Building Batteries - Chemistry

Grades 10-12 Chemistry

Strand/Standard CHEM.4.3 Design a device that converts energy from one form into another to solve a problem. Emphasize chemical potential energy as a type of stored energy. (PS3.B, ETS1.A, ETS1.B, ETS1.C)

Lesson Performance Expectations (description): Students will investigate the construction, design, and use of batteries to solve energy storage problems.

Materials: Per group:

- 200 ml beaker
- various solutions (saltwater, Baking Soda Water, Soda (not cola), weak hydrochloric acid (.1 M)
- strips of metals (https://www.carolina.com/electrochemistry/metal-strips-set-laboratory-grade/874850.pr)
- wires with alligator clips
- Voltmeter
- 1.5-volt motor

Time: 120 minutes

Teacher Background Information:

- "You cannot catch and store electricity, but you can store electrical energy in the chemicals inside a battery." -Antoine Allanore, MIT, Department of Materials Science and Engineering
- The development of improved batteries is essential for the increasing electronic age. Students need a well-developed understanding of batteries, how they work, their limitations, and their uses. This lesson will focus on how batteries work and what kinds work for what uses. For more background knowledge on the chemical nature of batteries, visit https://engineering.mit.edu/engage/ask-an-engineer/how-does-a-battery-work/

Student Background Knowledge:

- Students need a baseline understanding that substances are made of atoms and molecules and that they interact with one another.
- Students need to understand the basic nature of electricity (moving electrons). They should understand that a circuit carries electricity in a connected circle from one place to another.

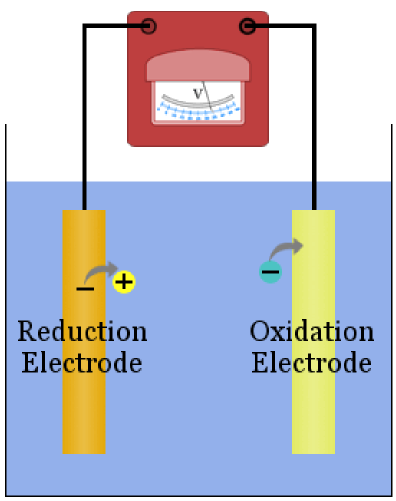
Teacher Step by Step: Teacher Step by Step: A 3-d lesson should insist students do the thinking. Provide time and space for the students to experience the phenomenon and ask questions. The student sheet provided below provides guidance but is only an example of how students might respond.

1. **Engage: Introduce *Phenomenon:*** *Ask students to observe the pictured batteries and write their observations on the student sheet.*
2. **Explore:** Ask students to write questions about batteries.
3. **Explain**: Tell students that they will build a battery from the materials provided. You can provide as many clues as you would like. Still, they should notice from their observations that batteries have metals, two electronic connections, and other substances listed on the outside. You might ask what electricity is and how an electric current is created.
4. **Elaborate**: Students will test the metals and liquids to determine the best combination. To help them summarize what they have learned, they could access these websites, or you could share the sites as a class: How Do Batteries Work? or MIT Ask an Engineer
5. **Evaluate:** The students should document their learning on the student sheet in the Claim, Evidence, Reasoning (CER) paragraph and answer the multiple-choice questions provided below. A list of battery types can be found after the student sheet.

This lesson is an introductory experience. Depending on the background of the students, additional lessons will be necessary.

Assessment of Student Learning.

Diagram of a Battery



1. What does the movement of electrons from electrode to electrode produce?
    a. Electricity*
    b. Waves
    c. New elements
    d. Light

2. The data below is from an experiment conducted in the classroom which combined different metals in a weak acid solution. The resulting voltage was measured. What should the students conclude?
    a. Copper and Zinc will last the longest in a battery.

b. Copper and Zinc are the best metals available for batteries.
c. Copper and Zinc are the strongest chemicals available for batteries.
d. Copper and Zinc are the best electron donor and acceptor pair tested.*

Metal	Voltage
Aluminum-Copper	1.1
Copper-Zinc	1.9
Zinc-Carbon	.7

3. Which factors influence the battery type people choose for a task? Choose all that apply.
   a. cost*
   b. appearance
   c. lifespan*
   d. size*

4. Why are scientists searching for new ways to store energy in batteries? Choose all that apply.
   a. Batteries are portable.*
   b. Batteries can store energy from alternative sources.*
   c. Batteries can create new sources of clean energy.
   d. Batteries are inexpensive to produce and recycle.

Extension of lesson: Use the voltmeter to determine which light bulbs can be lit and light the bulb (Stanford).

Career Connections: Possible careers that are related to this activity are Software Developer, Material Scientist, and Chemical Engineer

Batteries

Name________________________________

Phenomenon:

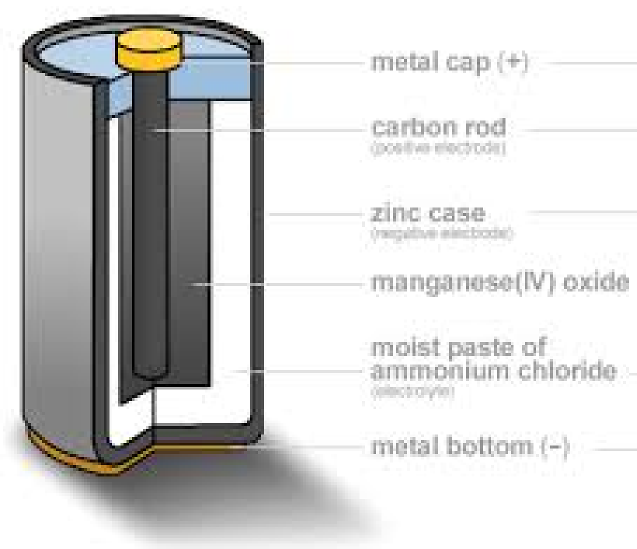
Lithium-ion battery

Lead–acid battery

Nickel–metal hydride battery

Lithium

Alkaline battery



What do you notice?

What questions do you have?

Guiding question: Which substances inside a battery produce the most electricity?

Materials: Metal strips, 2 leads (wires with clips on end), a beaker, a voltmeter, a light bulb, a variety of liquids (salt water, weak acid (lemon juice), baking soda, and water solution).

Procedures:

1.
2.
3.
4.
5.

Drawing of your experimental design:

Data:

Which internet resources did you lookup? (Use the name of the page)

Model:

Draw your experiment again and describe what you think is happening at the atomic level.

Choose a battery type to research from the list below.

Each student should choose a different battery type. Claim your battery and support it with three evidence statements from your research. Remember that our question was, “Which substances inside a battery produce the most electricity?” Explain your reasoning in the next paragraph. Remember that several characteristics define a good battery.

CER Paragraph:

Claim:

Evidence:

Reasoning:

Review your paragraph based on comments from your group. Rewrite if necessary.

Battery Types:

Primary Cells or Non-Rechargeable	Secondary Cells or Rechargeable

• Alkaline battery (zinc manganese oxide, carbon)
• Aluminum–air battery
• Atomic battery
• Bunsen cell
• Chromic acid cell (Poggendorff cell)
• Clark cell
• Daniell cell
• Dry cell
• Earth battery
• Frog battery
• Galvanic cell
• Grove cell
• Leclanché cell
• Lemon/potato battery
• Lithium battery
• Lithium-air battery
• Magnesium battery
• Mercury battery
• Molten salt battery
• Nickel oxyhydroxide battery
    ◦ Oxyride battery
• Organic radical battery
• Paper battery
• Pulvermacher's chain
• Silver-oxide battery
• Solid-state battery
• Sugar battery
• Voltaic pile
    ◦ Penny battery
    ◦ Trough battery
• Water-activated battery
• Weston cell
• Zinc-air battery
• Zinc–carbon battery
• Zinc chloride battery
	• Aluminum-ion battery
	• Carbon Battery
	• Flow battery
	    ◦ Vanadium redox battery
	    ◦ Zinc–bromine battery
	    ◦ Zinc–cerium battery
	• Lead-acid battery
	    ◦ Deep cycle battery
	    ◦ VRLA battery
	    ◦ AGM battery
	    ◦ Gel battery
	• Glass battery
	• Lithium-ion battery
	    ◦ Lithium-ion lithium cobalt oxide battery (ICR)
	    ◦ Lithium-ion manganese oxide battery (IMR)
	    ◦ Lithium-ion polymer battery
	    ◦ Lithium iron phosphate battery
	    ◦ Lithium-sulfur battery
	    ◦ Lithium–titanate battery
	    ◦ Thin-film lithium-ion battery
	    ◦ Lithium ceramic battery [5] [6]
	• Magnesium-ion battery
	• Metal–air electrochemical cells
	    ◦ Lithium-air battery
	    ◦ Aluminum–air battery
	    ◦ Germanium air battery
	    ◦ Calcium air battery
	    ◦ Iron air battery
	    ◦ Potassium-ion battery
	    ◦ Silicon–air battery
	    ◦ Zinc-air battery
	    ◦ Tin air battery
	    ◦ Sodium-air battery
	    ◦ Beryllium air battery
	• Molten salt battery
	• Nickel-cadmium battery
	• Nickel hydrogen battery
	• Nickel–iron battery
	• Nickel metal hydride battery
	    ◦ Low self-discharge NiMH battery
	• Nickel–zinc battery
	• Organic radical battery

	• Polymer-based battery • Polysulfide bromide battery • Potassium-ion battery • Rechargeable alkaline battery • Rechargeable fuel battery • Sand battery • Silicon air battery • Silver-zinc battery • Silver calcium battery • Silver-cadmium battery • Sodium-ion battery • Sodium–sulfur battery • Solid-state battery [7] • Super iron battery • UltraBattery • Zinc ion battery