

Electrochemistry & Batteries – Cheat Sheet (Theory Only)

1. Galvanic Cells (Voltaic Cells)

Electrochemical cells that convert **chemical energy into electrical energy** through spontaneous redox reactions.

Components:

- **Two electrodes (Anode & Cathode).**
- **Electrolyte solution (Ionic conductor).**
- **Salt bridge (Maintains charge balance).**

Example: Daniel Cell (Zinc & Copper electrodes).

2. Single Electrode Potential

The potential difference between a **metal electrode** and its **ion solution**.

Depends on **metal type, ion concentration, and temperature**.

3. Standard Electrode Potential (E°)

Electrode potential at standard conditions (**1M concentration, 25°C, 1 atm pressure**).

Used to predict **spontaneity of redox reactions**.

Positive E° → Strong tendency to gain electrons (**good oxidizing agent**).

Negative E° → Strong tendency to lose electrons (**good reducing agent**).

4. Electrochemical Series

A list of elements arranged by their **standard electrode potentials**.

Applications:

- Predicts **reactivity of metals**.
 - Determines **electrochemical cell voltage**.
 - Helps in **corrosion prevention**.
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5. EMF of a Cell & Its Measurement

Electromotive Force (EMF) → The potential difference between **two electrodes in a galvanic cell**.

Measured using a **potentiometer or voltmeter** under open circuit conditions.

6. Nernst Equation

Relates **electrode potential to ion concentration, temperature, and number of electrons transferred**.

Used to **calculate the actual EMF of a cell under non-standard conditions**.

7. Electrolyte Concentration Cells

A type of electrochemical cell where **both electrodes are the same**, but **electrolyte concentrations differ**.

Generates EMF due to **ion concentration differences**.

Used in **sensors and biological membranes**.

8. Reference Electrodes

Reference Electrode	Description	EMF (V) vs SHE
Standard Hydrogen Electrode (SHE)	Primary reference, Pt electrode in H ₂ gas at 1 atm	0.00V
Calomel Electrode	Mercury + Hg ₂ Cl ₂ in KCl solution	0.242V (saturated KCl)
Silver-Silver Chloride (Ag/AgCl) Electrode	Ag wire in AgCl + KCl solution	0.197V (saturated KCl)

Used in pH measurements, electrochemical studies, and corrosion analysis.

9. Batteries & Fuel Cells

Types of Batteries

1. Alkaline Battery (Primary Cell)

Uses **zinc anode & manganese dioxide cathode**.

Non-rechargeable, used in remotes, toys, flashlights.

2. Lead-Acid Storage Battery (Secondary Cell)

Used in **automobiles, UPS systems**.

Rechargeable, operates on **Pb/PbO₂ electrodes & sulfuric acid electrolyte**.

3. Nickel-Cadmium (Ni-Cd) Battery

Rechargeable, used in **cordless phones, power tools**.

Uses **Nickel Hydroxide & Cadmium electrodes**.

Long cycle life but **toxic cadmium content**.

10. Fuel Cells

Converts **chemical energy from fuel (H₂, methanol) directly into electrical energy**.

Hydrogen-Oxygen (H₂ - O₂) Fuel Cell

Anode Reaction → Hydrogen is oxidized to protons.

Cathode Reaction → Oxygen is reduced to form water.

Applications:

- Spacecraft & submarines (NASA fuel cells).
 - Electric vehicles (Hydrogen-powered cars).
 - Sustainable energy generation.
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Applications of Batteries & Fuel Cells

Automobiles (Lead-acid battery, Li-ion battery in EVs).

Portable Devices (Alkaline & Ni-Cd batteries).

Renewable Energy Storage (Hydrogen fuel cells).

Medical Equipment (Pacemakers, hearing aids).

This **Electrochemistry & Batteries Cheat Sheet** covers **galvanic cells, electrode potential, electrochemical series, EMF, reference electrodes, Nernst equation, batteries, and fuel cells**. Let me know if you need further explanations!