OCT 2 1 2019

THE LITHIUM ION BATTERY

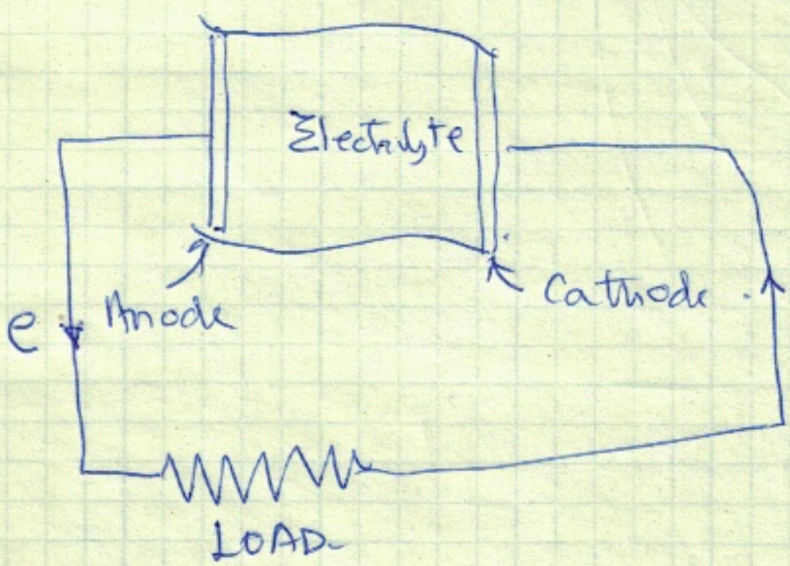
Elements of the System

Anode $Li \rightarrow Li^+ + e$

Electrolyte Transports Li^+

Cathode $Li^+ + e = Li$

External Circuit Transports electrons.



Lithium Ion Battery

Chemical Potentials.

μ_{Li} of Li atoms

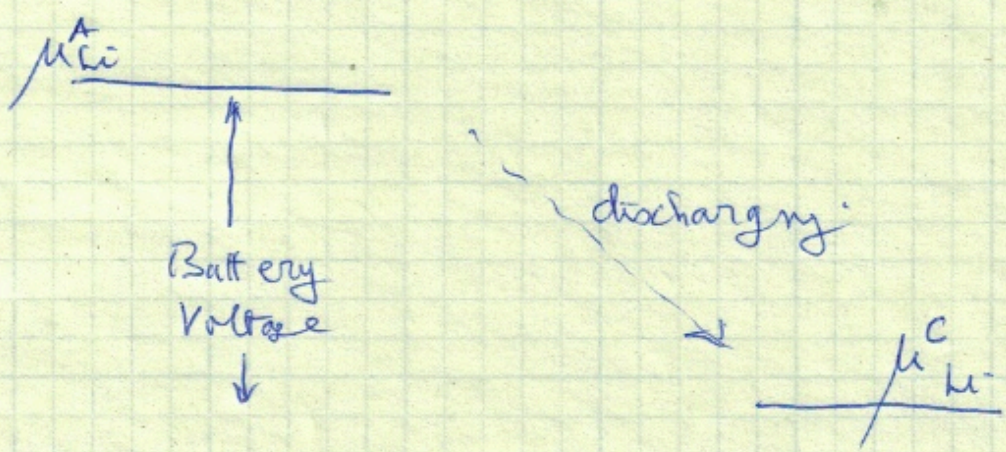
μ_{Li^+} of Li ions

μ^A_{Li} at anode

μ^C_{Li} at cathode

μ_{Li^+} in the electrolyte.

Energy Levels



Battery is charged.

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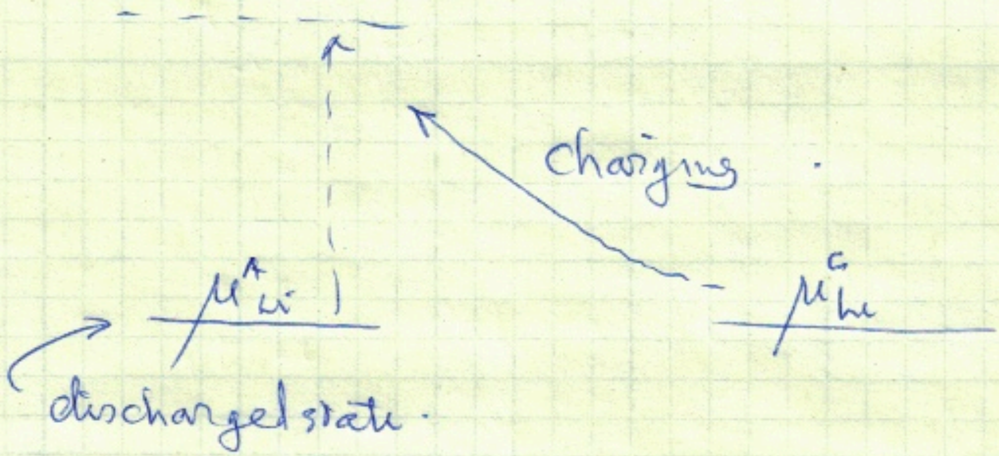
Lithium Ion Battery

③



Parameters that describe performance

① How much energy the battery can store?

Volumetric Capacity Wh/m^3

Gravimetric Capacity Wh/kg

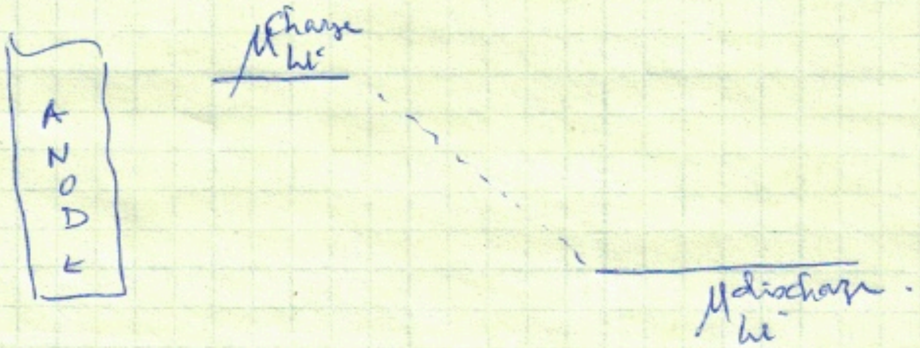
Total volume = Anode + Electrolyte + cathode
or Total weight = + Current Collectors + overhead

usually a constant.

PACKAGING.

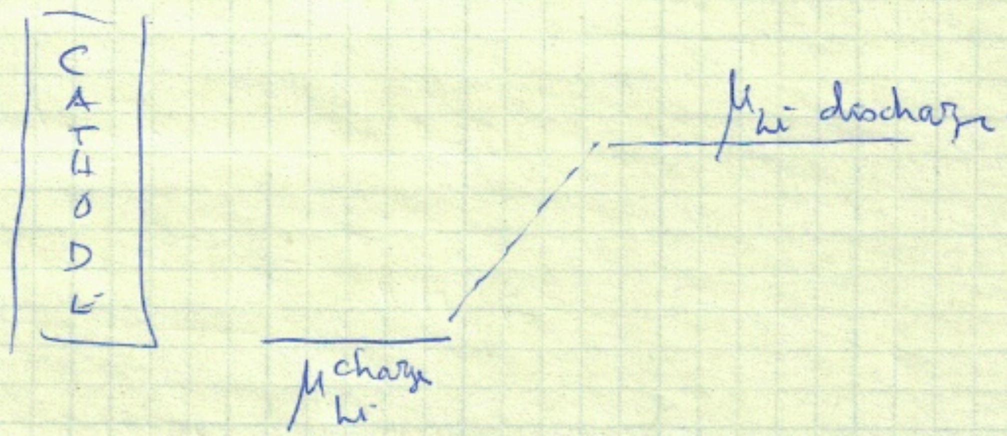
Lithium Ion Battery

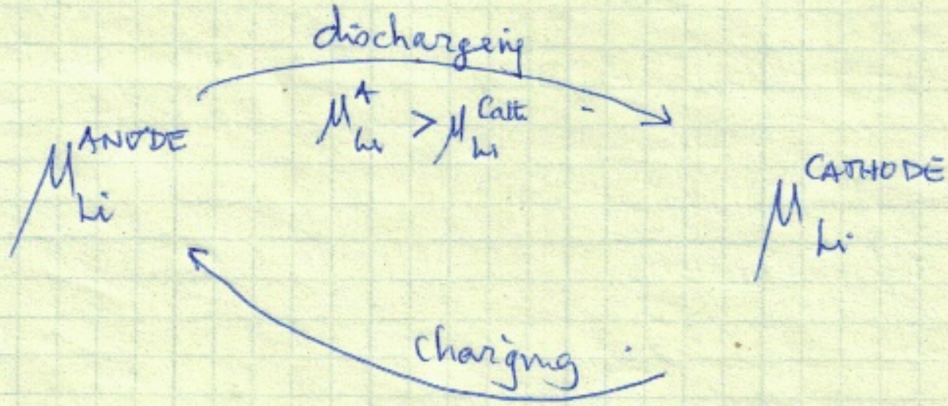
Anode.



Li atoms per gram of anode at maximum charge.

Cathode





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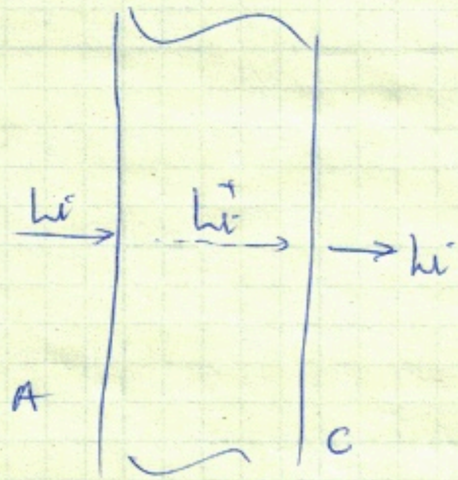
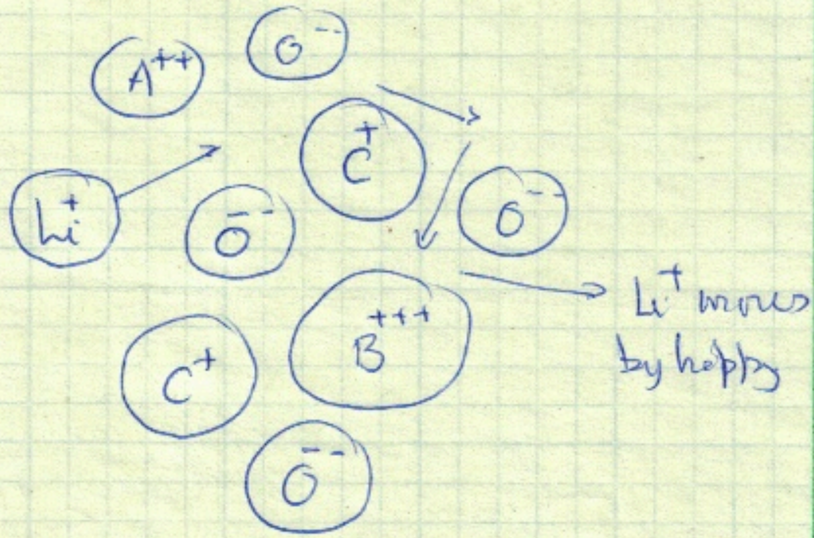
Lithium Ion Batteries

Electrolyte



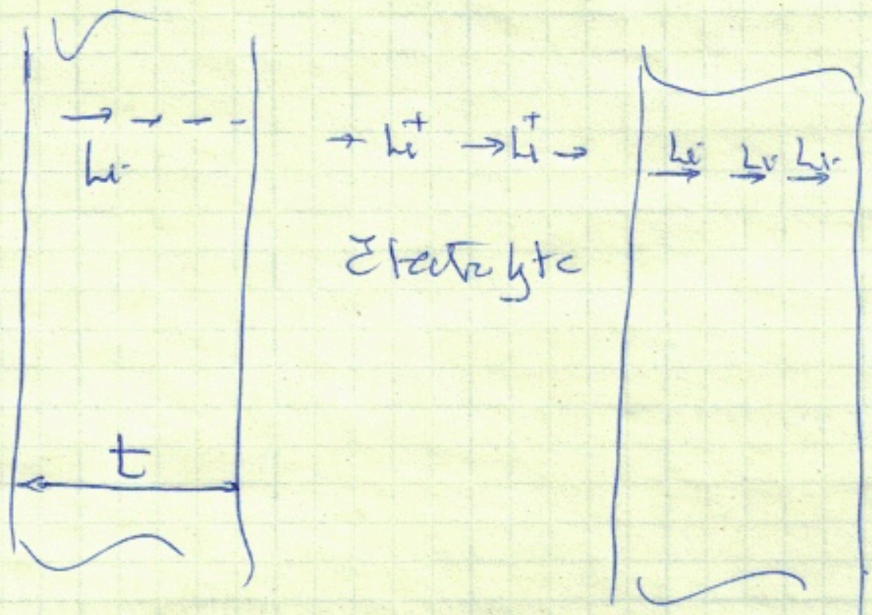
- Open chemical structure so Li^+ can move easily.
- Thin is better

Solid state electrolyte



Li Ion Battery

FAST, DISCHARGE, & CHARGE

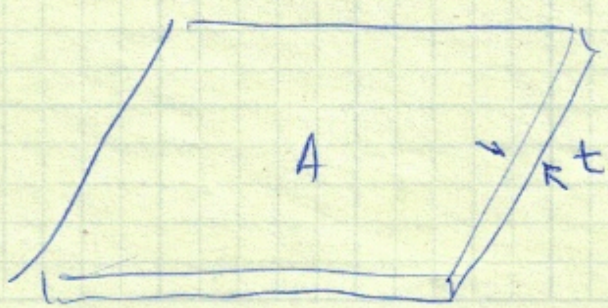


thickness: small t is better – faster transport.

BUT

volumetric density = # Li atoms / per unit volume.

High volume
small thickness } surface to volume ratio



volume = A×t

Surface area = A

Li Ion Battery

$$\text{Surface to Volume ratio} = \frac{A}{A \times t} = \frac{1}{t}$$

Small thickness → high surface area.

Design Constraints

- Anode, ~~of~~ cathode → thin sheets (to enhance discharge rate)
- Electrolyte thin (usually constrained by processing)

- volumetric & gravimetric capacity is material selection dependent
- Battery voltage is material selection dependent.

Design a battery with thin sheets that contact one another and can be hooked to the external electrical circuit.