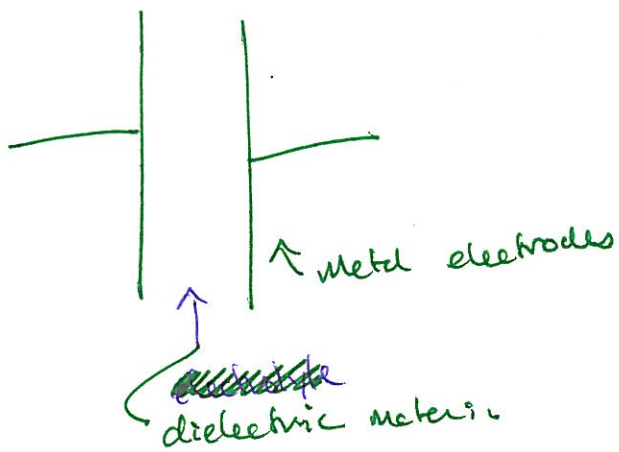
B. Super capacitors (electric double-layer capacitor)

* – advantage → high power density
* – disadvantage → lower energy density than Li-ion ~~or~~ batteries (~ 1/10th)

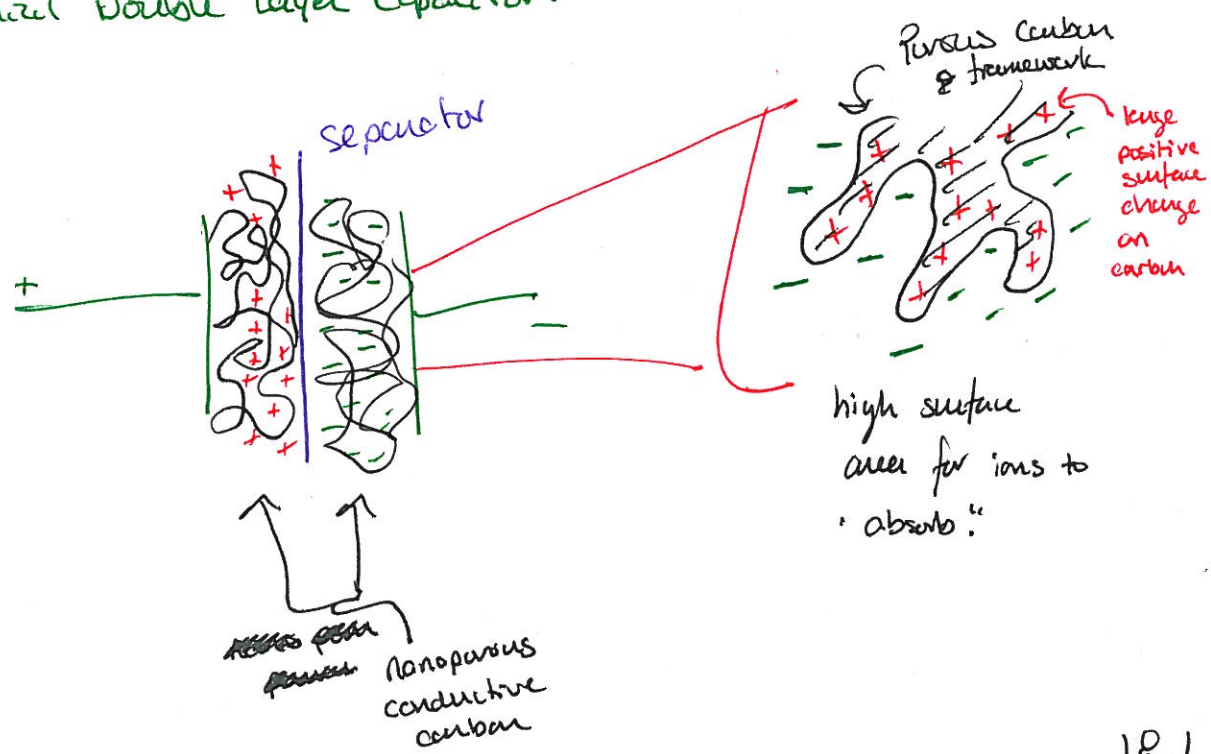
(show Ragone Plot)

traditional capacitor:



What is the difference between a supercapacitor (below) and a battery?

Electrochemical Double Layer Capacitor:



Applications: - load - leveling (i.e. smoothing out fluctuations in the power)

- regenerative breaking

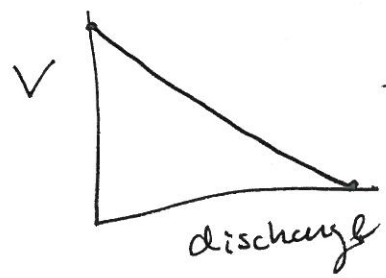
disadvantages

→ loose energy faster w/ time

→ voltage output function of charge

$C = \frac{Q}{V}$ $\boxed{V = Q/C}$

need



→ need power regulation to maintain constant output.

Carbon materials.

Advanced

→ graphene

→ CNT's

Simple

→ Activated Carbon

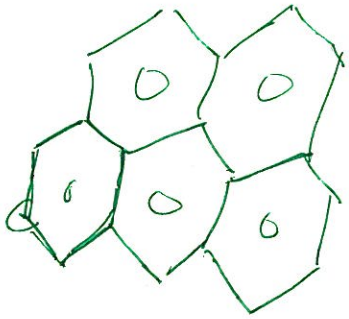
Pseudo capacitors and Pseudo capacitance.

Again... what is the difference between capacitor and battery?

only double layer charge transfer!

Faradaic charge transfer

Concept Breaks down at the nanoscale



Consider single graphene sheet charged positive sitting on metal current collector

what is difference between faradaic and non-faradaic charging?

Is the graphene being "oxidized"?

or is it still double layer charging?

Pseudo Capacitive Materials

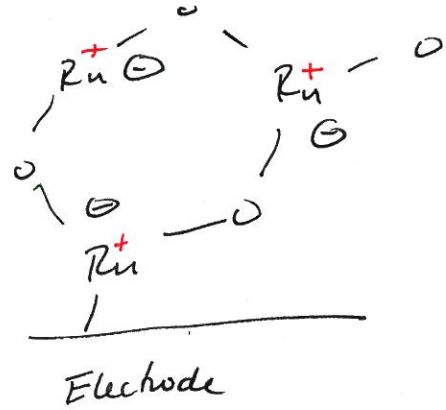
- undergo very fast faradaic charge transfer associated w/ thin films or surface-confined redox species.

a. RuO_2

b. MnO_2

c. polyaniline

d. poly pyrrole



- Conductive framework
- counter ions intercalate upon faradaic charging

→ similar to capacitive charging, because the counter-ion does not matter (much)

→ v. different from battery, where typically new phase is formed upon Li intercalation / deintercalation

→ hybrid super capacitors → use C electrode on one side, pseudo capacitor material on the other side