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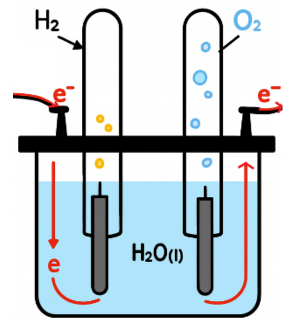
Electrolytic Cells

Read from **Lesson 3: Electrolytic Cells** in the **Chemistry Tutorial** Section**, Chapter 18** of **The Physics Classroom:**
Part a: Electrolysis and Its Applications **Part b:** The Stoichiometry of Electrolysis

Part 1: Electrolysis

1. Electrolysis



- **Electrolysis uses electrical energy to force a non-spontaneous redox reaction**.
- **Electrolytic cells require an external power source** because their cell potentials are negative ($\Delta G > 0$).
- **Stoichiometry of electrolysis connects current, time, charge, moles of electrons, and mass of product** using Faraday's constant and half-reaction coefficients.

2. Galvanic vs. Electrolytic Cells

Feature	Galvanic Cell	Electrolytic Cell
Spontaneous?	Yes ($E°_{cell} > 0$)	No ($E°_{cell} < 0$)
Energy	Produces electrical energy	Requires electrical energy
Electron Flow	Anode → Cathode	Anode → Cathode (same direction)
ΔG	Negative	Positive
Applications	Batteries	Electroplating, metal refining, chemical production

Shared properties:
- Oxidation always occurs at the **anode**.
- Reduction always occurs at the **cathode**.
- Both require an electrolyte for ion movement.

3. What Is Electrolysis?

- Electrolysis is the process of using electricity to drive a chemical change that **would not occur on its own**.
- Examples of products made using electrolysis include:
  - **Electroplating** — coating objects with thin metal layers (e.g., jewelry, chrome parts)
  - **Refining metals** (e.g., purifying copper)
  - **Producing industrial chemicals** like chlorine, hydrogen, and sodium hydroxide
  - **Extraction of reactive metals** like aluminum from ores

4. Electrolysis of Water

Half-reactions:
- Oxidation (anode): $H_2O\ (l) \rightarrow O_2\ (g) + 4\ H^+\ (aq) + 4\ e^-$
- Reduction (cathode): $H_2O\ (l) + 2\ e^- \rightarrow H_2\ (g) + 2\ OH^-\ (aq)$
- **Overall reaction:** $H_2O\ (l) \rightarrow 2\ H_2\ (g)\ ) + O_2\ (g$
- **Note:** Twice as much $H_2\ (g)$ is produced as $O_2\ (g)$

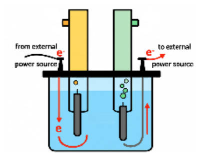
Electrochemistry

Questions

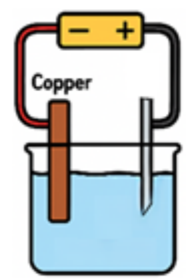
For all questions, use the Standard Reduction Potential Values found on the Chemistry Tutorial Reference Section: **[Standard Reduction Potential Values](#)** – E values for several half-cells.

1. What is electrolysis, and why does it require an external power source to occur?

2. Aaron Agin and Tessa Coil are setting up an electrolysis experiment using aqueous sodium chloride. Aaron claims that sodium metal will be produced during electrolysis. Is Aaron correct? If not, how can Tessa clearly explain what products are actually formed and why?



3. Which of the following metals—silver (Ag), aluminum (Al), iron (Fe), or zinc (Zn)—would most likely cause the spontaneous reduction of aqueous copper ions (Cu^{2+})? Which metal would be least likely to do so?



4. Sketch an electrolytic cell for the electrolysis of copper(II) sulfate using copper electrodes. Label:
   a. anode and cathode b. the oxidation and reduction reactions at each electrode
   c. the direction of electron flow through the external circuit

Electrochemistry

Part 2: Stoichiometry of Electrolysis

- Electrolysis stoichiometry connects **amount of current and time** to **amount of product formed**.

Stoichiometry of Electrolysis Problem-Solving

Step	Quantity	Equation or Conversion	Notes
1. Time conversion	Time (t)	t = min ● 60 s/min t = hr ● 3600 s/hr	Convert all time to seconds
2. Current	Current (I)	Given in amperes (A)	1 A = 1 C/ s
3. Charge	Charge (Q)	Q = I ● t	Units: coulombs (C)
4. Moles of electrons	mol e^-	mol e^- = Q / 96485	Faraday's constant = 96485 C/mol e^-
5. Moles of product	mol product	Use half-reaction coefficients	e.g., 2 mol e^- → 1 mol Zn
6. Mass of product	mass	mass = mol ● molar mass	Use periodic table molar mass

Questions

1. a. A 1.20 A current is passed through a solution of copper (II) sulfate for 30.0 minutes. How many grams of copper are deposited?

   b. Calculate the current required to deposit 4.0 g of copper in 30 minutes from a solution of copper (II) sulfate.

c. A current of 12.0-A is used to deposit 15.96 g of copper from a solution of copper (II) sulfate. How many minutes did the process last?

2. Metallic magnesium can be produced by the electrolysis of molten magnesium chloride.

a. What mass of Mg is formed when a 2.65-A current is passed through molten magnesium chloride for 12.0 hours?

b. How many seconds of electrolysis are required to produce 48.62 g of Mg from molten magnesium chloride using a 4.00-A current?

c. A 5.00-A current is passed through molten magnesium chloride for 40 minutes. How many grams of chlorine gas are released at the anode (at STP)?