Reduction & Oxidation

Unit 11 - *Level 2*

Topic 1
Redox Reaction Skills - Review

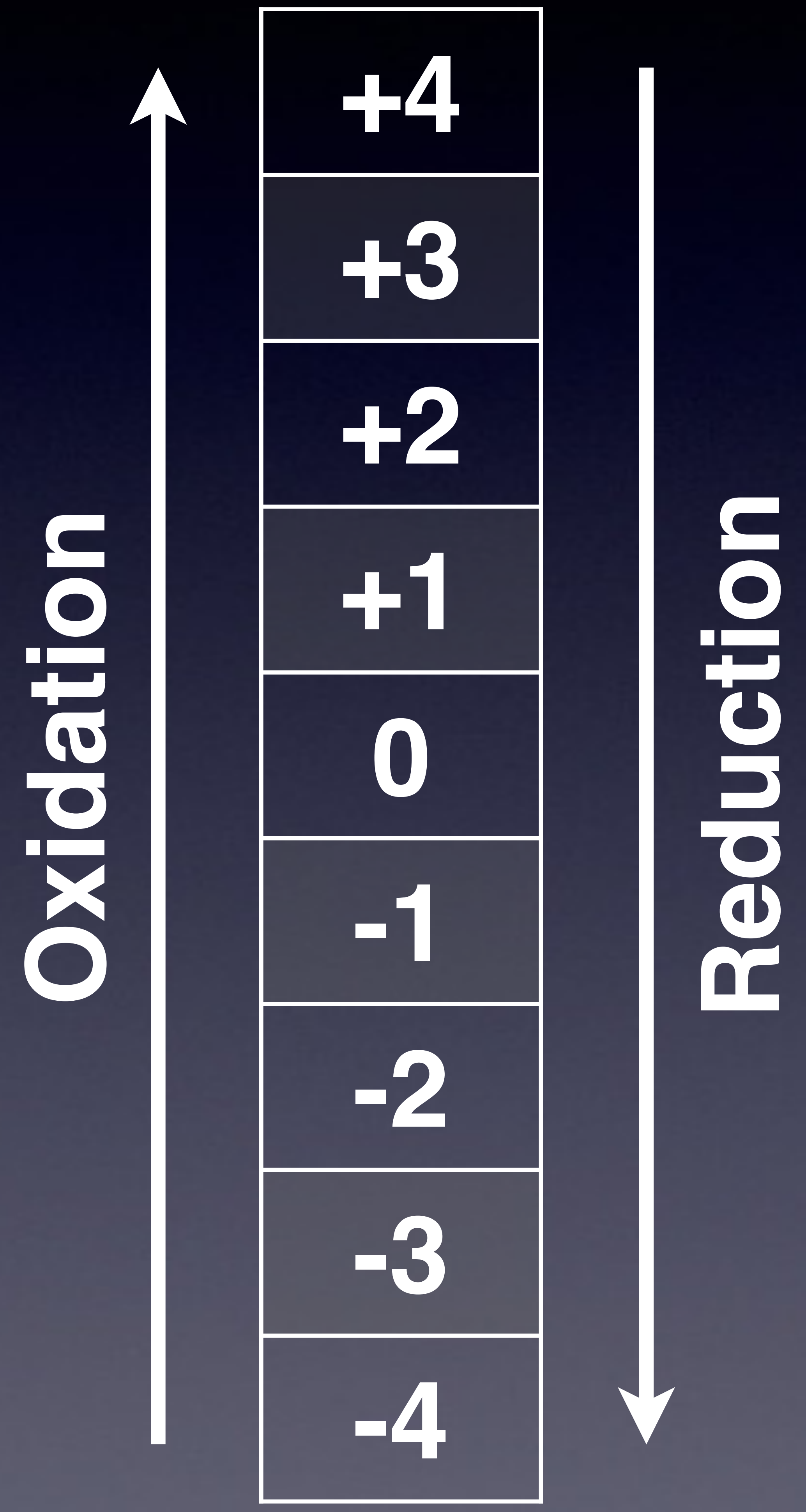
What does this picture remind you of?

LEO the lion says GER!

Redox Reactions Revisited

- LEO - losing electrons
- oxidation
  - *Metals*

- GER - gaining electrons
- reduction
  - *Non-metals*



What we’ve done already...

1. Assign oxidation states
2. Identify a REDOX reaction
3. LEO says GER
4. Assign change in oxidation states
5. Species Oxidized & Species Reduced
6. Balance mass and charge!

Example

SINGLE REPLACEMENT reactions are ALWAYS redox!

$$P + HNO_3 \rightarrow H_2O + NO_2 + H_3PO_4$$

Your turn to try…

- Balance the equation
- Assign oxidation states
- Determine which is gaining and which species is losing electrons.

Oxidation

P^0 → P^{5+}

$$P + 5HNO_3 \rightarrow H_2O + 5NO_2 + H_3PO_4$$

N^{5+} → N^{4+}

Reduction

Topic 2
Half Reactions & Net Ionic Equations

Oxidation: Ba^0 → Ba^{2+}

$$3Ba + 2AlCl_3 \rightarrow 2Al + 3BaCl_2$$

Cl^{-1} (in $2AlCl_3$) Cl^{-1} (in $3BaCl_2$)

Reduction: Al^{3+} → Al^0

1. Assign oxidation states.

2. Which species does NOT participate in the oxidation and reduction?

3. These are called SPECTATOR IONS. Why do you think so?

4. Now we can write a net ionic equation!

Thermodynamic Review

In ALL chemical changes, 3 things are conserved:

- *Mass (balance equation)*
- *Energy (total energy in = total energy out)*
- *Charge (electrons)*

$$Ba + AlCl_3 \rightarrow Al + BaCl_2$$

$$3Ba + 2AlCl_3 \rightarrow 2Al + 3BaCl_2$$

Net Ionic Equation!

$$3Ba^{\circ} + 2Al^{+3} \rightarrow 2Al^{\circ} + 3Ba^{+2}$$

Writing Half Reactions & Net Ionic Equations

1. Assign oxidation states and determine species oxidized and reduced.
2. Write a half reaction for the oxidation (electrons on the right b/c lost)
3. Write a half reaction for the reduction (electrons on the left b/c gain)
4. Make sure # **of electrons lost = # of electrons gained**
   - conservation of **charge**
5. Combine half reactions to write redox 'skeleton' or net ionic equation.

$$3Ba + 2AlCl_3 \rightarrow 2Al + 3BaCl_2$$

$$3(Ba^{\circ} \rightarrow Ba^{+2} + 2e^{-})$$

$$2(Al^{+3} + 3e^{-} \rightarrow Al^{\circ})$$

$$3Ba^{\circ} + 2Al^{+3} + \cancel{6}e^{-} \rightarrow 2Al^{\circ} + 3Ba^{+2} + \cancel{6}e^{-}$$

$$3Ba^{\circ} + 2Al^{+3} \rightarrow 2Al^{\circ} + 3Ba^{+2}$$

Examples

$Na + Cl_2 \rightarrow NaCl$

$Pb + AgNO_3 \rightarrow Pb(NO_3)_2 + Ag$

$K + CaCl_2 \rightarrow$

1. Balance the equations
2. Write 1/2 reactions
3. Net Ionic Equations
4. Are there any Spectator ions?

Topic 3
Reactivity & Table J

- Oxidizing Agents
- Reducing Agents
- Metal Reactivity

Table J – Activity Series

Metals

- Most reactive metals on top (lose electrons = oxidized)
- When 2 metals react:
  - The more active metal will lose electrons (oxidized).
  - The less active metal will gain electrons (reduced).
- The metal being *oxidized* is called the **reducing agent** and the metal being *reduced* is called the **oxidizing agent**.

Table J
Activity Series**

	Metals	Nonmetals	
Most	Li	F_2	Most
	Rb	Cl_2	
	K	Br_2	
	Cs	I_2	
	Ba		
	Sr		
	Ca		
	Na		
	Mg		
	Al		
	Ti		
	Mn		
	Zn		
	Cr		
	Fe		
	Co		
	Ni		
	Sn		
	Pb		
	**H_2		
	Cu		
	Ag		
	Au		
Least			Least

**Activity Series based on hydrogen standard

Table J – Continued

Non-metals

- Most reactive non-metals on top (gain electrons = reduced)
- At the top, non-metal elements are oxidizing agents (being reduced).
- At the bottom, non-metal elements are reducing agents (being oxidized).

Table J
Activity Series**

	Metals	Nonmetals	
Most	Li	F_2	Most
	Rb	Cl_2	
	K	Br_2	
	Cs	I_2	
	Ba		
	Sr		
	Ca		
	Na		
	Mg		
	Al		
	Ti		
	Mn		
	Zn		
	Cr		
	Fe		
	Co		
	Ni		
	Sn		
	Pb		
	**H_2		
	Cu		
	Ag		
Least	Au		Least

**Activity Series based on hydrogen standard

Determining Spontaneity

- When an atom reacts with an ion, a reaction will be spontaneous if the **ATOM** is **<u>HIGHER</u>** than the **ION** on Table J.

- **<u>Example #1</u>:** The two metal system of Zinc and Iron. Which reaction will be spontaneous?

$Zn + Fe^{2+} \rightarrow Fe + Zn^{2+}$ ***or*** $Fe + Zn^{2+} \rightarrow Fe^{2+} + Zn$

Zinc is above iron on Table J. <u>Atom</u> higher than <u>Ion</u>. So, Zn is **<u>oxidized</u>** and Fe^{2+} is **<u>reduced</u>**.

Non-Metal Activity

- **Example #2:** The two non-metal system of Bromine and Iodine. Which reaction will be spontaneous?

$Br + I^{-1} \rightarrow I + Br^{-1}$ $I + Br^{-1} \rightarrow Br + I^{-1}$

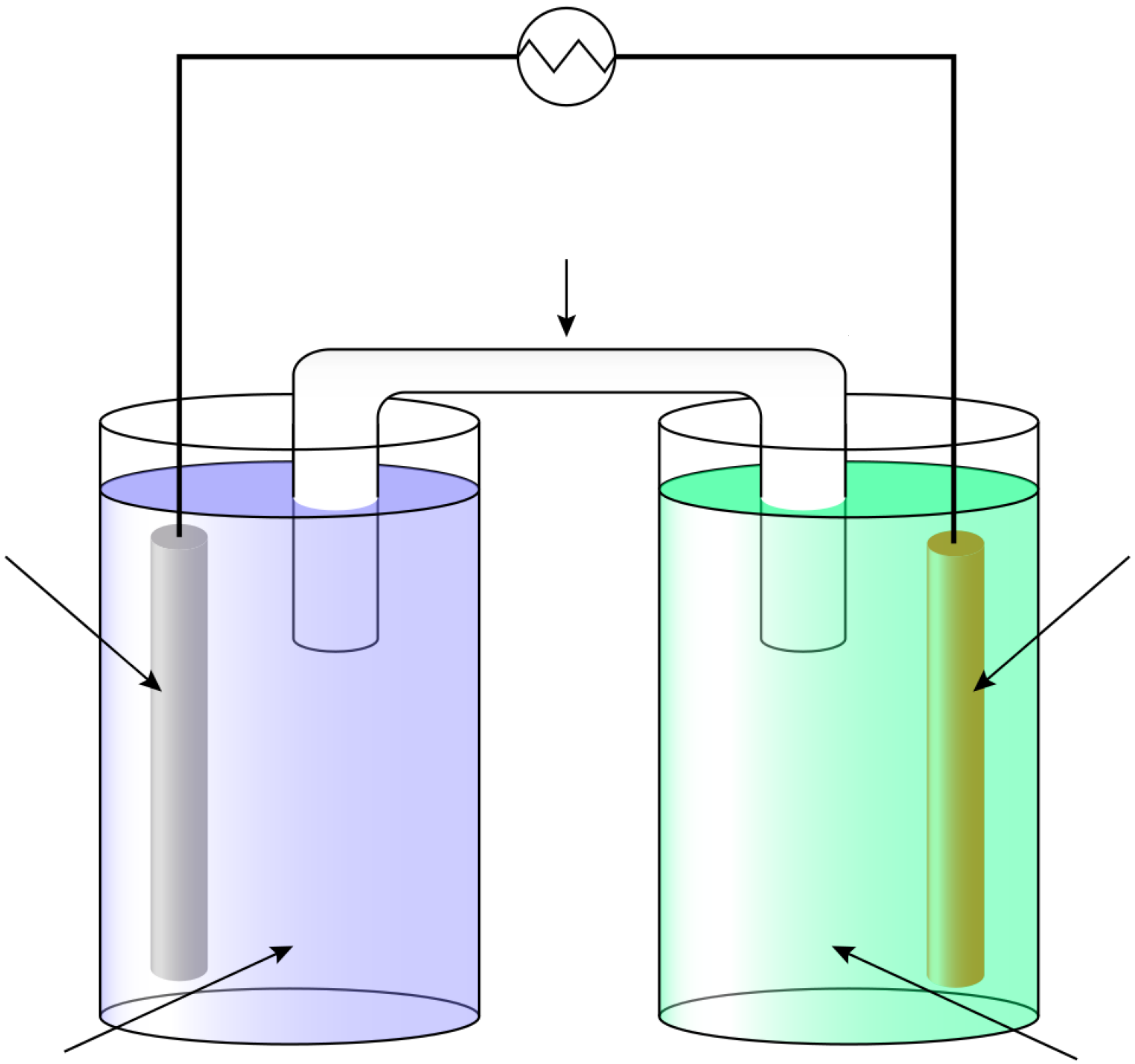
Bromine is above iodine on Table J. **Atom** is higher than **Ion**. So, Br is **reduced** and I^{-1} is **oxidized**.

Topic 4
Electrochemical Cells

- Voltaic (Galvanic)
- Electrolytic

Voltaic Cells

- Converts chemical energy to electrical energy.
- Reaction is spontaneous
- Contains 2 half cells and a salt bridge
- A battery is an example of this type of electrochemical cell

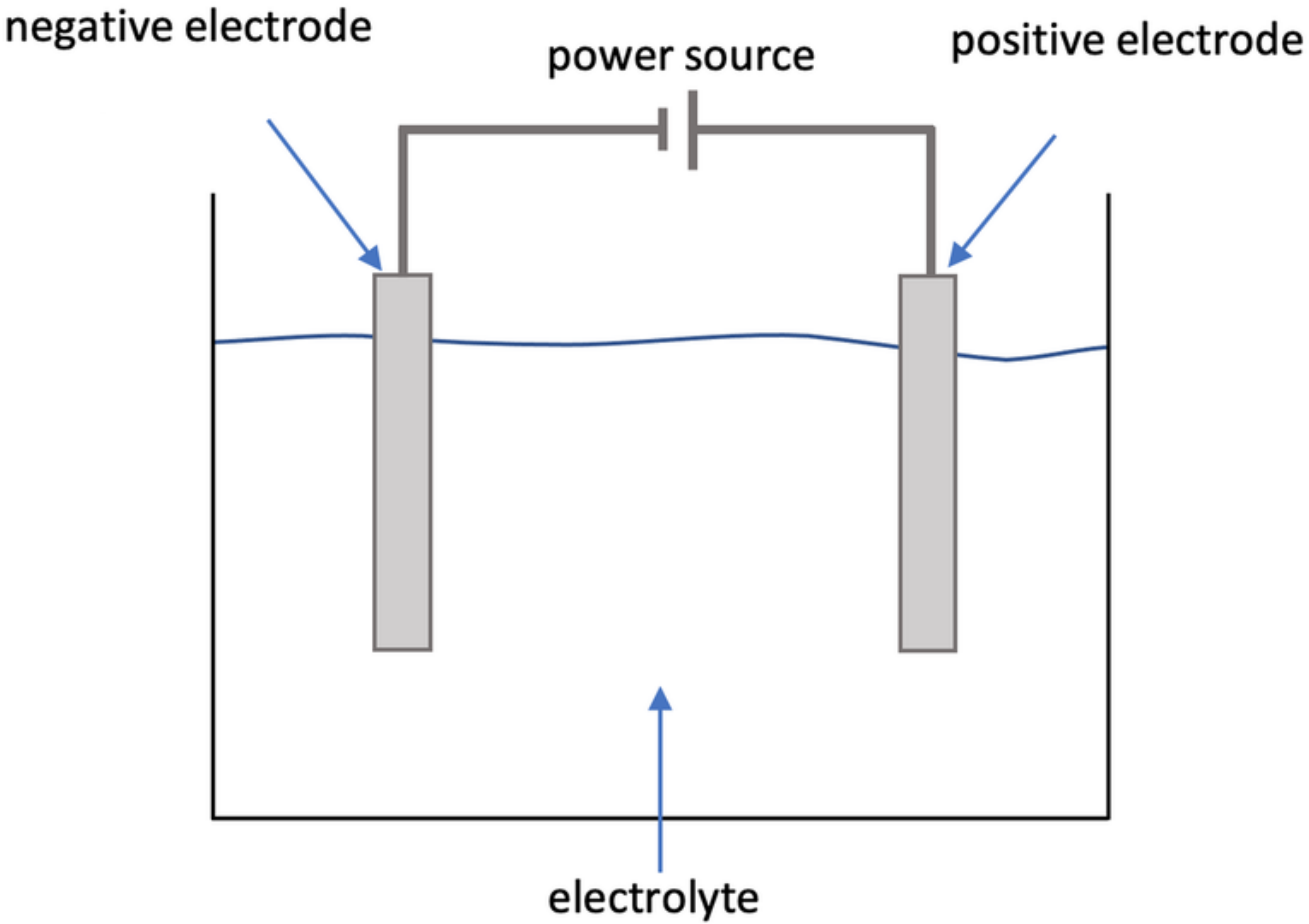


Labeling Voltaic Cells

1. Find the 2 metals on Table J to determine who is the “biggest loser” (the metal higher on table J will lose electrons).
2. Draw in the direction of electron flow.
3. Label the metal that loses electrons with OXIDATION and the metal that gains electrons with REDUCTION.
4. Label the **BIG RED CAT** is **POSITIVE** (reduction at cathode is <u>positive</u> electrode and gets bigger).
5. Label the other electrode with the opposites (oxidation at anode is negative electrode and gets smaller).
6. Write half reactions for each half cell (remember reduction has electrons on the reactant side/gained and oxidation has electrons on the product side/lost).

Electrolytic Cells

- Converts electrical energy to chemical energy
- Reaction NOT spontaneous (refer to Table J)
- Needs a power source, such as a battery or plug, to get it going.
- Only needs one container, NO salt bridge needed.
- Use this type of cell for electroplating metals.


negative electrode
power source
positive electrode
electrolyte

Labeling an Electrolytic Cell

1. Find the electrode that is getting bigger and label it. In an electrolytic cell, the BIG RED CAT is NEGATIVE (reduction at cathode is NEGATIVE electrode and gets bigger)

2. If you can't tell which electrode is getting bigger, look for a (+) or (-) on the battery to help you label. Remember the BIG RED CAT is the NEGATIVE electrode - you may need to follow the wires.

3. Label the other electrode with the opposites (oxidation at anode is positive electrode and gets smaller)

4. Draw in the direction of electron flow (oxidation is losing electrons and reduction is gaining)

5. Write half reactions for each electrode (remember reduction has electrons on the reactant side/gained and oxidation has electrons on the product side/lost).

Comparisons

Voltaic Cell	Electrolytic Cell
Energy is released (exothermic) from spontaneous redox reaction	Energy is absorbed (endothermic) to drive non-spontaneous redox reaction
System does work on surroundings	Surroundings (power supply) do work on system (cell)