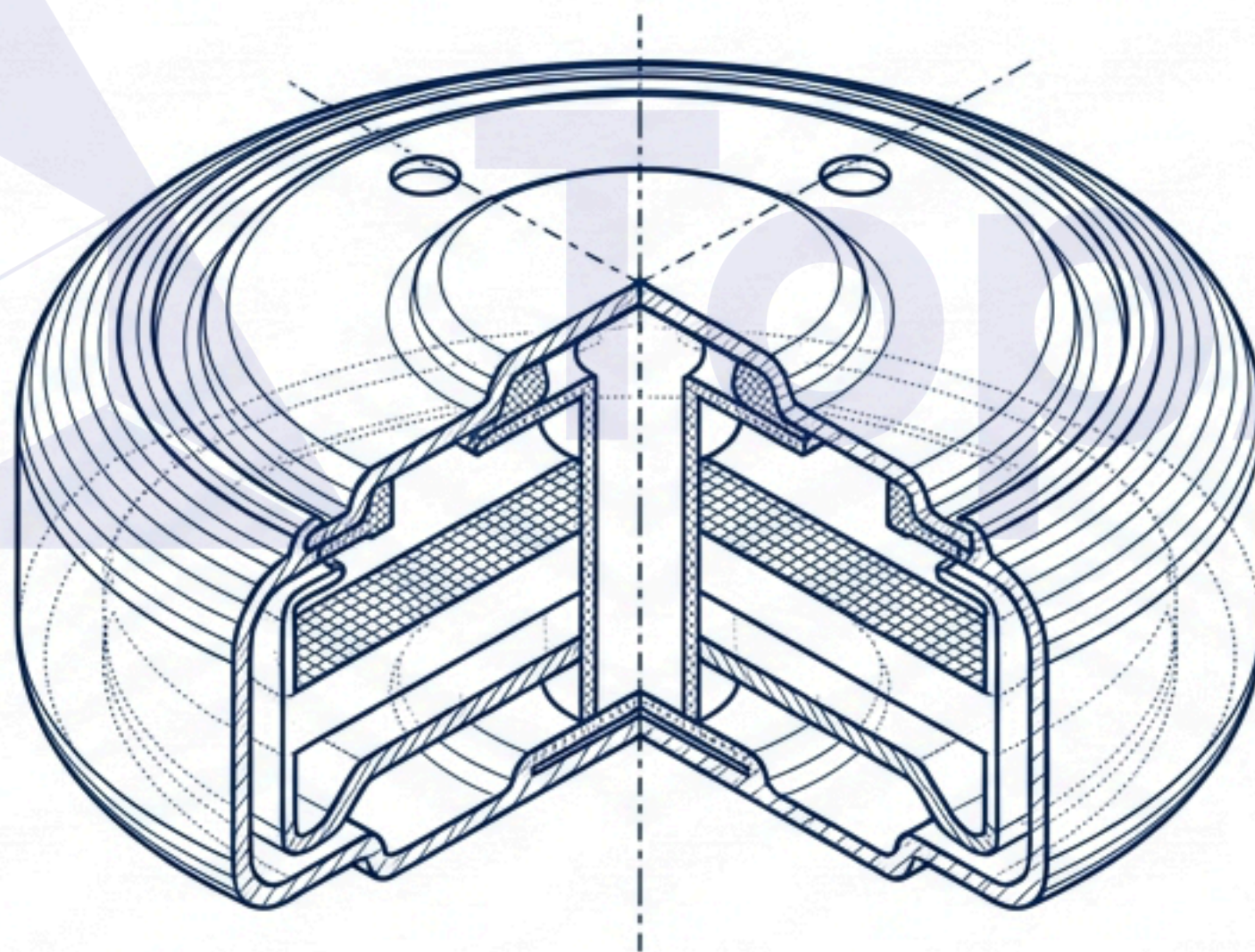


2.6.1 Primary Batteries

Anatomy, Chemistry, and Thermodynamics of the Mercury Cell



Defining the Primary Battery

Primary

CORE TRAIT



Reaction occurs only once.

Mechanism: One-way conversion of chemical energy (Gibbs free energy) to electrical work. Strictly non-reversible.

Lifecycle: Consumed and disposed of after a single use.

Examples:

Dry Cell (Leclanche)

Mercury Cell

Secondary

CORE TRAIT



Reaction is reversible.

Mechanism: Can be recharged by passing electrical current in the opposite direction.

Lifecycle: Supports multiple charge and discharge cycles.

Examples:

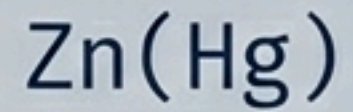
Lead Storage

Ni-Cd

Mercury Cell Construction

Top Cap / Anode (-)

Zinc-mercury amalgam



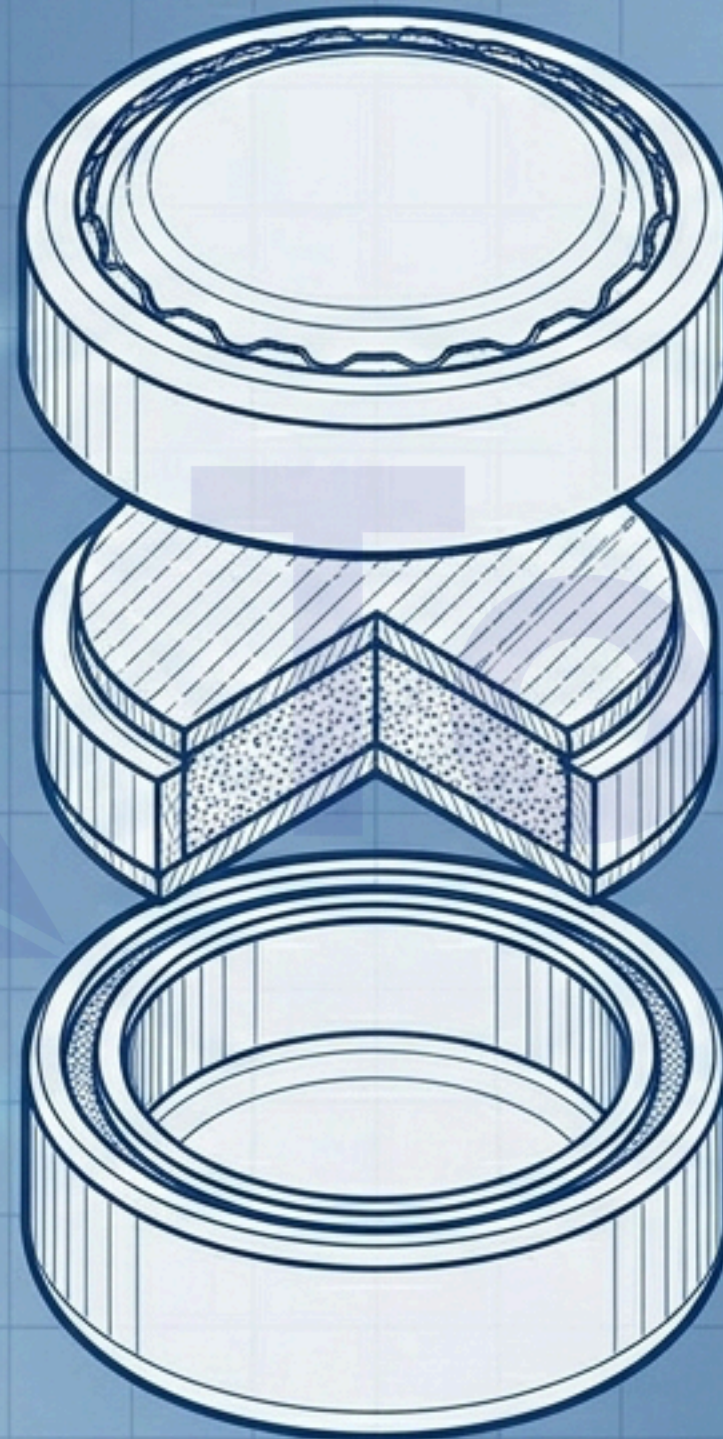
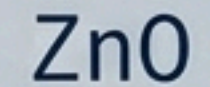
Bottom Can / Cathode (+)

A paste of Mercury(II)
Oxide and carbon.



Separator / Electrolyte

Porous separator filled
with a moist paste.





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$$E=mc^2$$



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The Chemical Engine: Half-Reactions

Anode (-)

Oxidation



Zinc oxidizes, releasing electrons into the external circuit.

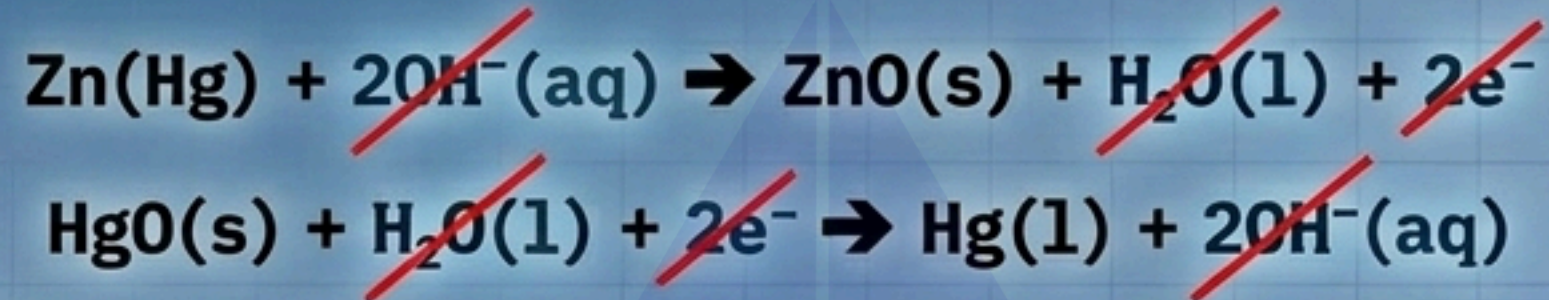
Cathode (+)

Reduction

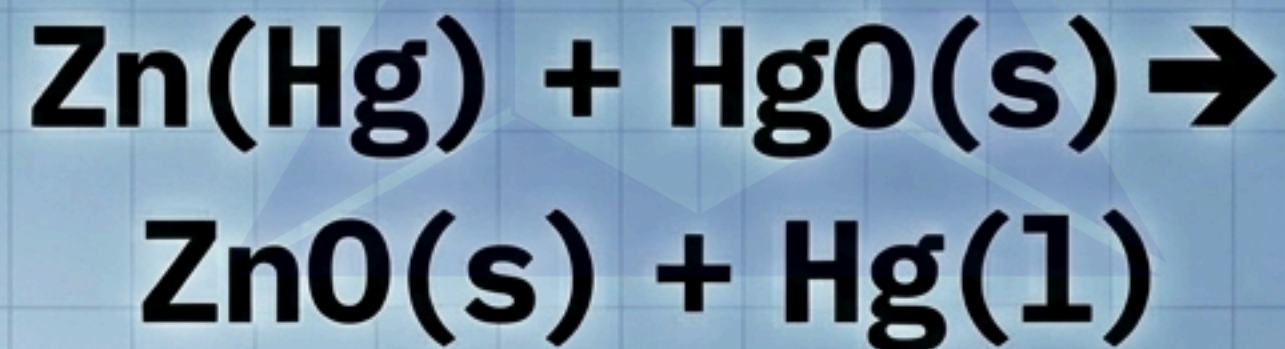


Mercury(II) oxide reduces to liquid mercury, consuming the incoming electrons.

Overall Reaction & Constant Potential



+

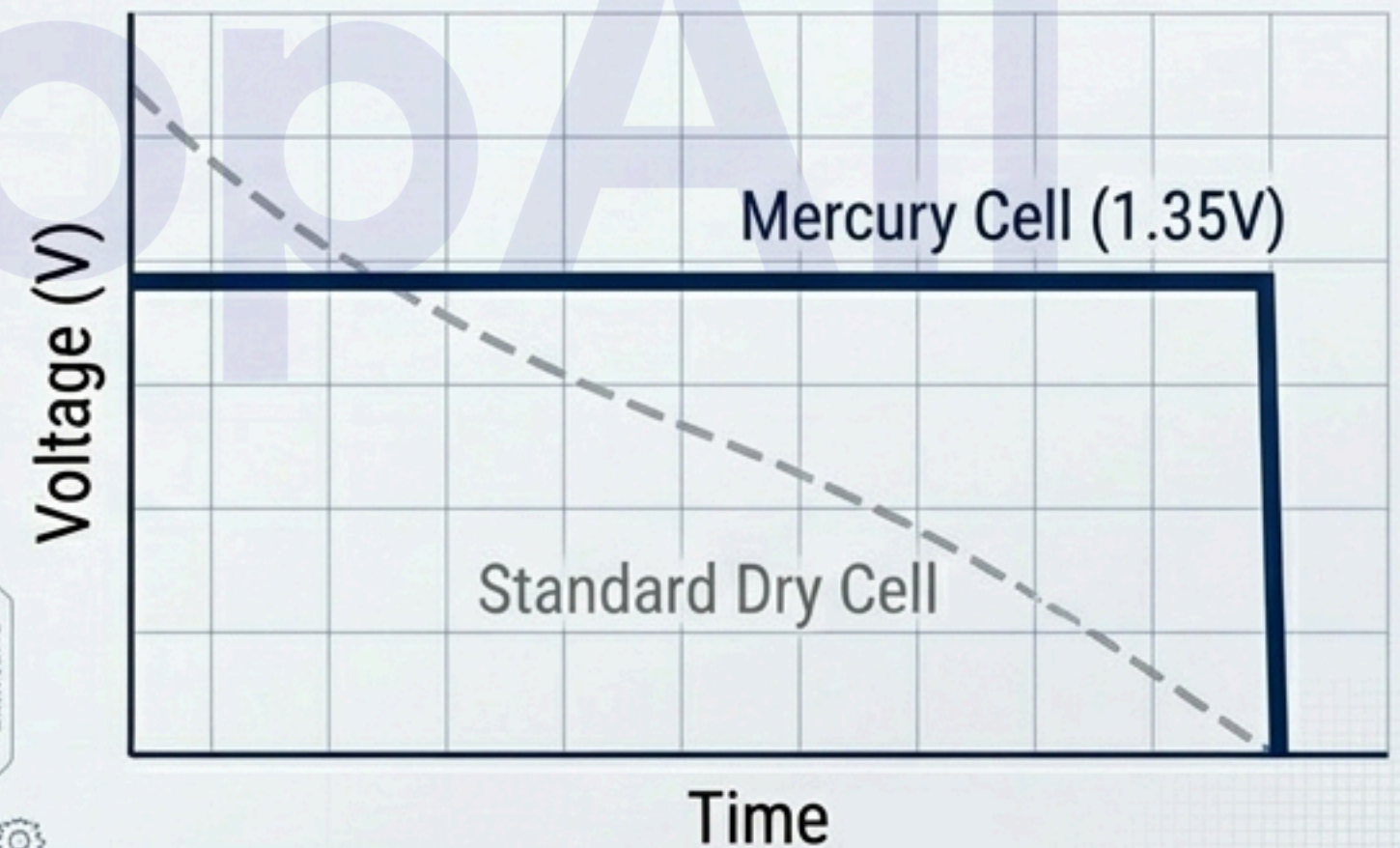


Key Takeaway: There are no aqueous ions involved in the overall reaction.

Because the concentration of pure solids and liquids is unity, the reaction quotient $Q = 1$. Therefore, $\ln(Q) = 0$.

$$E_{\text{cell}} = E^{\circ}_{\text{cell}} - (RT/nF)\ln(1)$$

$$E_{\text{cell}} = 1.35\text{V (Constant)}$$

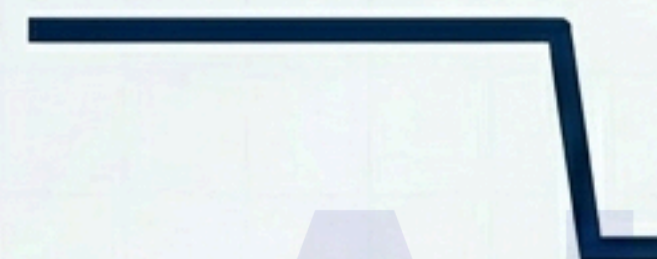


Final Recap: The Mercury Cell



One-Way Energy

As a primary battery, it undergoes a single, non-reversible conversion of Gibbs free energy into electrical work. It is completely dead once the reactants are consumed.



Stable Output

Delivers a constant 1.35V potential throughout its lifespan. Because no aqueous ions are consumed or produced, the reaction quotient remains permanently locked at 1.



Target Applications: Ideal for low-current devices requiring unwavering voltage, such as hearing aids, watches, and pacemakers.



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