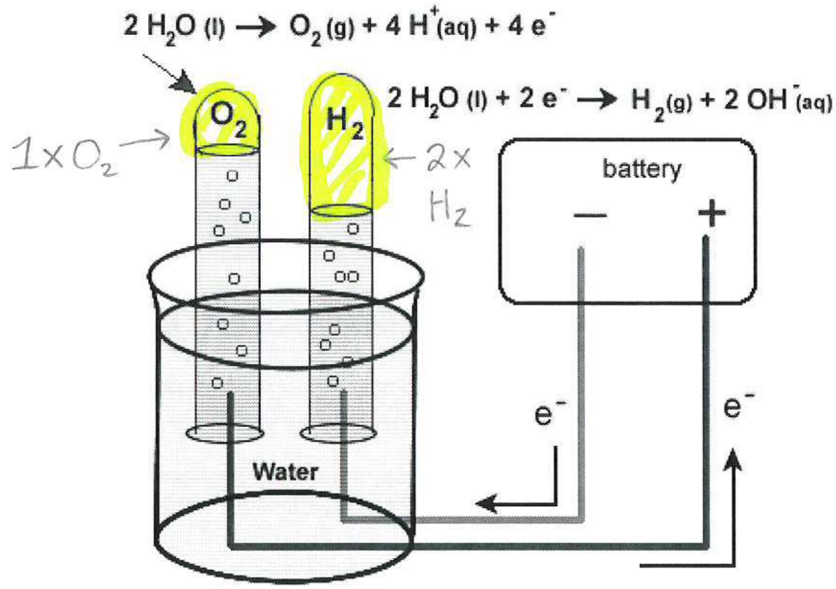
Applications of Electrolysis

1. Electrolysis of water → used to generate hydrogen for fuel cells!
   - As water dissociates, 2 moles of hydrogen gas are formed for every 1 mole of oxygen gas, according to the balanced reaction shown below.
   - Note: water is being dissociated at the SAME rate in both test tubes, but twice as much gas is being produced in the hydrogen gas test tube!

$$2\,H_2O(l) \rightarrow 2\,H_2(g) + O_2(g)$$

Anode	Cathode
$2\,H_2O(l) \longrightarrow O_2(g) + 4\,H^+(aq) + 4\,e^-$	$2\,H_2O(l) + 2\,e^- \longrightarrow H_2(g) + 2\,OH^-(aq)$

← need to know! (or be able to derive)



Let's Practice!

1. In the dissociation of water, what is being reduced? Justify your answer using oxidation states.

   $H_2O_{(l)}$ (H: +1 → 0) [+1 in $H_2O(l)$, 0 in $H_{2(g)}$]

2. In the dissociation of water, what is being oxidized? Justify your answer using oxidation states.

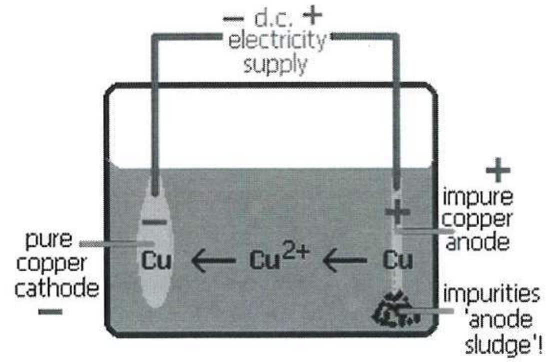
   $H_2O_{(l)}$ (O: −2 → 0) [−2 in $H_2O_{(l)}$, 0 in $O_{2(g)}$]

3. During a lab demonstrating the electrolysis of water, 2.7 mL of $O_2(g)$ was collected. What volume of $H_2(g)$ should be collected? Explain.

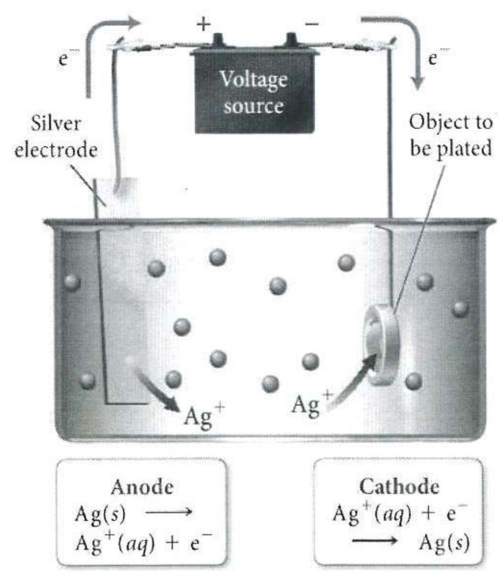
   $2.7\text{ mL } O_2 \times \frac{2\text{ mL } H_2}{1\text{ mL } O_2} = \boxed{5.4\text{ mL } H_2}$ b/c 2:1 mol ratio for $H_2 : O_2$ (twice as much! ^‿^)

2. **Electrorefining:** Purification of metals (often ore) through electrolysis
   - The anode is the impure metal (i.e. ore) to be purified. (An ox = An ore ü)
   - The cathode is the electrode at which the pure metal will be deposited (often made of a thin sheet of the pure metal).
   - The electrolyte (solution) contains the cation of the metal to be purified.
   - This process can be used to purify multiple metals, including copper, nickel, cobalt, lead, and tin.

Electrolytic Cell for Copper Ore Purification



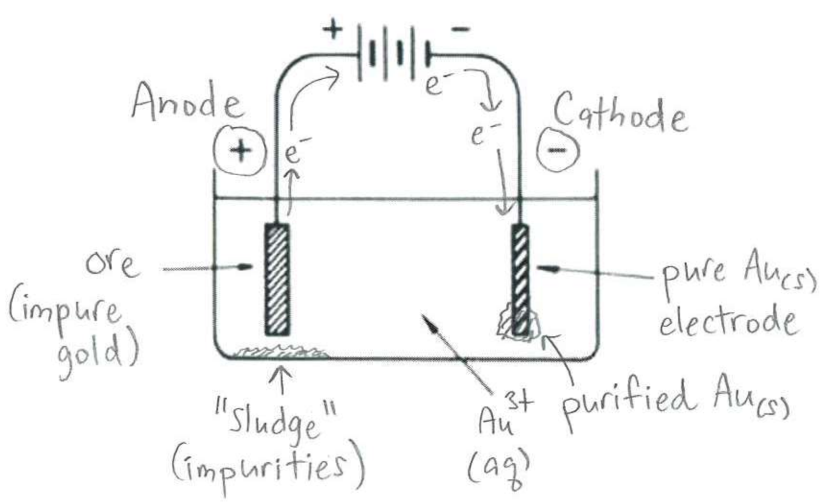
Electrolytic Cell for Silver Plating



3. **Electroplating:** Applying a thin layer of an expensive metal onto a less expensive one for structural or cosmetic reasons
   - The object to be plated is the cathode.
     - Remember: Fat Cat! (wants mass!)
   - The electrolyte (solution) contains the cation of the metal to be plated on the object.
   - The best anode is made of the metal to be plated onto the object.

Example: Gold ore, when discovered in nature, often contains impurities. If a sample of gold ore contains some silver impurity, the ore can be purified by electrolysis. (Assume Au(s) will form a $Au^{3+}(aq)$ cation.)

a. On the diagram below, identify the anode (and what it's made of), the cathode (and what it's made of), the direction of electron flow, and the location where the newly purified gold will be found.



b. Where will the purified gold be found? Add it into the diagram on the left.

on the cathode

c. What might be a possible electrolyte for use in this solution?

$Au(NO_3)_{3(aq)}$ (100% soluble!)