Battery 3

- LED flashlight → Basically a resistance and a power supply
  - (power supply) ↓ the batteries

  ↓

  Four AA batteries → show series voltage → 1 cell, 2 cells, 4 cells

  ↓

  How much power does the flash light need?

  ↓

  Measure V → OCV
  → under load

  - Measure i → indirectly (load box)
  → directly (in-line)

→ Measure V in parallel

→ Measure i in series

→ Why does V decrease w/time?

→ Consumption → composition change
- give AA A/C chemistry
→ mass transport

→ How much change is there?

→ called capacity

Calculating Battery Capacity

First, determine the limiting reactant in the cell: Commercially, it is:

$$MnO_2 + H_2O + e^- \rightarrow MnOOH + OH^-$$

Theoretical capacity $\equiv \frac{\text{Charge}}{\text{mass}} = \frac{\frac{\text{mole}^-}{\text{mol}} \cdot \frac{C}{\text{mole}^-}}{g/\text{mol}} \rightarrow \text{unit} = \frac{C}{g}$

remember: $1A = 1C/1s$

or

$C = A \cdot s$

↳ means: Charge = current × time

So,

$$\text{theoretical capacity } (mAh/g) = \frac{nF}{3.6 \cdot MW}$$

But: 1A is a lot of current

1s is a short amount of time

↳ people prefer mAh

For MnO_2,

$$\text{Capacity} = \frac{(1)(96485.3)}{(3.6)(86.94)}$$

$$= 308.3\ mAh/g$$

Let's convert:

$$1A \cdot s \cdot \frac{1000mA}{A} \cdot \frac{1h}{3600s}$$

$$1A \cdot s = \frac{mAh}{3.6}$$

In a AA, there is typically ~ 10g MnO_2:

Battery Capacity $\cong$ 3000 mAh

How much energy?

Energy (J) = Charge · Voltage   remember 1J ≡ 1C · 1V

$\cong$ (3000mA·h)(1.6 V) = 4800 mAh·V

= 4.8 W·h

= 17 kJ

Specific energy (mWh/mass) = $\frac{4.8 \text{ W·h}}{25 \text{g}} \cdot \frac{1000 \text{g}}{\text{kg}}$ = 190 Wh/kg

(mass → total battery)

(190 Wh/kg → similar to Li-ion!)

What about a toy?

→ Globe V w/t

→ Globe i w/t

→ complicated assortment of loads

↓

Base load

↓

transient peak load → your battery will need to consider this

All of the devices we have looked at connect in series only, but there are advantages to series + parallel arrangements

Series → increases V

parallel → increases i

↓

Similar to just increasing Area

↓

so, why not just make one <u>big</u> battry?

↓

redundancy

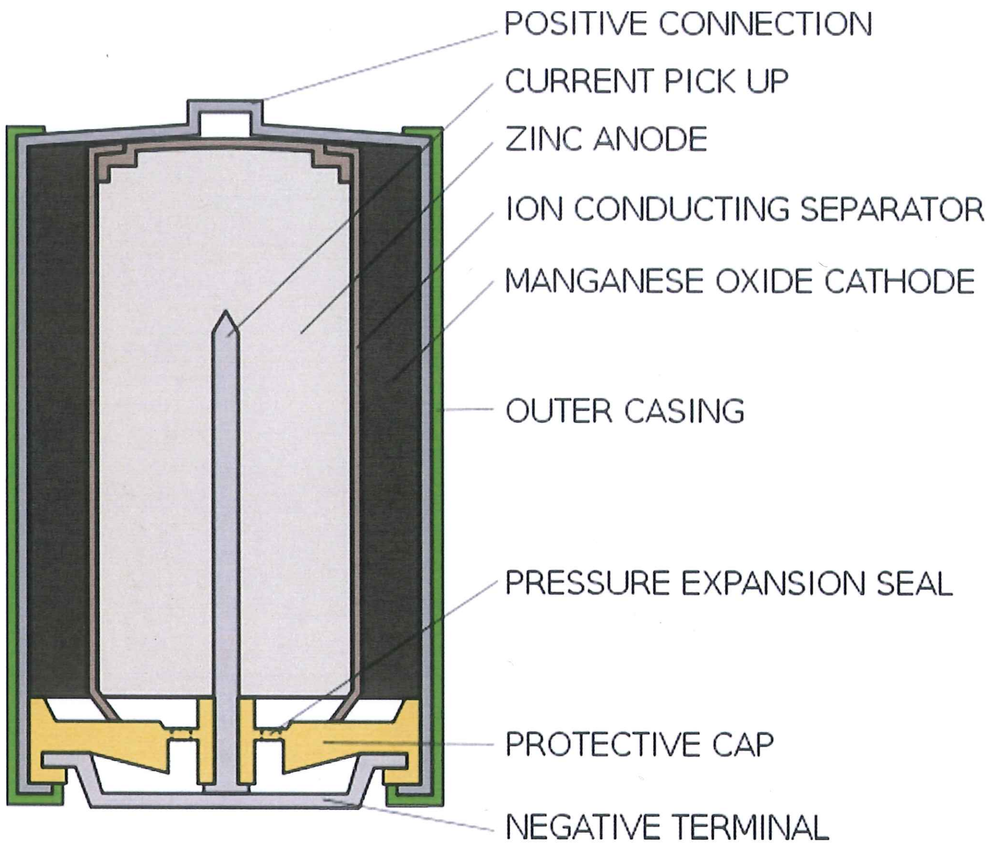
One bad cell in series → device dead

One bad cell in parallel → reduced performance, but still ok usually

↓

good for un-optimized cells like yours!

- Last, show pic of AA cross-section + discuss structure → minimizing V, increasing A


POSITIVE CONNECTION
CURRENT PICK UP
ZINC ANODE
ION CONDUCTING SEPARATOR
MANGANESE OXIDE CATHODE
OUTER CASING
PRESSURE EXPANSION SEAL
PROTECTIVE CAP
NEGATIVE TERMINAL