Class 12 Chemistry – Electrochemistry | Study Guide

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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
   ↓
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:

```
Zn(s) | Zn²⁺(aq) || Cu²⁺(aq) | Cu(s)
Oxidation  Zn → Zn²⁺ + 2e⁻
Reduction  Cu²⁺ + 2e⁻ → Cu
```

- **Electron flow:** Anode → Cathode

2. **Electrolytic Cell** – Uses **electric energy → chemical reaction**
   - Example: Electrolysis of molten NaCl

   Visual:

```
NaCl (l) → Na⁺ + Cl⁻
Cathode (-): Na⁺ + e⁻ → Na
Anode (+): 2Cl⁻ → Cl₂ + 2e⁻
```

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:**

$$E = E^0 - \frac{0.0591}{n} \log Q$$

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

Mnemonic: "OIL RIG" → Oxidation Is Loss, Reduction Is Gain

1.5 Conductance

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

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

Visual: Think of ions as **electric "cars" carrying charge**. More ions → higher conductivity.

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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 ∝ Q	Q = I × t
Faraday's 2nd law	m ∝ Eq. wt	m = (Q × M) / (nF)
Conductivity	κ = 1/R × (cell constant)	R = resistance
Molar Conductivity	Λm = κ × 1000 / C	Λm ↑ as C ↓

Memory Trick: "Cathode minus Anode gives EMF glow"

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3. Solved Numerical Problems

Example 1: EMF of Cell

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

Solution:
EMF = E_c - E_a = 0.34 - (-0.76) = 1.10 V

Example 2: Faraday's Law

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

Solution:
m = (Q × M) / (nF) = (2 × 63.5) / 2 = 63.5 g

Tip: 1 Faraday = 96500 C

Example 3: Nernst Equation

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

Solution:

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

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

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**.

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5. Quick Revision Notes / Important Points

- **EMF:** Cathode – Anode
- **Faraday Law:** m = (Q × 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
   ↓
Key Formulas → EMF, Faraday, Nernst
```

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6. Predicted / Likely Questions

1. EMF of Zn-Cu, Fe-Cu cells
2. Electrolysis of molten NaCl / $CuSO_4$
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 C
- **Shortcut:** Mass deposited = (I × t × M) / (n × F)
- Use **flowchart for solving**: Identify cell → Determine E° → 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