# Topic 9.11: Electrolysis and Faraday's Law

Revision Notes · AP Chemistry

UNIT 9 · THERMODYNAMICS AND ELECTROCHEMISTRY

On ExamFitter.com: Topic 9.11 Quiz · Topic 9.11 Worksheet · Unit 9: All Topics · AP Chemistry Home

## Electrolysis Is Forced Redox

**Electrolysis uses electrical energy to drive a redox reaction that would not run on its own.** An external supply pushes electrons into one electrode and pulls them out of the other, forcing reduction and oxidation to happen where a galvanic cell would never put them.

**The electrode jobs never change, but their signs flip.** Oxidation still happens at the anode and reduction still happens at the cathode, in every cell. Only the charges flip: galvanic anode negative and cathode positive, electrolytic anode positive and cathode negative.

## The Charge Pipeline

Current and time give charge, charge gives moles of electrons, moles of electrons give moles of substance, and moles of substance give grams or liters. No step can be skipped.

**Step 1: charge from current and time.** Current in amperes times time in seconds gives charge in coulombs. Convert minutes and hours to seconds first; this is the most common slip in the topic.

$Q = I \times t$

**Step 2: moles of electrons from charge.** Divide by Faraday's constant F = 96,485 C $mol^{-1}$, the charge carried by one mole of electrons.

$\text{mol } e^- = Q / F$

**Step 3: moles of substance from moles of electrons.** Divide mol $e^-$ by n, the electrons per mole of the substance asked about: 2 for copper, 3 for aluminum.

$Cu^{2+} + 2e^- \rightarrow Cu$

© 2026 ExamFitter.com · Free AP Chemistry revision notes

$Al^{3+} + 3e^- \rightarrow Al$

**Step 4: convert to the requested unit.** Multiply moles of metal by its molar mass for grams, or by 22.4 L $mol^{-1}$ for a gas volume at STP. Backward, run the chain in reverse to time:

$t = Q / I$

## Reading a Half Reaction for n

**n is the electrons per mole of the substance in the question, read straight from the balanced half reaction.** The three half reactions below give n = 2 per mole of copper, n = 1 per mole of silver, and n = 3 per mole of aluminum.

$Cu^{2+} + 2e^- \rightarrow Cu$

$Ag^+ + e^- \rightarrow Ag$

$Al^{3+} + 3e^- \rightarrow Al$

**Gas half reactions need the same care.** For the two half reactions below, n = 2 per mole of hydrogen gas and n = 4 per mole of oxygen gas.

$2H^+ + 2e^- \rightarrow H_2$

$2H_2O \rightarrow O_2 + 4H^+ + 4e^-$

**Scaling a half reaction scales its electrons with it.** Doubling the copper half reaction below changes n to 4, but the substance amount doubled too, so the ratio is still 2 mol $e^-$ per mole of copper.

$Cu^{2+} + 2e^- \rightarrow Cu$

$2Cu^{2+} + 4e^- \rightarrow 2Cu$

## Predicting the Products

**At each electrode, the easiest reaction wins.** The species most easily reduced is reduced at the cathode, and the species most easily oxidized is oxidized at the anode.

**Molten sodium chloride is the clean case.** Only $Na^+$ and $Cl^-$ are present: $Na^+$ is reduced to sodium metal at the cathode, and $Cl^-$ is oxidized to chlorine gas at the anode, giving the overall reaction below.

$2Na^+ + 2Cl^- \rightarrow 2Na + Cl_2$

© 2026 ExamFitter.com · Free AP Chemistry revision notes

**Aqueous sodium chloride is the trap case, because water competes.** Water is reduced more easily than $Na^+$, so hydrogen gas forms at the cathode, while chloride is still oxidized to chlorine gas at the anode. The products are $H_2$ and $Cl_2$, not sodium metal.

**Water electrolysis shows both gas half reactions at once.** Cathode: the hydrogen half reaction below. Anode: the oxygen half reaction below it. For any given charge, the hydrogen volume is double the oxygen volume.

$2H^+ + 2e^- \rightarrow H_2$

$2H_2O \rightarrow O_2 + 4H^+ + 4e^-$

**Very active metal ions lose to water at the cathode.** $Na^+$, $K^+$, and $Al^{3+}$ are harder to reduce than water, so their aqueous solutions give hydrogen gas at the cathode, never the metal. $Cu^{2+}$ and $Ag^+$ plate out as metals instead.

## Cells in Series

**Cells wired in series share one current, so they share one charge.** The same moles of electrons pass through every cell in the chain. Products differ only by half reaction stoichiometry.

**One mole of electrons makes different moles of different metals.** Through an $Ag^+$ cell and a $Cu^{2+}$ cell in series, 1.00 mol $e^-$ deposits 1.00 mol of silver (1 electron per ion) but only 0.50 mol of copper (2 per ion).

For any metal, the mass deposited by one mole of electrons is its molar mass divided by n: copper gives 63.55 / 2 = 31.78 g, silver gives 107.9 / 1 = 107.9 g. For the same charge, the copper deposit weighs 31.78 / 107.9 = 0.295 times the silver deposit.

## Worked Examples

> **Example 1: Copper plated by a steady current. A current of 3.00 A flows for 1.00 hour through a $Cu^{2+}$ cell. Time is 3600 s, so Q = (3.00)(3600) = 10,800 C, moles of electrons are 10,800 / 96,485 = 0.1119 mol, moles of copper are 0.1119 / 2 = 0.05597 mol, and mass is 0.05597 × 63.55 = 3.56 g of copper.**

> **Example 2: Time to plate a target mass, worked backward. How long does it take to plate 10.0 g of copper at 5.00 A? Moles of copper are 10.0 / 63.55 = 0.1574 mol, so moles of electrons are 0.1574 × 2 = 0.3148 mol, and charge is 0.3148 × 96,485 = 30,372 C. Time is 30,372 / 5.00 = 6074 s, which is 101 min.**

© 2026 ExamFitter.com · Free AP Chemistry revision notes

**Example 3: Time to deposit aluminum. How long does a current of 1.50 A take to deposit 2.70 g of aluminum? Moles of aluminum are 2.70 / 27.0 = 0.100 mol, so moles of electrons are 0.100 × 3 = 0.300 mol, and charge is 0.300 × 96,485 = 28,946 C. Time is 28,946 / 1.50 = 19,297 s, which is 5.36 h.**

**Example 4: Hydrogen volume from a water cell. A current of 2.0 A flows for 30.0 min through an acidic water electrolysis cell. Time is 1800 s, so Q = (2.0)(1800) = 3600 C, moles of electrons are 3600 / 96,485 = 0.0373 mol, moles of hydrogen are 0.0373 / 2 = 0.0187 mol, and volume at STP is 0.0187 × 22.4 = 0.42 L of $H_2$. The oxygen volume from the same charge is half as much, 0.21 L.**

## Traps That Cost Marks in Topic 9.11

**Forgetting to convert time to seconds.** Q = I × t needs seconds: 3.00 A for 1.00 hour is 10,800 C, not 3.00 C. Convert before multiplying.

**Treating moles of electrons as moles of product.** Dividing charge by F gives moles of electrons, not moles of metal. For $Cu^{2+}$, forgetting the factor of 2 doubles the answer.

**Swapping the hydrogen and oxygen electron counts.** Hydrogen needs 2 electrons per molecule and oxygen needs 4, so the oxygen volume from a given charge is half the hydrogen volume, not equal to it.

**Giving series cells the same moles or the same mass.** Series cells share charge and moles of electrons, not moles of product and not mass.

**Confusing electrode signs between cell types.** In electrolysis the anode is positive and the cathode is negative, the reverse of a galvanic cell.

**Thinking current and mass are related by a square, or rounding too early.** Doubling the current doubles the mass; it does not quadruple it. Keep at least 4 significant figures through the charge and mole steps, and round only the final answer.

© 2026 ExamFitter.com · Free AP Chemistry revision notes

**Key Relationships to Remember**

- $Q = I \times t$ (amperes × seconds = coulombs)
- mol $e^-$ = $Q / F$, with $F = 96{,}485$ C $mol^{-1}$
- mol substance = mol $e^-$ / n, n from the balanced half reaction
- mass = mol × molar mass; gas volume at STP = mol × 22.4 L $mol^{-1}$
- Backward chain: mass → mol → mol $e^-$ → Q → $t = Q / I$
- Series cells share charge and mol $e^-$; products differ only by n, masses by molar mass as well
- Cathode: easiest reduction wins; anode: easiest oxidation wins; water beats very active metal ions
- Same charge makes twice the volume of $H_2$ as $O_2$ (2 $e^-$ versus 4 $e^-$ per molecule)
- Mass per mole of electrons = molar mass / n (Cu is 0.295 times Ag for the same charge)

**Continue Revising**

Topic 9.11 Quiz: Electrolysis and Faraday's Law

Topic 9.11 Worksheet

Unit 9: All Topics

© 2026 ExamFitter.com · Free AP Chemistry revision notes