

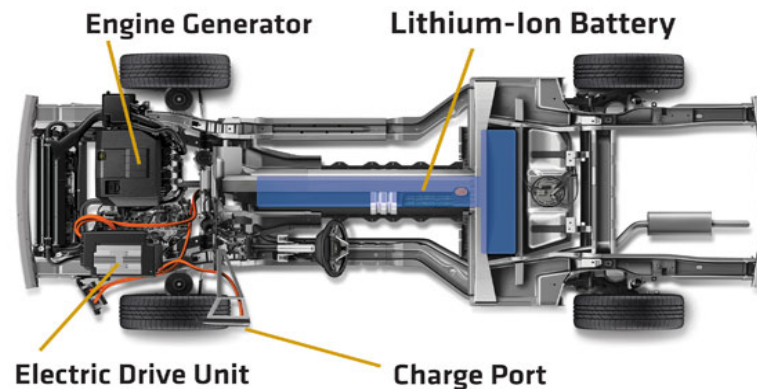
# Batteries



[www.energizer.com](http://www.energizer.com)

# Uses and Definition

- A battery is an device that stores electrical energy
- Two main categories
  - 1) Single Use – primary batteries
  - 2) Rechargeable – secondary batteries
- Currently investigated for uses in electric cars and storage of “green” energy



Chevy Volt - [www.discover.com](http://www.discover.com)

# History

Named by Benjamin Franklin  
because early batteries, Leiden Jars,  
reminded him of a battery of  
cannons

Volta invented the modern battery  
with zinc and copper in about 1800



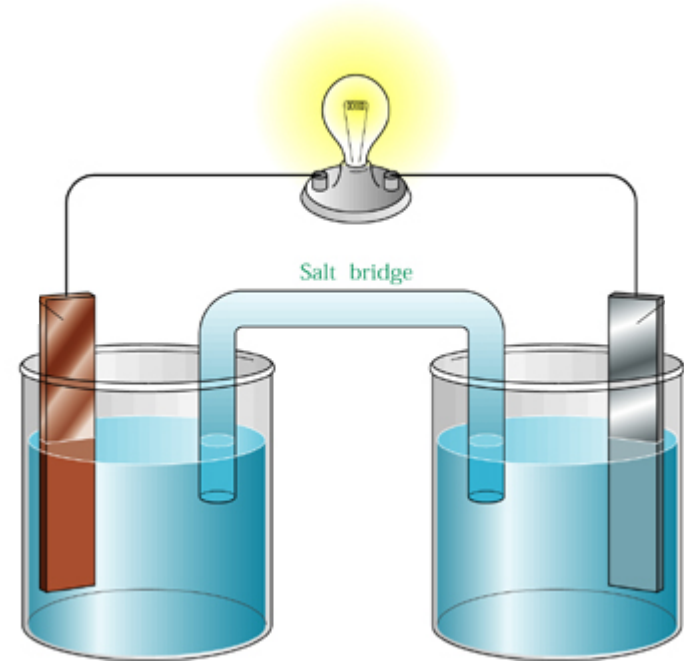
Voltaic pile, National Museum  
of Science and Technology,  
Milan Italy.  
[www.photographersdirect.com](http://www.photographersdirect.com)

# Theory – Chemical

Uses two half cell reactions  
One at anode, one at cathode

The electrons flow from anode to cathode allowing the energy from the reaction to be used as electricity

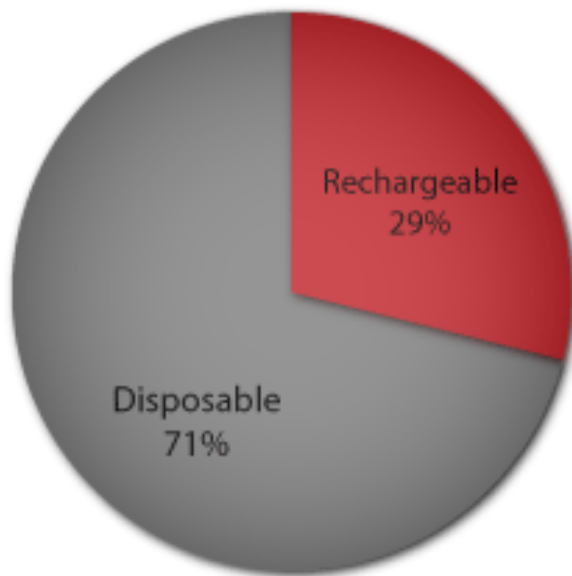
To recharge (for rechargeable batteries) a current is applied in the opposite direction (cathode to anode)



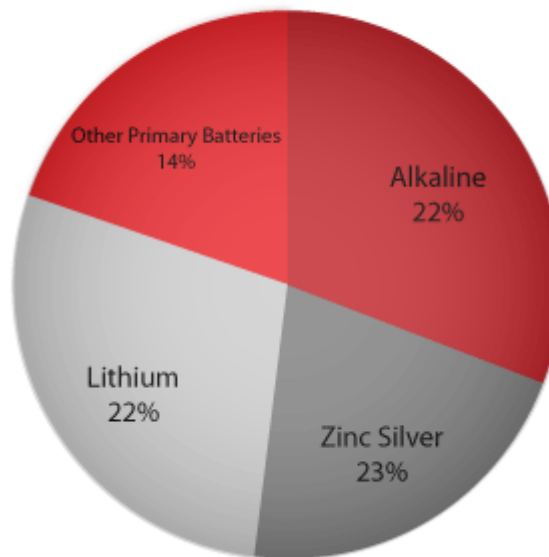
Galvanic Cell  
wps.prenhall.com

# Common Varieties

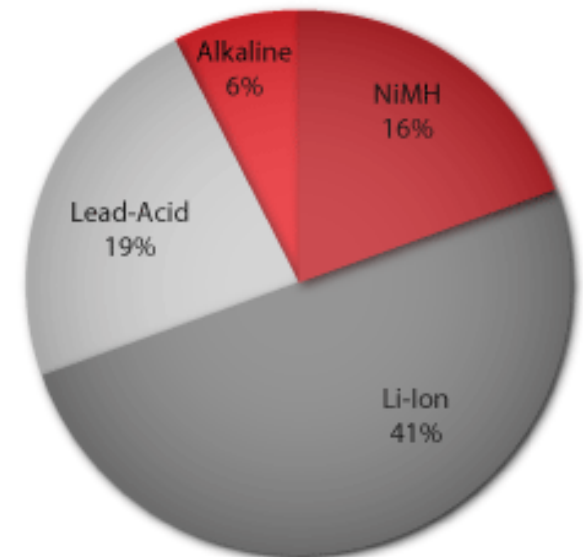
Percentage of Batteries Used Yearly



Types of Disposable Batteries



Types of Rechargeable Batteries



Battery usage by number of batteries - [www.batteryreview.org](http://www.batteryreview.org)

# Alkaline

Consumer devices (ie duracell)

Reasonable energy density and lifespan

Cheap

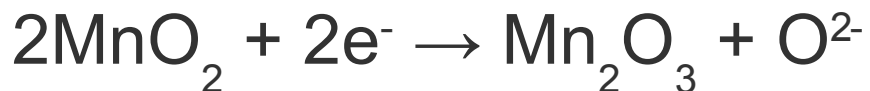
Voltage  $\sim 1.5$  V

Powdered zinc and manganese (IV) oxide in KOH

Anode:



Cathode:



# Lead Acid

Common in cars

Durable ~ 500 – 800 cycles

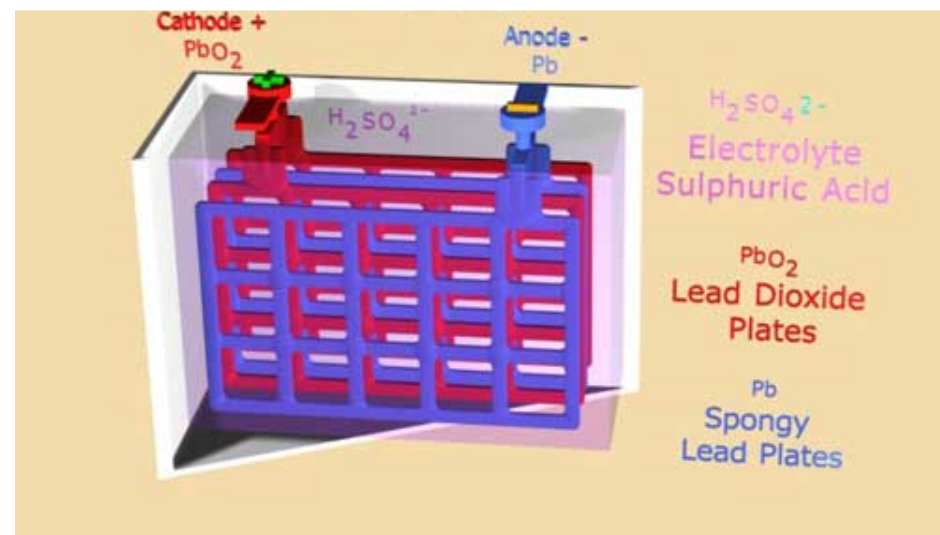
Voltage ~ 2.2 Volts

Spongy Pb and  $\text{PbSO}_4$  in sulfuric acid

Anode:



Cathode:



# Lithium Ion

Higher end batteries

Rechargeable

Lightweight

Moves Li and  $\text{Li}^+$  using carbon and cobalt

Multiple different varieties by chemistry

Longlife ~ 1200 cycles

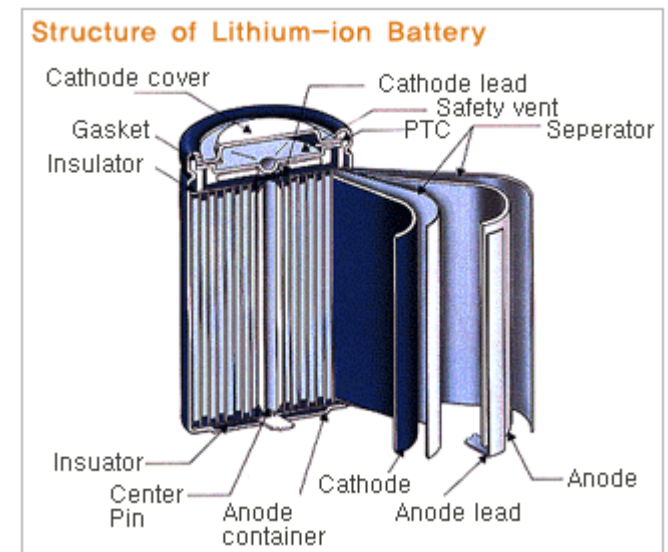
Voltage ~ 3.7 V

Anode:

$\text{Li on carbon} \rightarrow \text{Li}^+ + \text{carbon} + \text{e}^-$

Cathode:

$\text{Li}^+ + \text{CoO}_2 + \text{e}^- \rightarrow \text{LiCoO}_2$



Lithium Ion battery  
[www.gm-volt.com](http://www.gm-volt.com)



# Advances

EESstor – developing a capacitor they claim can hold 100x the charge of an equivalently sized lead acid battery

Organic batteries – thought to be a holy grail of medicine, can be used indefinitely on chemicals (ie sugars) from the body

Nanobatteries – used by increasingly shrinking robotics, nanosensors