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Lab: Juicy Fruit

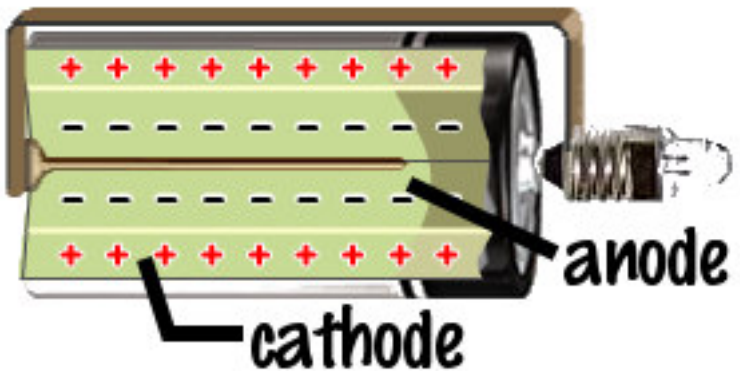
Introduction

A battery is really a portable energy source that is made up of three basic components - an anode, a cathode and an electrolyte. The cathode and anode are collectively called electrodes.

Anode: The negative portion of the battery. Cathode: The positive portion of the battery. Electrolyte: A liquid solution that aids in the flow of energy.

These three components can be made up of many different materials and combined in an almost endless array of shapes and sizes. The choice of materials used and the quality, grade, and density of these materials play a major role in determining the energy levels and performance of a battery.

To illustrate how a battery works and how the components interact, let's take a simplified battery and attach it to a light bulb.



As the light bulb draws power from the battery, electrons start to flow from the anode (the negative part of the battery) through the external bulb connection and back to the cathode (the positive part of the battery).

This flow of energy from the battery to power the light results in a decrease in the voltage (the energy level) of the battery. In other words, as a battery is used or discharged over time, the voltage drops as the anode and cathode undergo electrochemical changes.

This energy exchange will continue until the anode can no longer give up electrons and the cathode can no longer receive electrons. Once a battery reaches this state, the light bulb will no longer light up.

In this lab, you will be constructing a type of battery called a voltaic cell, which changes chemical energy into electrical energy. In a solution of water and an electrolyte, an excess of electrons collects on one end of the electrodes. At the same time, electrons are lost from the other electrode.

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Your task is to make the best battery, ideally something that will power the flashlight bulb to light.

Materials

- ☐ 2 test leads with alligator clips (one black, one red)
- ☐ 1- 400 mL beaker
- ☐ distilled water
- ☐ 5 mL lemon juice
- ☐ 100 mL salt solution
- ☐ 10 mL apple juice
- ☐ DC voltmeter (0 - 10 Volts)
- ☐ 2 copper electrodes
- ☐ 2 zinc electrodes
- ☐ 2 magnesium electrodes

> **Notes about Voltmeters:**
> A voltmeter measures voltage across (in parallel) a resistance or load. To measure voltage, the voltmeter is placed in parallel across the component; that is, one lead is place on each side of the component. Set an analog voltmeter to the highest range when measuring an unknown voltage, then switch to the next lowest rage until maximum deflection of the pointer is obtained while remaining on the scale. In this case, you will probably need to hook up to the 0 to 3 V scale. Make sure you read the numbers on that scale.

Procedure

CAUTION: BE CAREFUL NOT TO LET THE TWO ELECTRODES TOUCH ONE ANOTHER! IF AT ANY TIME THE VOLTMETER READING DROPS BELOW ZERO, SWITCH THE ELECTRODE WIRE TO REVERSE THE CURRENT.

1. Attach the ends of two test leads to the terminals of a voltmeter.
2. Attach the free end of each of the two test leads to two different copper strips. These are your electrodes. Dip the electrodes into the distilled water and write the voltmeter reading into your Data Table: Voltage Readings for Different Solutions.
3. Detach one of the copper electrodes from the test lead and attach a magnesium electrode in its place. Dip the electrodes into the distilled water and write the reading into your Data Table: Voltage Readings for Different Solutions.
4. Replace the magnesium electrode with a zinc electrode, dip the electrodes into distilled water and write the reading into your Data Table: Voltage Readings for Different Solutions.
5. Test the following electrode combinations: magnesium/magnesium, magnesium/zinc, and zinc/zinc. Write the readings into your Data Table: Voltage Readings for

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Different Solutions.

6. Thoroughly clean each electrode. Then repeat the entire test using a lemon juice solution made by pouring the 5 mL of lemon juice into your distilled water.
7. Thoroughly clean each electrode. Then repeat the entire test using a salt solution made by diluting your 100 mL of salt solution with another 150 mL of distilled water. (this is to keep all liquid volumes approximately equal).
8. Thoroughly clean each electrode. Then repeat the entire test using an apple juice solution made by pouring the 10 mL of apple juice into 140 mL of distilled water.
9. **Clean and dry each electrode when finished.**
10. Construct a bar graph with the information in the Data Table: Voltage Readings for Different Solutions. The horizontal axis should show the various combinations of electrodes that were tested for each electrolyte. The vertical axis should show the voltage that was recorded. Since you tested 4 different electrolytes, you should construct four different bar graphs to compare you data. Be sure to label each axis and place an appropriate title on each graph.
11. When you have found the strongest combination of metal electrodes and electrolyte, test the circuit using the light bulb in place of the voltmeter. Can you get the bulb to light? (answer this in question #9)

Data Table: Voltage Readings for Different Solutions

	Voltmeter Reading			
Electrode	**Distilled Water**	**Water & Lemon Juice**	**Salt Water**	**Water & Apple Juice**
Copper/Copper				
Copper/Zinc				
Zinc/Zinc				
Zinc/Magnesium				
Magnesium/ Magnesium				
Magnesium/Copper				

Conclusions. Answer these on a **separate sheet of paper**.

1. Which electrode pair produced the highest voltage?	2. Which electrode pair produced the lowest voltage?
3. Which electrolyte was the best conductor of electricity?	4. Which electrolyte was the poorest conductor of electricity?

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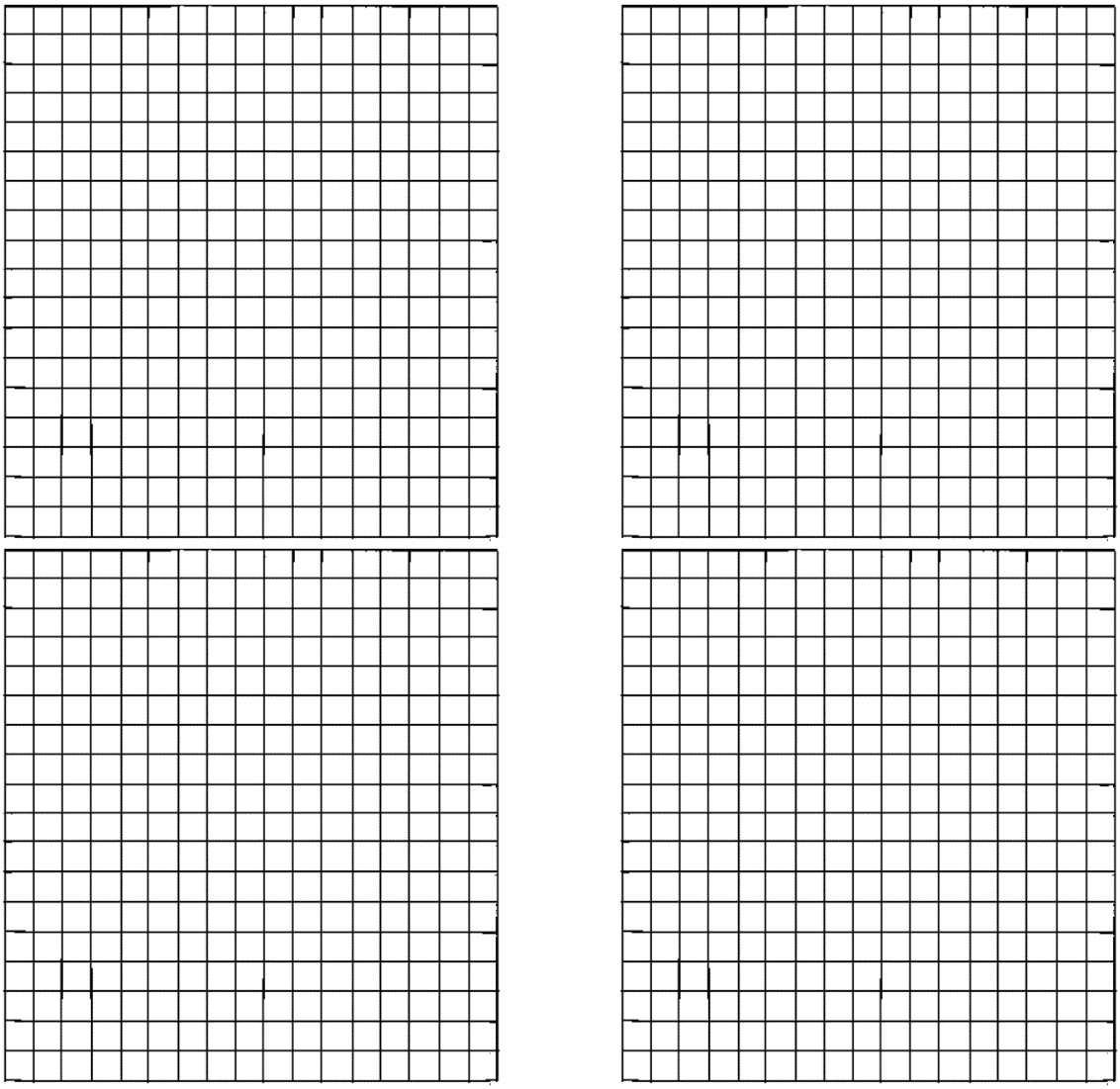
5. Why did the identical electrode pairs produce relatively low current?	6. Why is salt water a good conductor of electrical current?
7. Why is tap water a better conductor of electric current than is distilled water?	8. What type of current was produced in this chemical cell? Why?
9. Which electrolyte did you use to try to get the light bulb to light? Which electrode pair? Did the circuit light? (see bottom of graph paper)	



Note About Lemon Energy

Some students do this project and then try to use the "battery" to light a small flashlight's light bulb. It does not work. Why? The reason is that the battery produces only a very small current (about one milliamp). This is not enough electric current to light the bulb. Even with multiple cells, the amount of current flowing through the wire is not enough. Though the voltage is high enough, the current is too weak. But, it is a great experiment! Even if an experiment doesn't work, it helps us to understand how things work. Good job! For more information on a type of battery that *might* light the bulb, check out the following website -- http://www.energyquest.ca.gov/ask_quester/answers_electricity.html

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