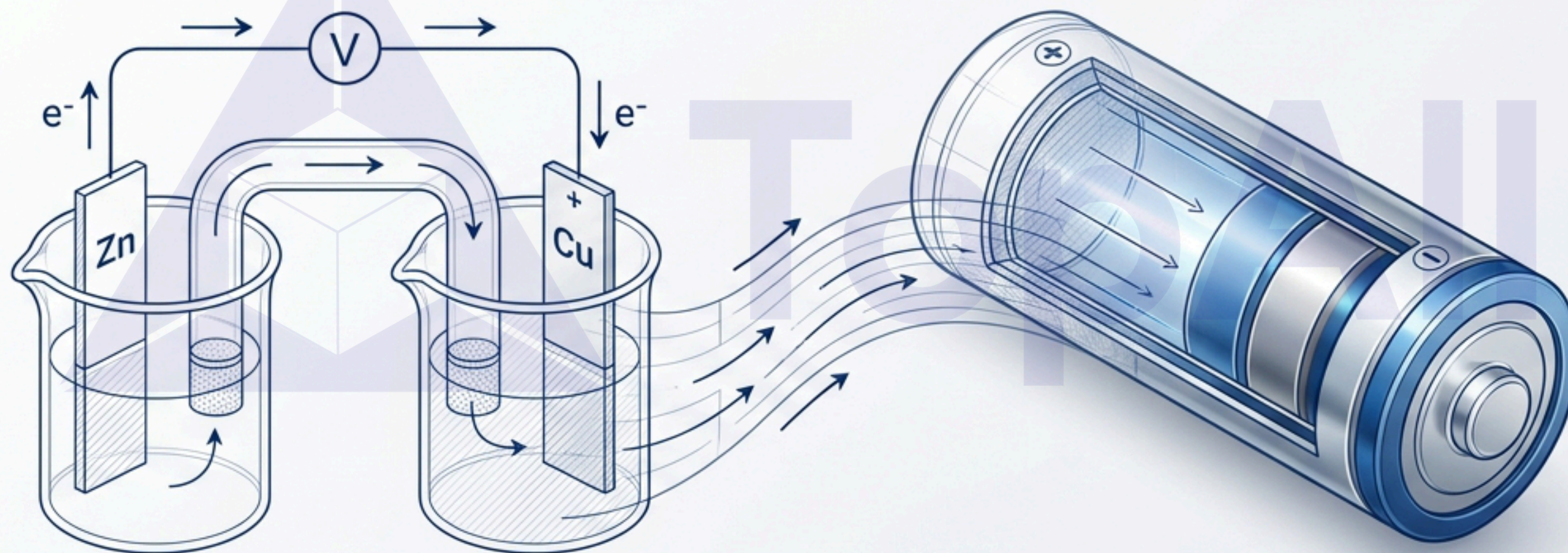


2.6 Batteries

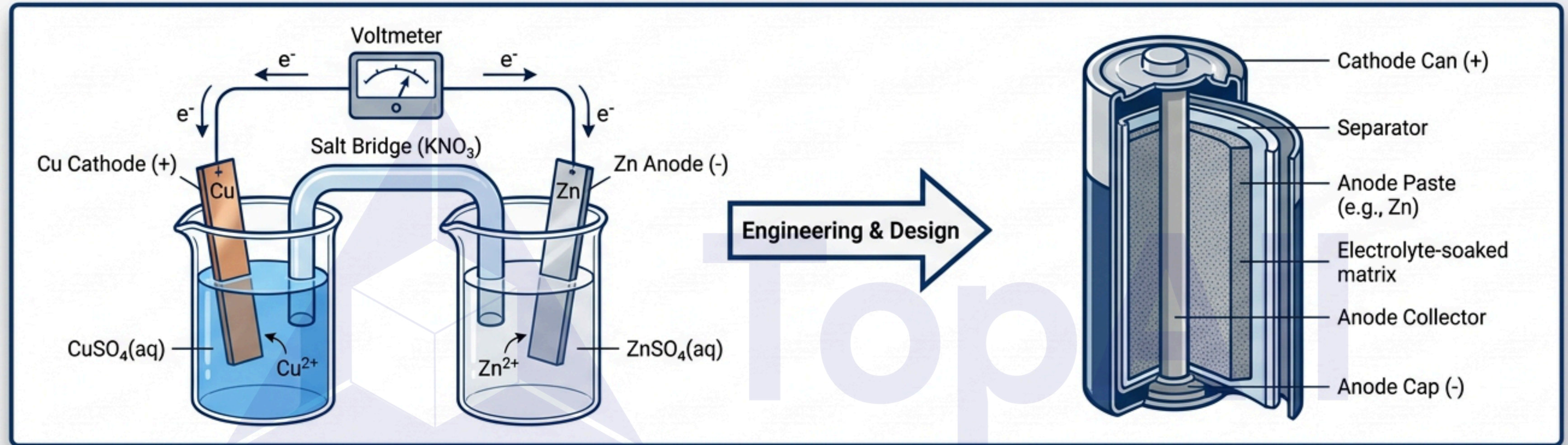
Converting Chemical Energy into Electrical Power



Spontaneous Redox Reactions

Portable Galvanic Cells

What a Battery Is in Electrochemistry



The Core Principle

A battery is fundamentally one or more **Galvanic cells** connected in series. It directly converts the chemical energy of a spontaneous redox reaction into electrical energy.

Practical Requirements

For a battery to be commercially viable, it must be reasonably light, compact, and capable of maintaining a steady, non-varying voltage during use.

Thermodynamic Basis

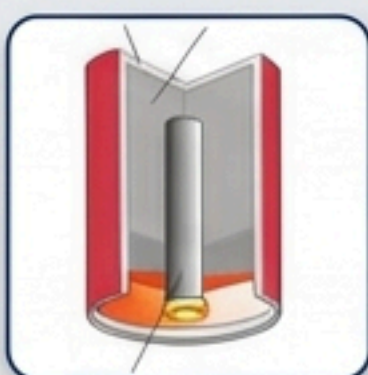
The underlying chemical reaction must be spontaneous. The electrical work done relies entirely on a decrease in Gibbs free energy.

$$\Delta G = -nFE_{(\text{cell})} < 0 \mid \text{Chemical Energy} \rightarrow \text{Electrical Energy}$$

Primary vs Secondary Batteries

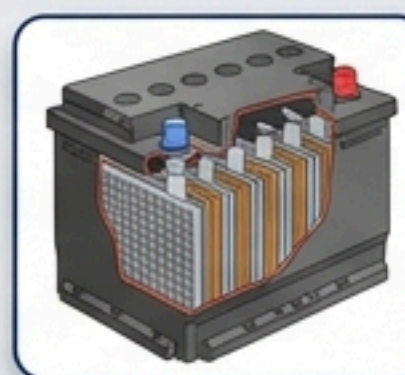
Feature	Primary Batteries	Secondary Batteries
The Core Difference	Non-Rechargeable (One-time use)	Rechargeable (Multiple cycles)
Chemical Reaction	Unidirectional; cell becomes dead over time.	Reversible by passing an opposing current.
Exam Examples	Dry Cell (Leclanche), Mercury Cell	Lead Storage Battery, Nickel-Cadmium Cell

Primary Example (Dry Cell)

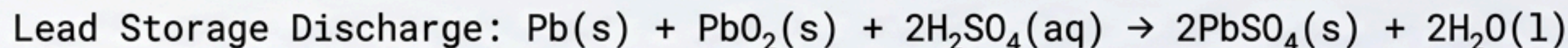


- **Anode:** Zinc container
- **Cathode:** Carbon (graphite) rod + MnO_2
- **Application:** Transistors, clocks ($\sim 1.5\text{V}$)

Secondary Example (Lead Storage)



- **Anode:** Lead (Pb)
- **Cathode:** Lead grid packed with PbO_2
- **Electrolyte:** 38% H_2SO_4
- **Application:** Automobiles, inverters





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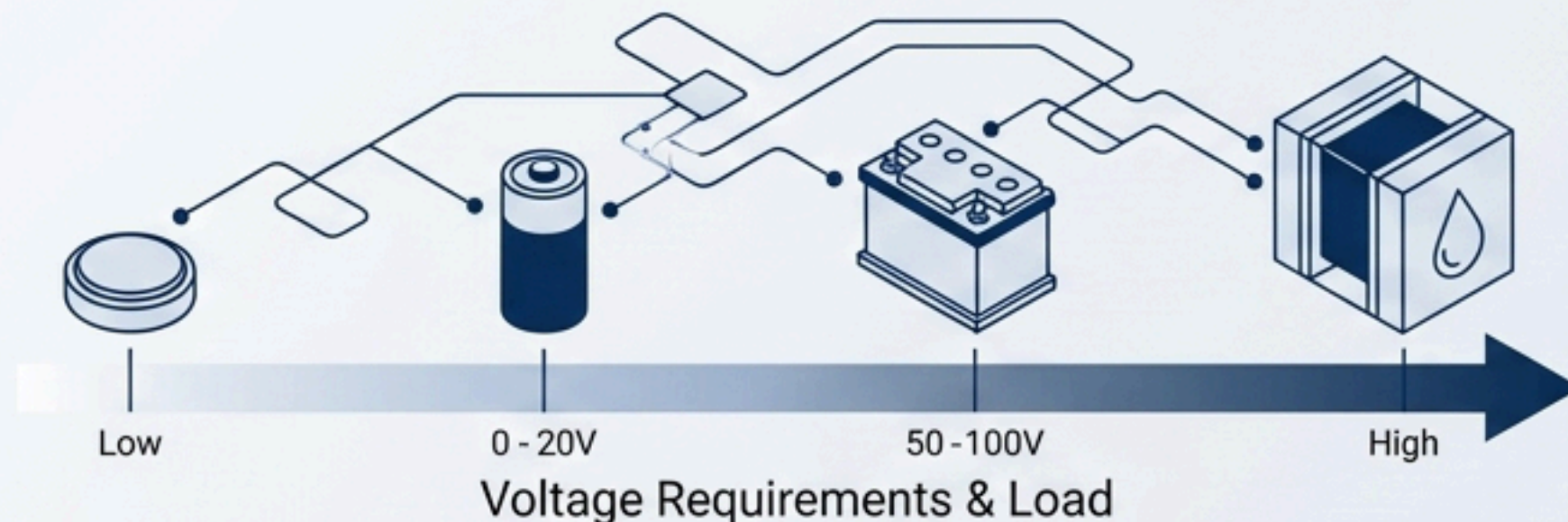
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REAL-WORLD IMPACT

Why Batteries Matter in Daily Life



Micro Electronics



Devices: Hearing aids, watches.

Cell Type: Mercury Cells.

Why: The overall reaction does not involve ions in solution whose concentration can change, delivering a highly consistent 1.35V potential over its entire lifespan.



Heavy Automotive



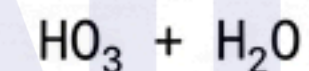
Devices: Car ignitions, home inverters.

Cell Type: Lead Storage Batteries.

Why: Capable of enduring a large number of intense discharging and charging cycles.



The Future



Concept: Fuel Cells (e.g., Hydrogen + Oxygen).

Why: Converts combustion energy directly to electricity. 70% efficient (vs. thermal plants), continuous feed, and zero pollution (byproduct is water).

From micro-devices to automobiles and clean energy grids, electrochemical cells drive modern portability and sustainability.

Final Recap: Chemical Energy Stored for Electrical Use

[Spontaneous Redox Reaction ($\Delta G < 0$)]



[Engineered Cell Container]



[Electrical Work (Voltage/Current)]

The Core Definition:

Batteries are Galvanic Cells. They package the energy of spontaneous redox reactions into a light, compact form with a steady voltage.

The Two Categories:

Primary vs. Secondary. Primary cells (Dry, Mercury) are single-use because their reactions are unidirectional. Secondary cells (Lead-storage, Ni-Cd) can reverse their chemistry when recharged with an opposing current.

The Broader Impact:

Efficiency & Scale. Beyond portable storage, fuel cells represent a highly efficient (70%) method of continuously converting chemical fuel into electricity.

Chemical Energy → Electrical Energy



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