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The Lithium-Ion battery: The electrochemistry behind the world's most popular rechargeable battery

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The Lithium-Ion Battery:

The electrochemistry behind the world's most popular rechargeable battery.

**Li-Ion Advantages:**
- High energy density and electrochemical potential for its weight.
- No memory effect.
- Maintenance free.
- Very low self-discharge.

**Li-Ion Disadvantages:**
- Subject to aging.
- High temperature sensitivity.
- Needs protection circuit. Ruined if completely depleted.
- Expensive.

**Electrolyte:**
Lithium violently reacts with water so a nonaqueous electrolyte had to be developed.

Lithium salts (mainly Lithium hexafluorophosphate, LiPF₄) are dissolved into an aprotic solvent (propylene carbonate or ethylene carbonate) to make electrolyte.

Liquid or gel electrolyte acts as intermediate between phases.

**Cathode:**
- Positive electrode: Lithium material
- Anode: Negative electrode: Carbon
- Electrolyte: Ionic conductor or medium for transferring charge
- Separator: Positive/Negative separator
- Porous membrane that allows ions to flow but no electrical contact between the internal electrodes
- Container

**Lithium-Ion Physical Components:**

**The electrochemical reaction:**

- **Negative Electrode:**
  \[ \text{Li}(s) \rightarrow \text{Li}^+ + e^- \]
- **Positive Electrode:**
  \[ \text{Li}^+ + \text{CoO}_2 + e^- \rightarrow \text{LiCoO}_2(s) \]
- **Overall:**
  \[ \text{Li}(s) + \text{CoO}_2 \rightarrow \text{LiCoO}_2(s) \]

**Why Lithium?**
Lithium metal has the lowest reduction potential of all metals so it can easily undergo oxidation.
Lithium is a strong reducing agent.
Lithium is the lightest metal.

**Non Rechargeable Lithium Batteries:**

Because lithium is a powerful reducing agent, it is used in high energy disposable batteries as an anode. Modern rechargeable lithium-ion batteries use lithium as a cathode.

**The Future of Batteries... The Fuel Cell**
- Electrochemical cell where reactants are supplied continuously.
- Can operate without limit.
- No electrode material to replace.
- Fuel can be fed to continuously make power.