

Class 12 Chemistry – Electrochemistry | Study Guide

1. Theory in Simple Words with Visuals

1.1 What is Electrochemistry?

- **Definition:** Electrochemistry studies the **relationship between chemical reactions and electricity**.
- **Two types of reactions:**
 1. **Electrolytic reactions** – Chemical reaction caused by **electric current**
 2. **Galvanic (Voltaic) reactions** – Electric current produced by **chemical reaction**

Analogy: Like a **battery** that produces electricity from chemicals or uses electricity to make chemicals.

1.2 Basic Terms

Term	Meaning	Analogy / Visual
Electrode	Conductor where reaction occurs	Metal plate in solution
Electrolyte	Substance that conducts electricity in solution	Salt water
Anode	Electrode where oxidation occurs	"An-oxide" – loses electrons
Cathode	Electrode where reduction occurs	"Cat-ions go in" – gains electrons
Cations	Positive ions	Move to cathode
Anions	Negative ions	Move to anode

Flowchart:

Electrochemical Cell → Electrodes + Electrolyte

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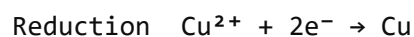
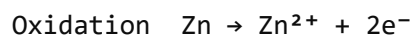
Anode (Oxidation) → Electrons released

Cathode (Reduction) → Electrons accepted

1.3 Types of Electrochemical Cells

1. **Galvanic / Voltaic Cell** – Converts **chemical energy** → **electrical energy**
 - Example: Daniell cell (Zn-Cu)

Visual:

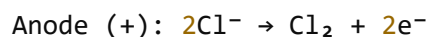
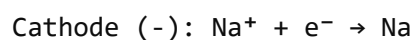
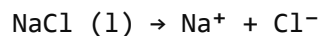


- **Electron flow:** Anode \rightarrow Cathode

2. Electrolytic Cell – Uses electric energy \rightarrow chemical reaction

- Example: Electrolysis of molten NaCl

Visual:



1.4 Important Concepts

- **Electrode Potential (E°):** Tendency of a species to gain electrons
- **Cell Potential / EMF:** $E_{\text{cell}} = E_{\text{cathode}} - E_{\text{anode}}$
- **Nernst Equation:**

$$E = E^{\circ} - \frac{0.0591}{n} \log Q$$

- **Faraday's Laws of Electrolysis:**
 1. Mass of substance \propto charge passed
 2. Mass \propto equivalent weight

Mnemonic: "OIL RIG" \rightarrow Oxidation Is Loss, Reduction Is Gain

1.5 Conductance

- **Conductivity (κ):** Ability of solution to conduct electricity
- **Molar Conductivity (Λ_m):** Conductivity per mole of solute
- **Relation:**

$$\Lambda_m = \frac{\kappa \times 1000}{C}$$

Visual: Think of ions as electric "cars" carrying charge. More ions \rightarrow higher conductivity.

2. Key Concepts & Formulas

Concept	Formula / Fact	Tip / Mnemonic
EMF of Cell	$E_{\text{cell}} = E_c - E_a$	Cathode - Anode
Nernst	$E = E^0 - \frac{0.0591}{n} \log Q$	At 25°C
Faraday's 1st law	$m \propto Q$	$Q = I \times t$
Faraday's 2nd law	$m \propto \text{Eq. wt}$	$m = (Q \times M) / (nF)$
Conductivity	$\kappa = 1/R \times (\text{cell constant})$	$R = \text{resistance}$
Molar Conductivity	$\Lambda_m = \kappa \times 1000 / C$	$\Lambda_m \uparrow \text{ as } C \downarrow$

Memory Trick: "Cathode minus Anode gives EMF glow"

3. Solved Numerical Problems

Example 1: EMF of Cell

Problem: Zn-Cu cell. $E_{\text{Cu}^{2+}/\text{Cu}}^0 = 0.34\text{V}$, $E_{\text{Zn}^{2+}/\text{Zn}}^0 = -0.76\text{V}$. Find EMF.

Solution:

$$\text{EMF} = E_c - E_a = 0.34 - (-0.76) = 1.10\text{ V}$$

Example 2: Faraday's Law

Problem: 2 Faradays of charge passed through Cu^{2+} solution. Mass of Cu deposited? ($M = 63.5\text{ g/mol}$, $n = 2$)

Solution:

$$m = (Q \times M) / (nF) = (2 \times 63.5) / 2 = 63.5\text{ g}$$

Tip: 1 Faraday = 96500 C

Example 3: Nernst Equation

Problem: Calculate E for Zn/Cu cell with $[\text{Zn}^{2+}] = 0.01\text{ M}$, $[\text{Cu}^{2+}] = 0.1\text{ M}$.

Solution:

$$E = E^0 - \frac{0.0591}{2} \log \frac{[\text{Zn}^{2+}]}{[\text{Cu}^{2+}]} = 1.10 - 0.02955 \log(0.01/0.1)$$

$$\log(0.1) = -1 \rightarrow E \approx 1.10 - 0.02955(-1) = 1.13\text{ V}$$

4. Previous Years' Board Questions (Solved)

1. EMF of various cells – 2017, 2018, 2020
2. Faraday's law problems – 2016, 2019
3. Electrolysis of molten salts – 2015, 2019
4. Nernst equation applications – 2018, 2021

Pattern: EMF, Faraday's Law, and electrolysis numericals are **high-weightage**.

5. Quick Revision Notes / Important Points

- **EMF:** Cathode – Anode
- **Faraday Law:** $m = (Q \times M)/(nF)$
- **Nernst Equation:** $E = E^0 - 0.0591/n \log Q$
- **Electrolysis tips:** Cathode → reduction, Anode → oxidation
- **Mnemonic:** "OIL RIG", "Cathode minus Anode = EMF"

Flowchart: Electrochemistry Concepts

Electrochemistry

↓

1. Galvanic Cell → Chemical → Electrical

2. Electrolytic Cell → Electrical → Chemical

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Key Formulas → EMF, Faraday, Nernst

6. Predicted / Likely Questions

1. EMF of Zn-Cu, Fe-Cu cells
 2. Electrolysis of molten NaCl / CuSO₄
 3. Faraday's law numerical problems
 4. Nernst equation with concentration changes
 5. Conductivity and molar conductivity comparison
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7. Exam Tips & Tricks

- Always **identify cathode/anode** before solving EMF
 - **Check units:** current in Amps, time in seconds, $F = 96500 \text{ C}$
 - **Shortcut:** Mass deposited = $(I \times t \times M) / (n \times F)$
 - Use **flowchart for solving:** Identify cell → Determine E^0 → Use EMF/Nernst → Solve
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8. Visual & Kid-Friendly Learning Style

- Draw **electron flow arrows** from anode → cathode
- Color-code **anode red (loss)**, **cathode blue (gain)**
- Picture ions as **tiny “electrons carriers” running in solution**
- Sketch **cell diagram** with salt bridge, electrodes, and labels