Challenge #5
Battery Challenge

Due Tuesday, April 28

On February 1, 2020 Occidental College hosted the Second Technical Workshop. This challenge is based on that workshop and will cover some of the same workshop materials, but also expand a bit into general battery technology.

Students that didn't attend that session can still do this challenge, as the resources below will help explain the information you need to complete the challenge.

Challenge Details:

- **Part One: Utilize the resources at Battery University:**
  - For part one of this challenge use the link for Battery University to answer the questions on the attached worksheet
  - https://batteryuniversity.com/
  - Almost all the questions will come from Part One: "Basics You Should Know"
    - Some questions might come from the other sections
    - Use the section titles in the menu bar on the left to guide you to the right section
- **Part Two: Lemon Battery:**
  - You want to answer the questions on the Part Two Worksheet
    - You can build a battery out of a lemon if you have the parts at home
    - If you don't have the parts at home, you can watch the Youtube clip below:
      - https://www.bing.com/videos/search?q=building+a+battery+out+of+a+lemon&&view=detail&mid=6BEDEA33EF62475D0E206BEDEA33EF62475D0E20&&FORM=VRDGAR&ru=%2Fvideos%2Fsearch%3Fq%3Dbuilding%2Ba%2Bbattery%2Bout%2Bof%2Ba%2Blemon%26FORM%3DHDRSC3

- If you cannot answer all of the questions, you will get credit if you make a guess that is explained to the best of your ability

You might also keep this as a reference, it might make a good science fair project someday.

This activity is worth 100 points. You will earn points based on the percentage of answers you get correct.

Responses can be emailed to Julie Miller Kalbacher at jamiller@mwdh2o.com Make sure to include your name and school name on your responses.

Good luck with this challenge and with all of your schoolwork.

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Worksheet 1

Almost all of the answers to the questions for this challenge can be found at the Battery University at:

https://batteryuniversity.com/

Most of the questions will come from Part One: “Basics You Should Know”.

There will also be a few questions from other areas, but they should be easy to find by scanning the section titles in the menu bars on the left.

1. When was the first battery invented? _____
2. By Whom? _____
3. Who invented the lead acid battery? _____
4. Who was the first to commercialize the lithium ion battery? _____
5. Draw a sketch of the lemon battery and briefly describe how it works?

6. What is an:
    a. Anode: _____
    b. Cathode: _____

7. When storing each type of battery should it be fully charged? Why?
    a. Lead Acid _____
    b. Lithium Ion _____

8. What is the “Rock Content” of a battery? _____
    _____

9. How does high internal resistance affect the performance of a lead acid battery?
    _____
    _____
    _____

10. What are the three phases of the lifetime of lead acid battery?
    1) _____
    2) _____
    3) _____

11. Besides age related issues, what are the two main killers of lead acid batteries?
    1) _____
    2) _____

12. What causes a Lithium Ion Battery to die? _____

13. Can a dead Lithium Ion battery be restored? _____

14. If so, how? _____
    _____

15. What does Elevated Self Discharge do? _____
    _____

16. In one sentence each, describe the three ways to measure CCA in a Lead Acid Battery:
    1) _____
    2) _____
    3) _____

17. How does elevated heat affect the lifetime of a battery? _____
    _____
    _____

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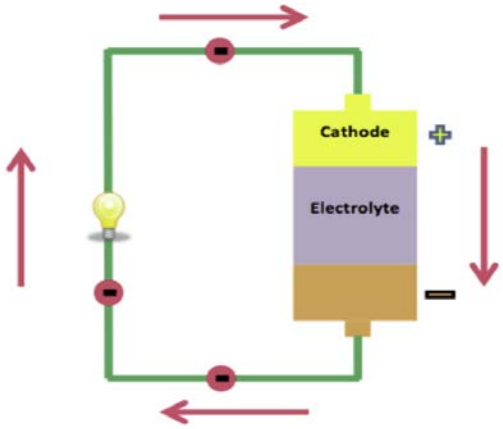
Worksheet 2

You know from the first part of this workshop that a battery is a portable device that stores chemical energy and is able to convert that stored chemical energy into electricity.



There are three main components to a battery: an anode, a cathode, and an electrolyte. The anode is the negative side of the battery and the cathode is the positive side of the battery. Both the anode and cathode are submerged in and separated by an electrolyte, such that the anode and cathode are not directly touching (UC Davis Chem Wiki). In the anode, a chemical reaction (oxidization) causes a buildup of electrons. These electrons want to travel to the electron-less cathode, but cannot travel through the electrolyte. Electricity is generated when a low-resistance circuit, such as a wire, connects the cathode and the anode. The electrons will travel along the circuit (current) to equilibrate the electron levels between the anode and cathode. As the electrons travel through the wire, they power the circuit, for instance providing electricity to light a light bulb. Eventually the battery will run out of power when the electrochemical reactions change the chemicals in the anode and cathode so that they no longer supply electrons.

Image from https://www.cmu.edu/gelfand/education/k12-teachers/succeed/energy-lesson-plans/battery-workshop.html

We can measure the voltage and current of the battery and use those to find the power generated by the battery. We know that voltage (V) is equal to the product of the current (I) and resistance (R), which gives us the equation $V = I * R$. Additionally, we also know that power (P) is equal to the product of voltage (V) and current (I), which gives us:

$$P = V * I = I^2 * R.$$

Activity: Building a battery using a lemon.

Use what you have learned from Battery University.com to help you fill in the questions below.

Even if you do not have the materials to actually make a lemon battery, you should be able to answer the questions.

If you are stuck just guess at the answer, but please explain why you guessed what you did. No credit will be given without an explanation.

If you don't have the materials need to build a battery out of a lemon you can watch the clip below to find information that will help you answer the questions.
https://www.bing.com/videos/search?q=building+a+battery+out+of+a+lemon&&view=detail&mid=6BEDEA33EF62475D0E206BEDEA33EF62475D0E20&&FORM=VRDGAR&ru=%2Fvideos%2Fsearch%3Fq%3Dbuilding%2Ba%2Bbattery%2Bout%2Bof%2Ba%2Blemon%26FORM%3DHDRSC3

Materials Needed:

- A lemon, or some citrus fruit—Roll the fruit on the table to release some juices
- A penny from before 1982/a source of copper
- Copper wire
- Wire stripper/clipper
- Galvanized nail/any source of zinc (aluminum foil is a good substitute)
- Multimeter

.

1. Why do we use a lemon? _____
   _____
2. Could we use another fruit or vegetable? Why/Why Not? _____
   _____

Next, cut a small slit in the middle of the lemon deep enough that you can insert your penny halfway through. Make sure that your slit is not too big, as you do want your penny to sit snugly in the lemon. Then, insert the penny and the nail into your lemon about 2 cm apart. These will serve as your cathode and anode. Make sure that the nail is not touching the penny inside the lemon, as this will short circuit your battery, but do ensure that both the penny and nail are deep enough to make contact with the lemon juice.

To record the voltage, simply attach the clips of the multimeter to the nail and the penny.

3. What voltage do you observe? _____
   _____

4. Try moving the nail either closer or further away from the penny. What happens to the voltage? _____
   _____

5. Why do you think this happens? _____
   _____

6. Zinc and copper served as our cathode and anode for this experiment. What do you think would happen if we changed the metals?
   _____
   _____

7. Made them the same? _____
   _____

Now, we are going to make a multi-cell lemon battery. For this, we will need 4 pennies (pre-1982), 4 galvanized nails, and 3 more pieces of copper wire, for a total of five pieces of wire.

Do the same steps as before, but now wind the copper wire around a penny and wind the other end to a nail. Make three pairs of this. Then, wrap one piece of wire around just a penny and a wire around just a nail. We will insert the penny and the nail ends to different lemons, so make sure that the copper wire is long enough.

Do the same steps as before to insert the penny and the nail into the lemons, but insert the penny that only has copper wrapped around it in your first lemon and the nail with only copper wrapped around it in your last lemon. Then, insert the penny-nail pairs into the lemons. Your system should look similar to this.

To measure the voltage, simply connect the clips of your multimeter to the free ends of the copper wires.

8. What voltage do you read? _____

9. Is this what you expected? Why? Why Not? _____
   _____

You can also attach the wires to an LED light. In the diagram below, the copper end depicts your copper source and the silver end represents your zinc source.

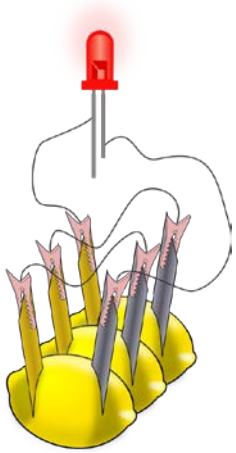


Image from https://en.wikipedia.org/wiki/Lemon_battery

10. How many lemons do you think it will take to light the LED? _____
    _____

11. What would happen if you hooked up 1,000 lemons? _____
    _____

12. At the battery workshop this year, one of the schools said they were going to power their Solar Cup boat using lemons. How many lemons do you think it would take?
    _____
    _____

13. 5 bonus points if you use the space below to make a sketch of what this boat would look like: