

ELECTROCHEMISTRY
APPLICATIONS:
4: BATTERIES AND ELECTROLYSIS

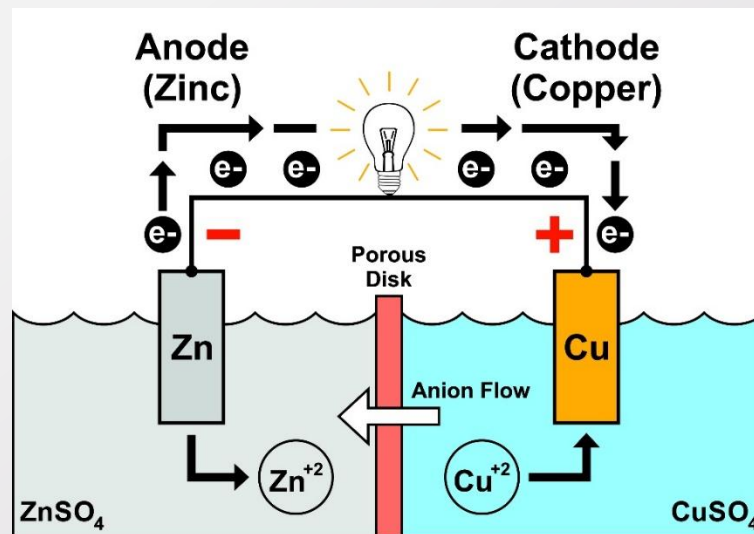
Dr. Sapna Gupta

ELECTROCHEMICAL CELLS

An **electrochemical cell** is a system consisting of electrodes that dip into an electrolyte and in which a chemical reaction either uses or generates an electric current.

A **voltaic** or **galvanic cell** is an electrochemical cell in which a spontaneous reaction generates an electric current.

An **electrolytic cell** is an electrochemical cell in which an electric current drives an otherwise nonspontaneous reaction.



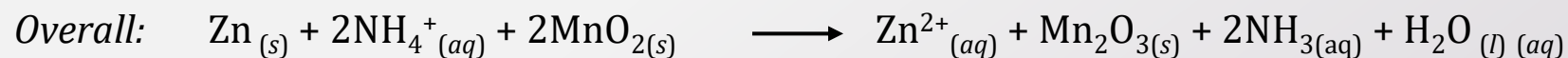
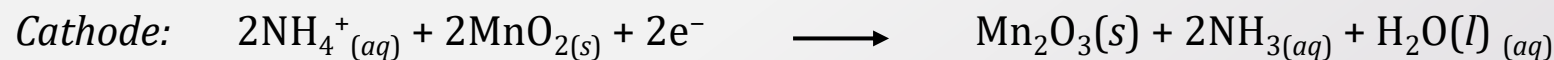
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GALVANIC CELLS

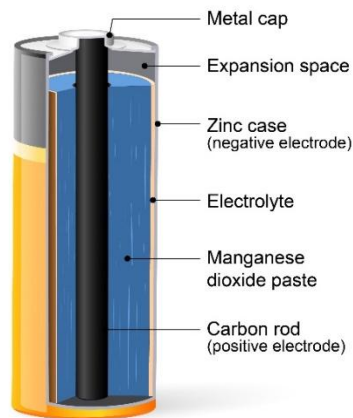
- **Galvanic cell** - the experimental apparatus for generating electricity through the use of a spontaneous reaction
- **Electrodes**
 - Anode (oxidation)
 - Cathode (reduction)
- **Half-cell** - combination of container, electrode and solution
- **Salt bridge** - conducting medium through which the cations and anions can move from one half-cell to the other.
- **Ion migration**
 - Cations – migrate toward the cathode
 - Anions – migrate toward the anode
- **Cell potential (E_{cell})** – difference in electrical potential between the anode and cathode
 - Concentration dependent
 - Temperature dependent
 - Determined by nature of reactants

BATTERIES

- A battery is a **galvanic cell**, or a series of cells connected that can be used to deliver a self-contained source of direct electric current.
- Dry Cells and Alkaline Batteries
 - no fluid components
 - Zn container in contact with MnO_2 and an electrolyte



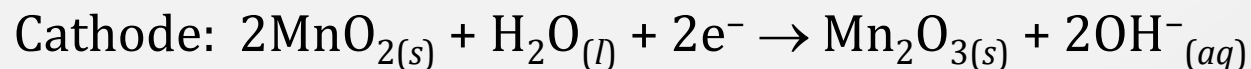
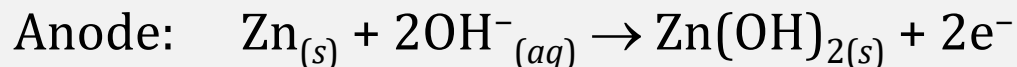
Dry cell battery



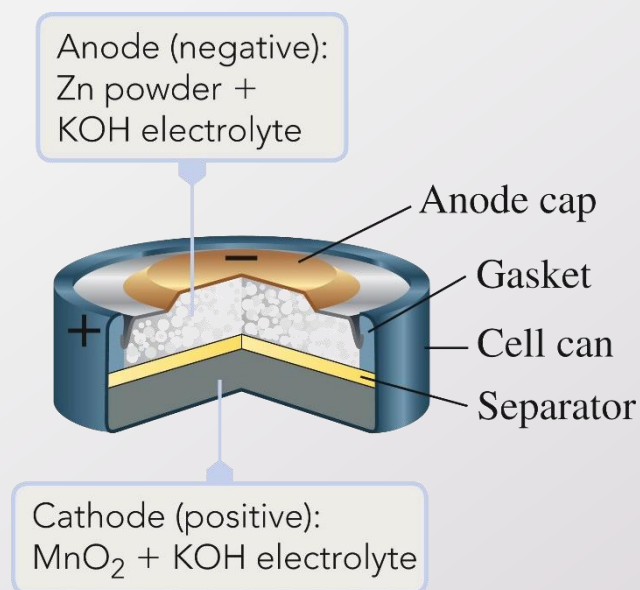
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ALKALINE CELL

- Common watch batteries



This cell performs better under current drain and in cold weather. It isn't truly "dry" but rather uses an aqueous paste.

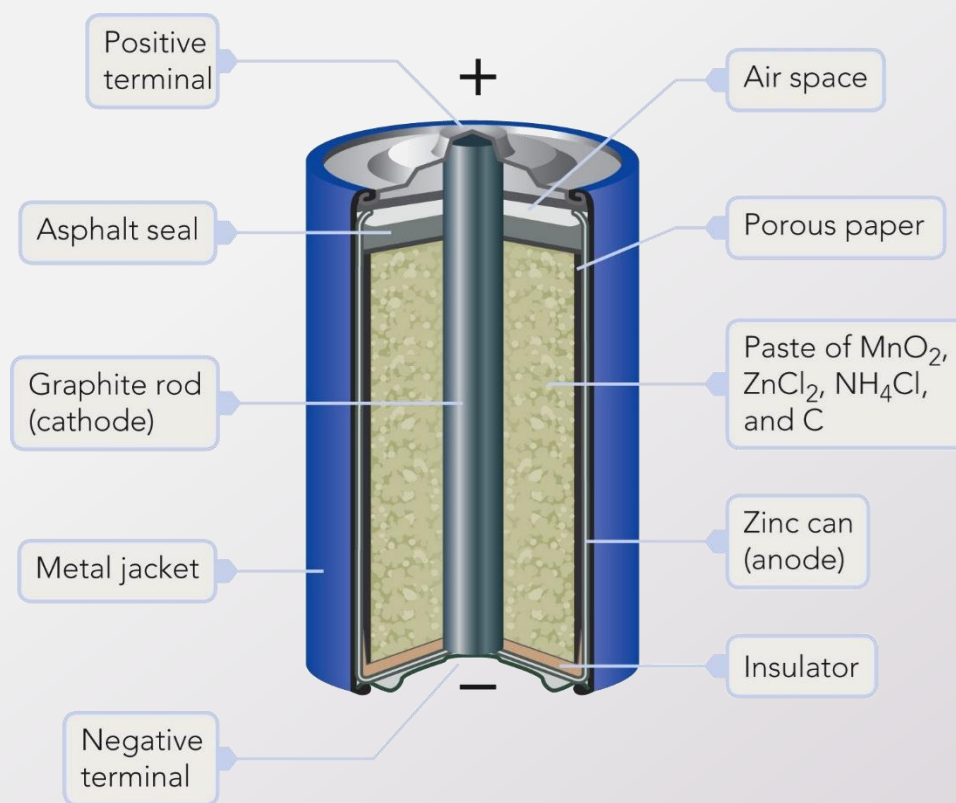


DRY CELLS – ZINC-CARBON

Anode: $\text{Zn}_{(s)} \rightarrow \text{Zn}^{2+}_{(aq)} + 2e^{-}$

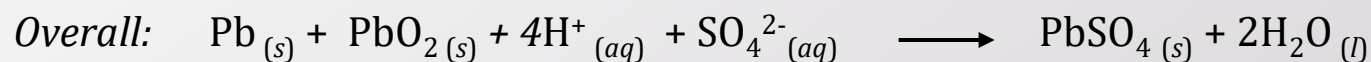
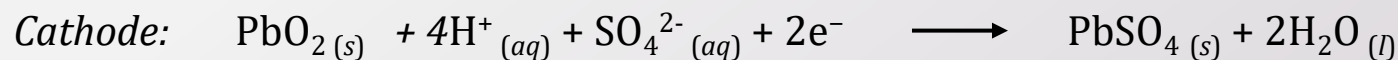
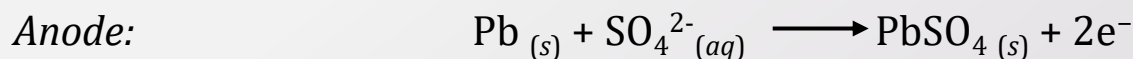
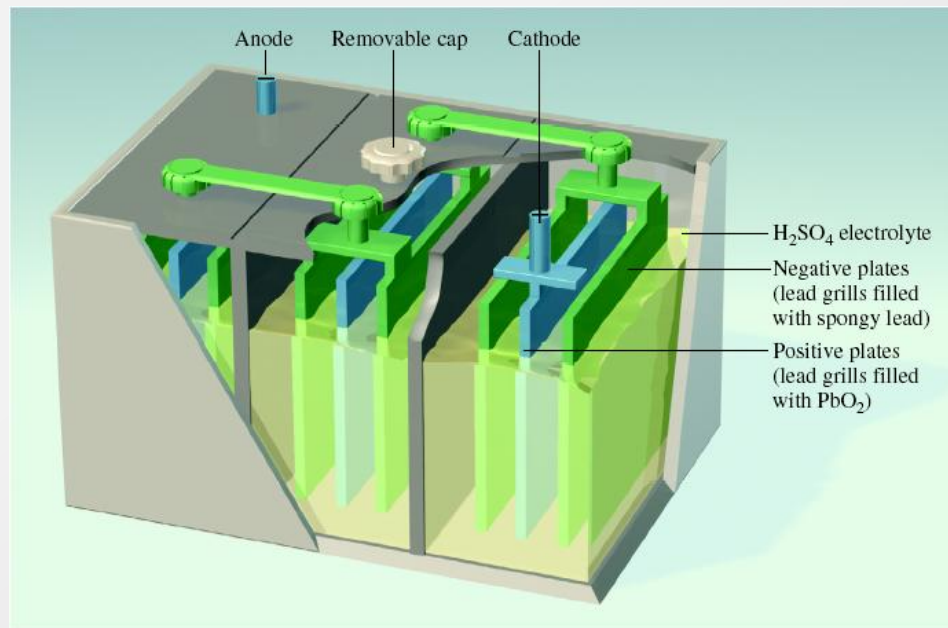
Cathode: $2\text{NH}_4^{+}_{(aq)} + 2\text{MnO}_{2(s)} + 2e^{-} \rightarrow \text{Mn}_2\text{O}_{3(s)} + \text{H}_2\text{O}_{(l)} + 2\text{NH}_{3(aq)}$

The initial voltage is about 1.5 V, but decreases and deteriorates rapidly in cold weather.



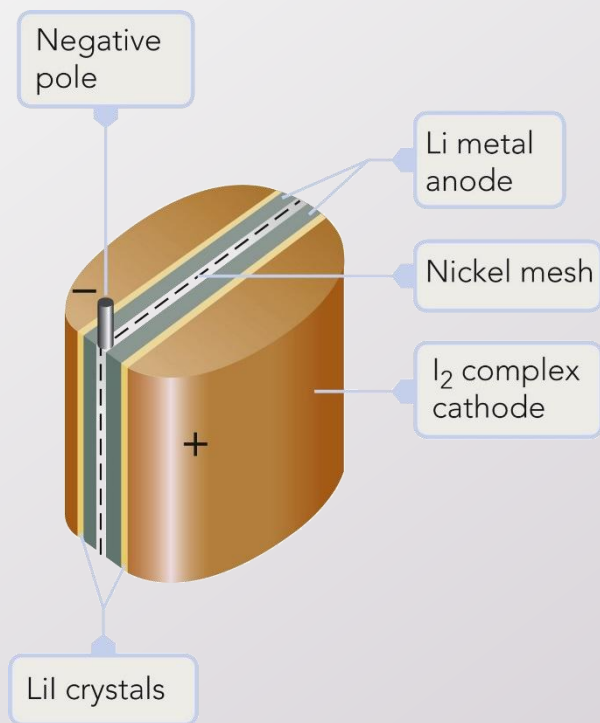
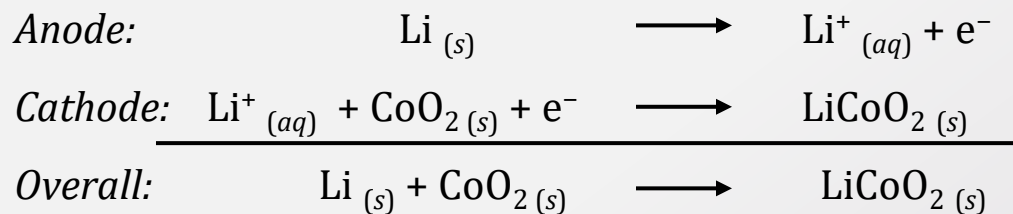
LEAD BATTERIES

- Six identical cells in series
- Lead anode and PbO_2 cathode
- Immersed in H_2SO_4
- Each cell delivers $\sim 2 \text{ V}$
- Rechargeable



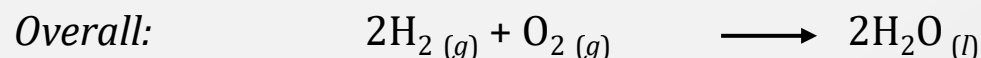
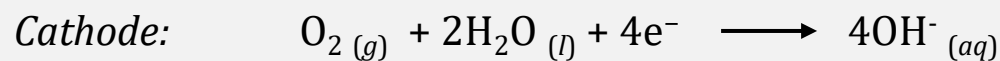
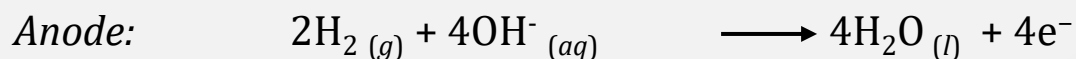
LITHIUM ION BATTERIES

- The overall cell potential is 3.4 V, which is a relatively large potential.
- Lithium is also the lightest metal—only 6.941 g of Li (its molar mass) are needed to produce 1 mole of electrons.
- Recharged hundreds of times.

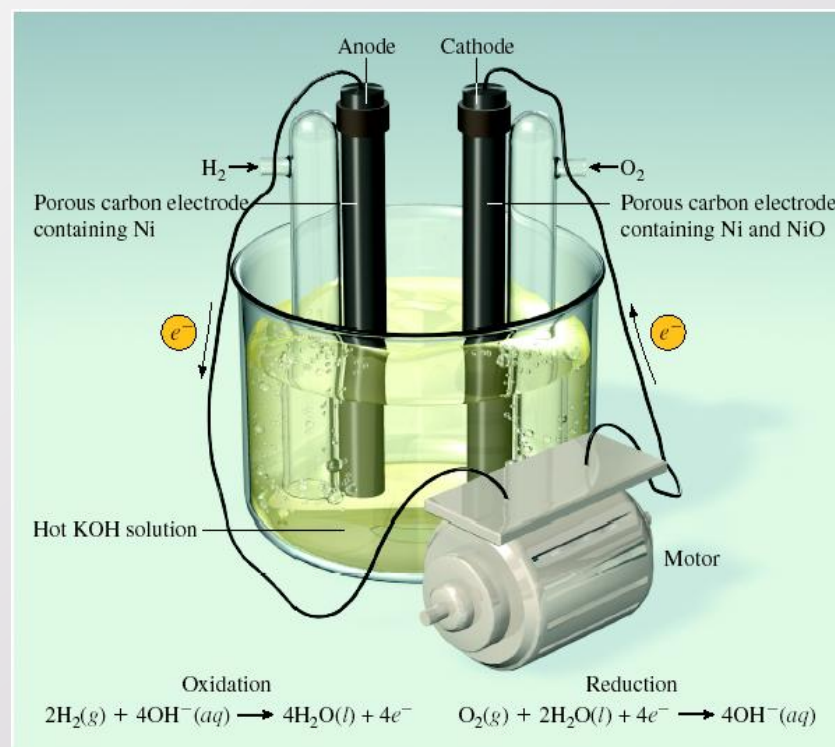


FUEL CELLS

- Direct production of electricity by electrochemical means
- Increased efficiency of power production



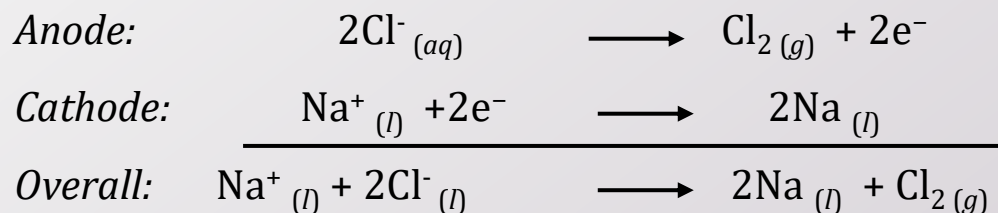
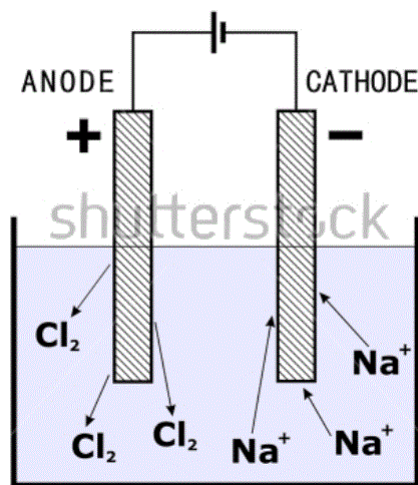
$$\begin{aligned} E_{\text{cell}}^{\circ} &= E_{\text{cathode}}^{\circ} - E_{\text{anode}}^{\circ} \\ &= 0.40 \text{ V} - (-0.83 \text{ V}) \\ &= 1.23 \text{ V} \end{aligned}$$



ELECTROLYSIS

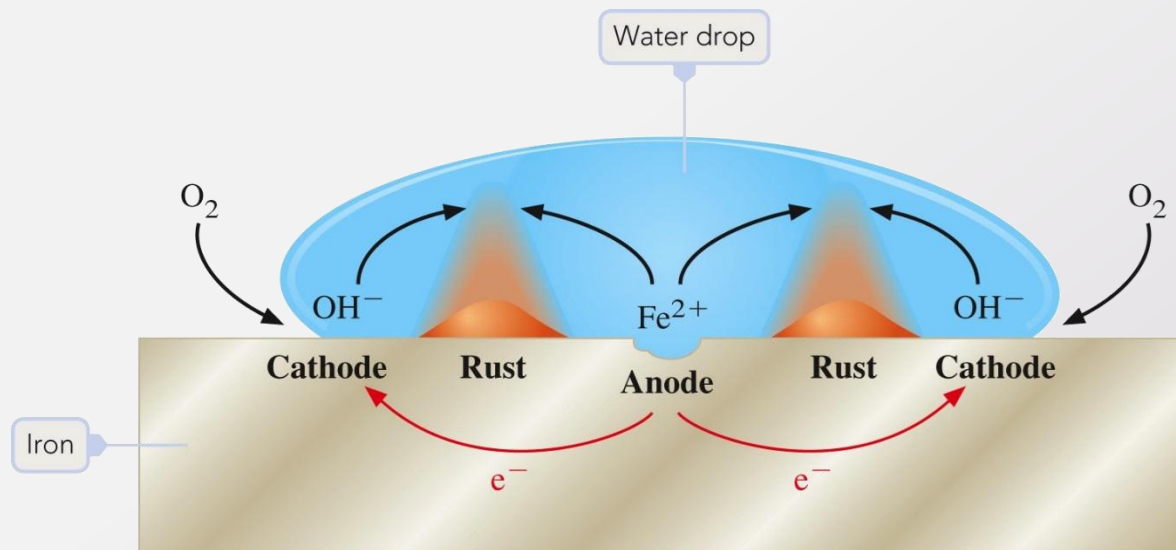
- **Electrolysis** - the use of electric energy to drive a nonspontaneous chemical reaction
- **Electrolytic cell** – the cell used to carry out electrolysis
 - same principles apply to both galvanic and electrolytic cells
 - in aqueous solutions you must also consider the oxidation or reduction of water
- Molten Sodium Chloride

Electrolysis of sodium chloride



CORROSION

- **Corrosion** - generally refers to the deterioration of a metal by an electrochemical process.
- Many metals undergo corrosion e.g. corrosion of Fe, oxidation of Al
- Can be enhanced by atmospheric conditions (e.g. acidic medium)



PREVENTING CORROSION

- Electrochemical processes can be used to prevent corrosion
 - **Passivation** – formation of a thin oxide layer by treating with an oxidizing agent
 - Formation of an alloy
 - Coating with a layer of a less active metal
 - Tin cans
 - **Galvanization** (zinc-plating)
 - Zinc oxide coating constitutes the protective coating

KEY CONCEPTS

- Batteries
 - Dry cell and alkaline batteries
 - Lead storage battery
 - Lithium-ion batteries
 - Fuel cells
- Electrolysis
 - Molten salts
 - Aqueous solutions
- Corrosion
 - Metal deterioration
 - Prevention