

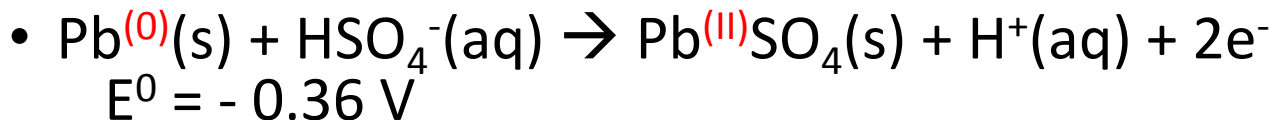
Redox Reactions in Batteries

Chem 253 November 11, 2013

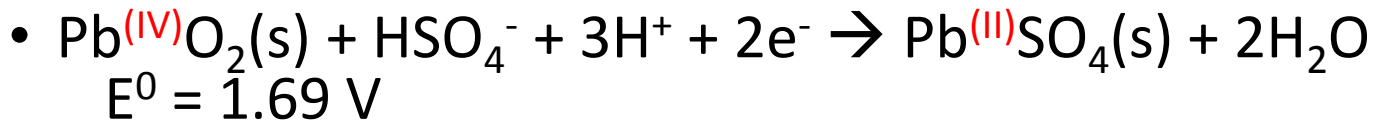
Lead-Acid

- 1859 Gaston Plante'
- Discharge – Galvanic Cell (Spontaneous)

- Negative plate:

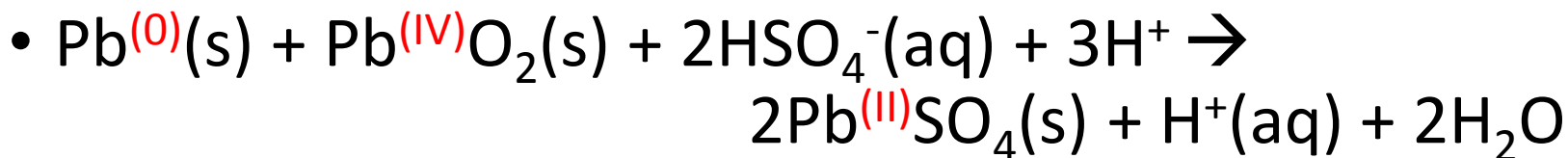


- Positive Plate



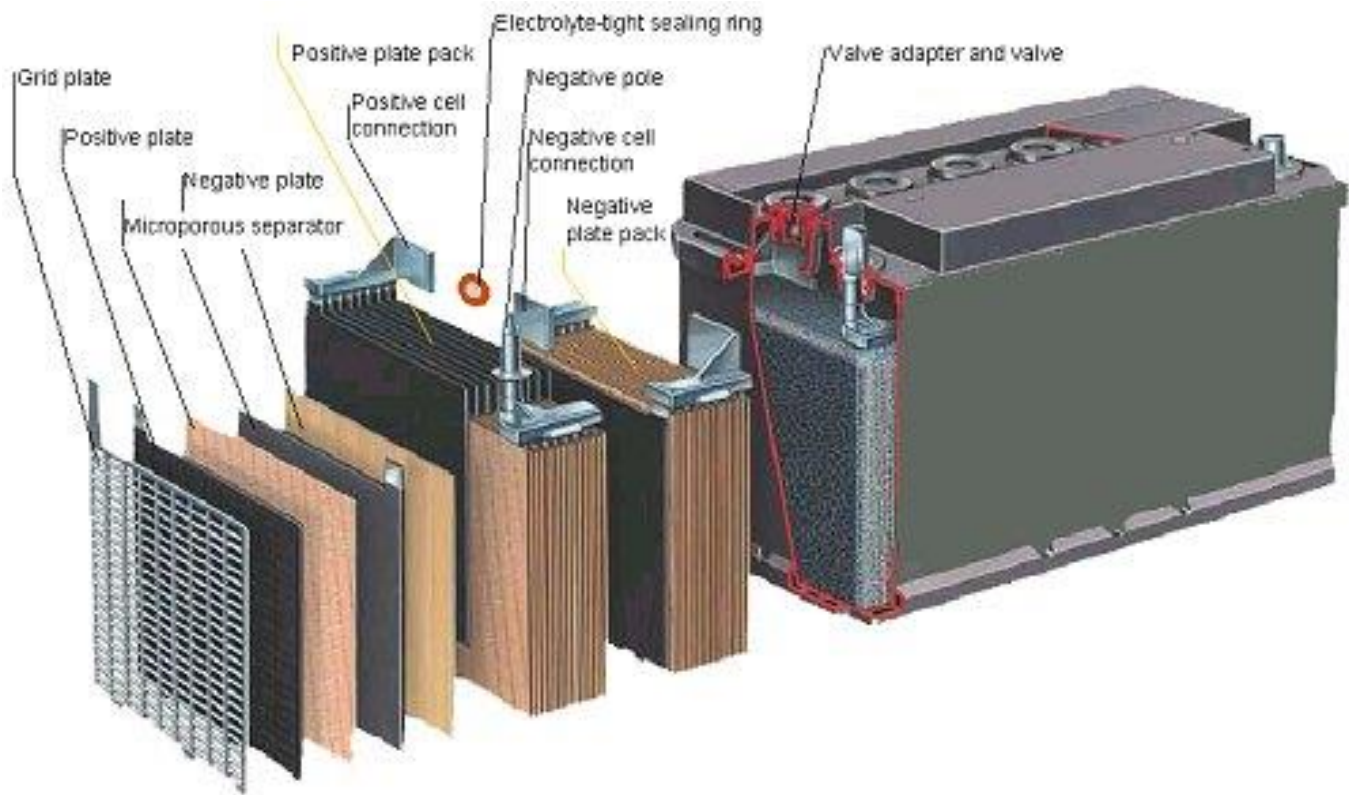
Cell Reaction

- Conc. H_2SO_4 (aq) (6 M)



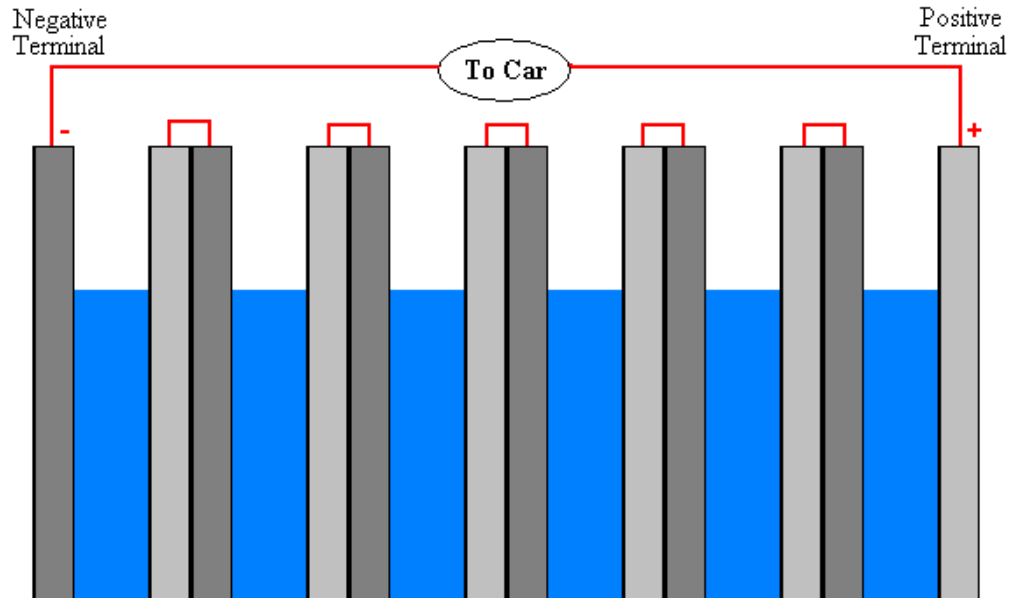
- $E_{\text{cell}} = E_{\text{cath}} - E_{\text{anod}} = 1.69 \text{ V} - (-0.36) \text{ V} = 2.05 \text{ V}$

- Complete discharge H_2SO_4 (aq) (3 M)



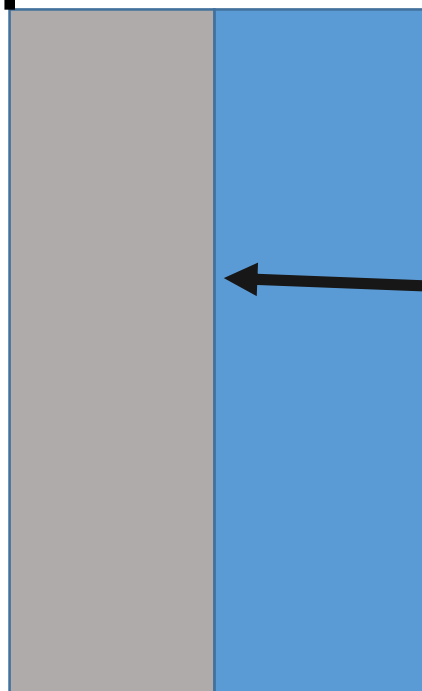
Car Battery 6 cell (series)

- $6 * 2.05 \text{ V} = 12 \text{ V}$ battery



Voltmeter or
Electrical Load

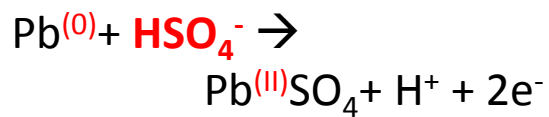
Rxn Zone
↓



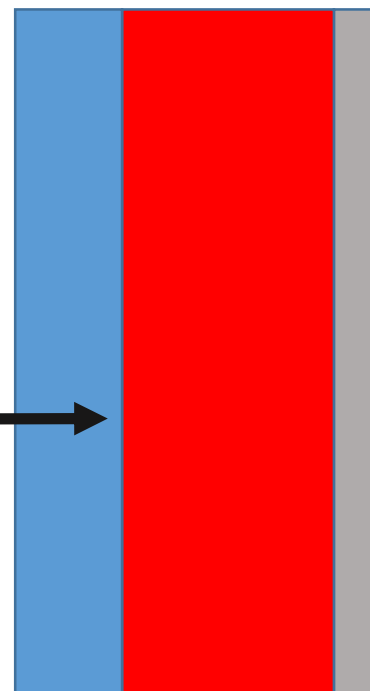
6 M H₂SO₄

HSO₄⁻

Pb Electrode PbSO₄(s)



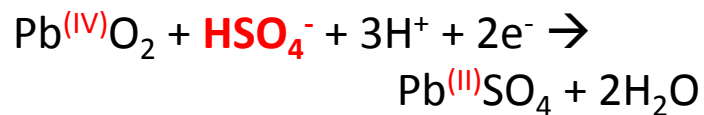
Rxn Zone
↓



HSO₄⁻

PbSO₄(s)

PbO₂(s)



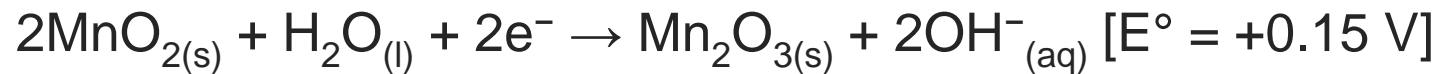
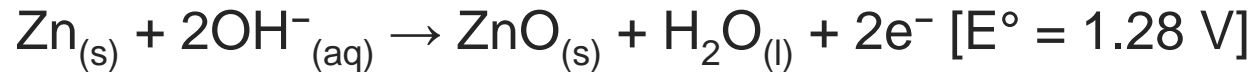
Lead Acid

- Rate of reaction – requires porous PbSO_4 layers
 - Rxn Rate \rightarrow electrical current
- Lead is abundant
- 99% recycled – none of Li Ion is recyclable
- 30-60% reaction yield

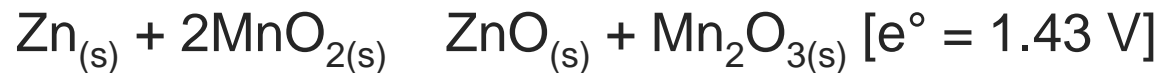
⇒

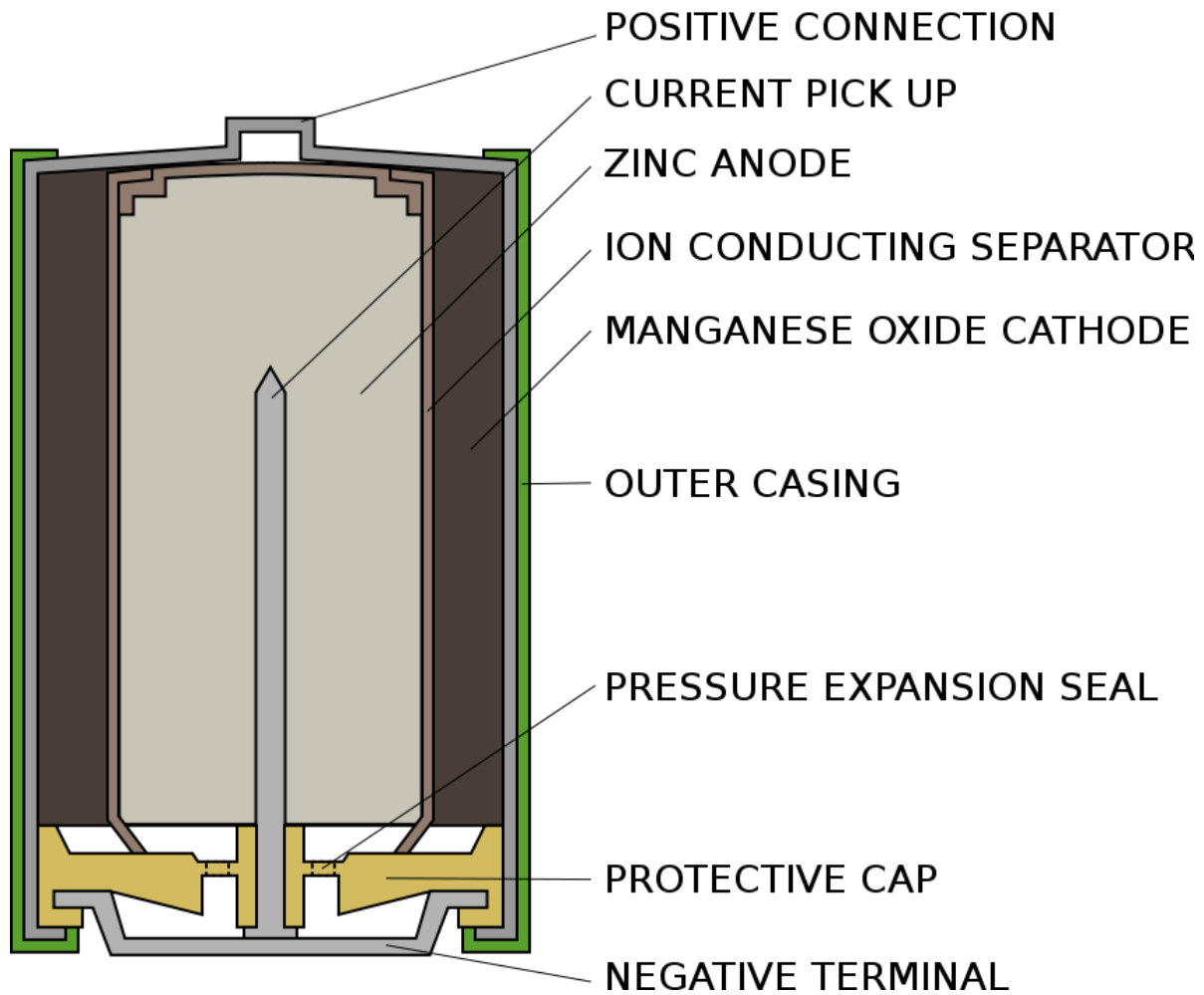
Alkaline Battery

http://en.wikipedia.org/wiki/Alkaline_battery



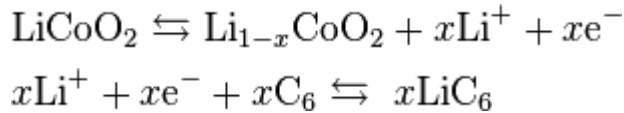
Overall reaction:



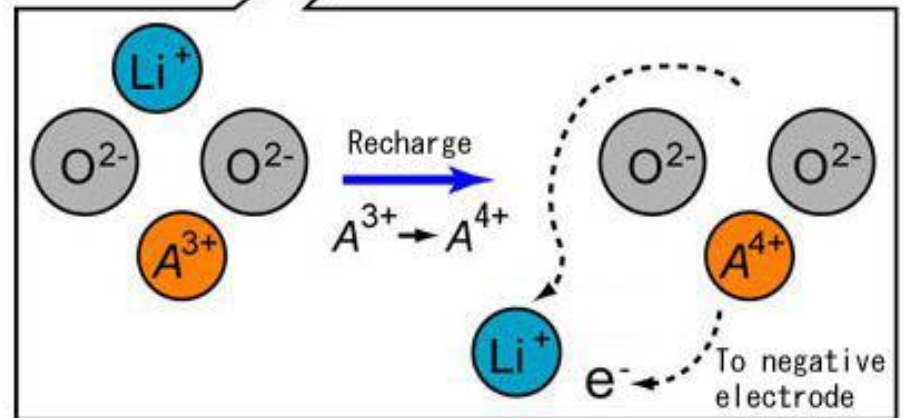
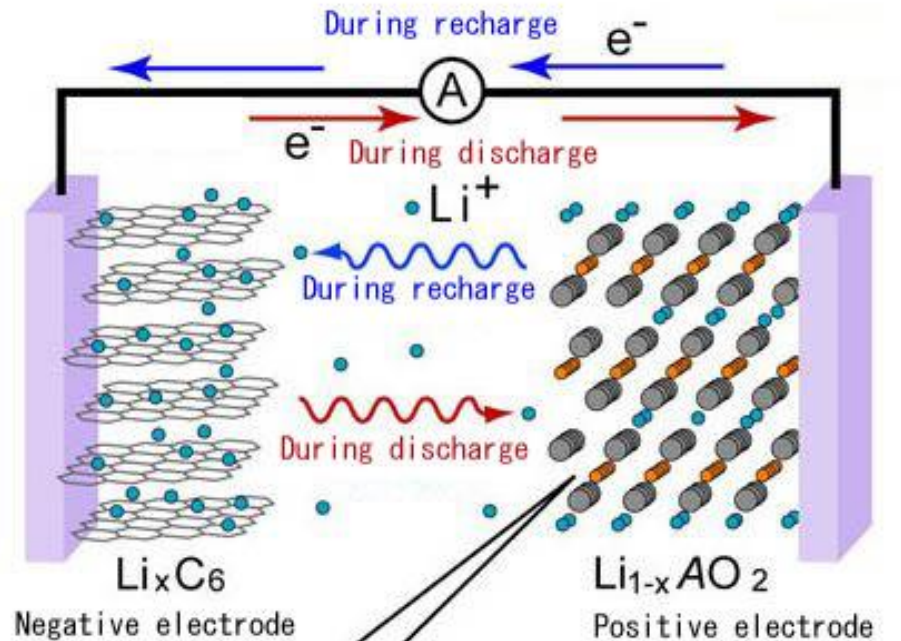


Li Ion Battery

The positive electrode [half-reaction](#) is:^[45]
 The negative electrode half reaction is:



http://en.wikipedia.org/wiki/Lithium-ion_battery

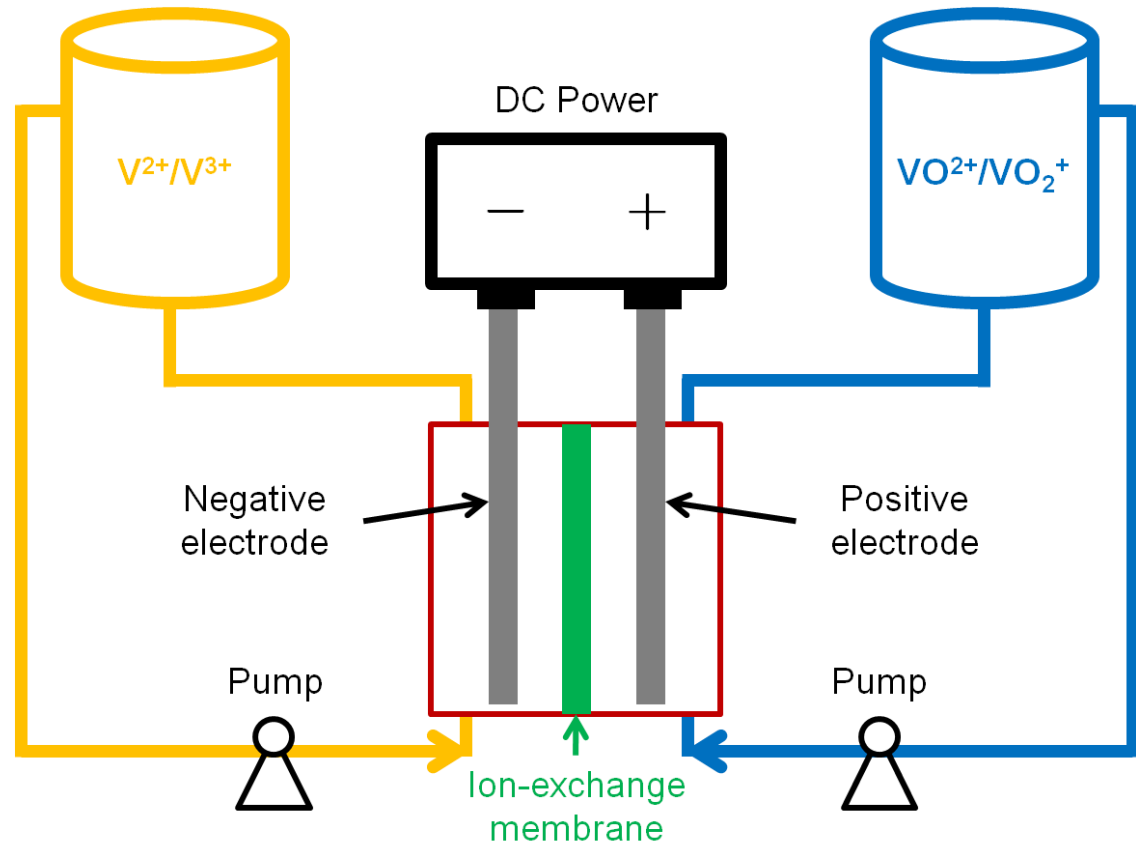


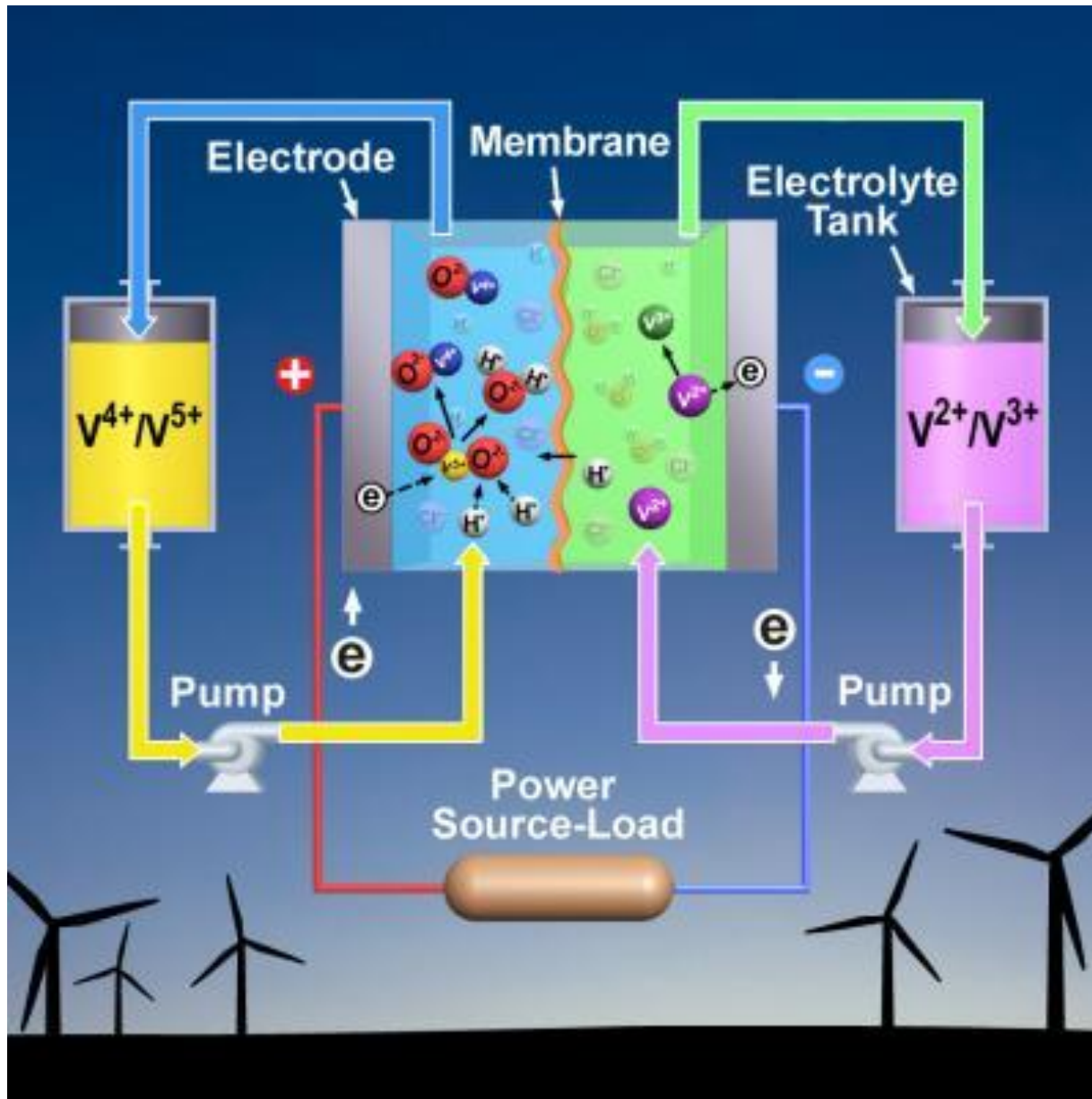
Schematic view illustrating operating principle of Li-ion secondary battery

http://techon.nikkeibp.co.jp/english/NEWS_EN/20080820/156592/

Redox Flow Battery

- New design





<http://esciencenews.com/articles/2011/03/17/upgrading.vanadium.redox.battery>

Vanadium Redox Flow Battery

- Aqueous system
- Discharge
- Positive Electrode:
 - $V^{(V)}O_2^+ + 2 H^+ + e^- \rightarrow V^{(IV)}O^{2+} + H_2O$ ($E^0 = 0.99$ V vs. SHE)
- Negative Electrode:
 - $V^{2+} \rightarrow V^{3+} + e^-$ ($E^0 = -0.26$ V vs. SHE)
- $E_{\text{cell}} = 0.99$ V $-$ (-0.26) = 1.25 V

VRF Future Research

- Electrodes for fast e- transfer
- H₂ interference during charging cycle
 - $V^{3+} + e^{-} \rightarrow V^{2+}$ ($E^0 = -0.26$ V vs. SHE)
 - $2H^{+} + 2e^{-} \rightarrow H_2$ $E^0 = 0.00$ V (preferred)
 - Generates OH⁻ poisons VRF battery