BATTERIES

Introduction

The first electrical storage device, the Leyden Jar was invented by Ewald Georg von Kleist of Pomerania (now a part of Germany) in 1745 and independently by Pieter van Musschenbroek of the University of Leyden, Holland in 1746. This device, actually a capacitor, allowed scientists to store static electrical charges and transport them to different locations. The actual explanation of how it worked was provided by Benjamin Franklin in 1747.

Figure 1. Leyden jars at the Smithsonian Museum, Washington, D.C.

A voltaic pile, the first battery, was invented about 1800 by Alessandro Volta used the interactions of dissimilar to generate an electrical. Volta's original voltaic pile used zinc and silver disks and a separator consisting of a porous nonconducting material saturated with sea water (salt water). Over the next 60 years, different combinations of metals and electrolytes were used to make variations of the voltaic pile and were the only practical source of electricity during that time.

The first "chemical" battery was developed in the 1860's by George Leclanché of France. His original version was a wet cell with the electrodes immersed in a pool of electrolyte. Because it was rugged, easy to manufacture, and had a good shelf life, the battery became popular. Later, it was improved by incorporating the electrolyte into a wet paste. As a result, the cell was produced as a sealed unit with no free liquid electrolyte. This battery was the forerunner of the carbon-zinc dry cell, still in use today, along with its related alkaline batteries. Such batteries are called primary batteries.

Figure 3. Electrochemical cells at the Smithsonian Museum, Washington, D.C.

Figure 2. A voltaic pile at the Smithsonian Museum, Washington, D.C.

In 1859 Raymond Gaston Planté invented the lead-acid battery. Using two thin lead plates separated by rubber sheets immersed in a dilute sulfuric acid solution, he was able to store a small electrical charge. This was improved about 1881 when Emile Alphonse Faure developed a process for covering both sides of a lead plate with a paste of lead powder and sulfuric acid producing a storage battery with a high capacity. Since that time, there have been continuous improvements in both materials and manufacturing processes of the lead acid storage battery. This type of battery, know as a secondary battery, is the type used in most automobiles.

Generally, the commercial batteries available today, each produce 1.5 volts of energy. By attaching batteries in series, voltages of 6, 9 and 12 volts are achieved.

In this experiment, you will be constructing a number of cells or batteries, measuring their output, and evaluating their usefulness.

I. A Voltaic Pile, the first battery

Materials Needed

Metals. Strips or coins made of copper, silver, nickel, and magnesium
Filter paper, small circles or squares or cut to size
Scissors
Clamps to hold metal strips or coins together
Electrolyte solution, 0.1 M NaCl
Dropper
Test leads (with alligator clip connectors, if available)
Steel wool, extra fine
Voltmeter or multimeter
Motor
Light bulb and socket assembly
Copper wire

Safety Precautions

Wear safety goggles at all times in the laboratory

There are no safety hazards with any of the materials in this part of the experiment.

Disposal

Used 0.1 M NaCl can be disposed of down the drain.

Rinse and dry all the metal pieces. Place all used laboratory metals in the proper containers in the lab.

Procedure:

Clean the coins and metal strips using fine steel wool.

Cut a piece of filter paper just slightly larger than the larger coin or metal strip to be used. Moisten the paper with a drop of 0.1 M NaCl solution.

Using two different metals, construct cell by placing the moist piece of filter paper between the two metals. Hold the metals together with a small non-metallic clamp. The metals must not be in direct contact with each other. If desired, small pieces of copper wire can be clamped in contact with each metal to make for easier connection to a voltmeter for reading the voltage.

Record the voltage of the metal pair in the table that follows.

Can you use the voltaic pile to power a small motor?

Can you use the voltaic pile to light a small light bulb or LED?

You may need to connect voltaic piles in series. Work with other groups. How many voltaic piles are needed?

Does the voltage change if you pile two alternating layers of the metals? Tell what you did and the results in the space below. (Make sure that no two metals are in direct contact. Also make sure that the moist filter papers from different layers do not touch.)

Repeat the procedure using two different metal coins or strips.

Try all combinations of the available metals.

Cell Voltages

Metals used				
Copper	Copper			
Silver		Silver		
Nickel			Nickel	
Zinc				Zinc
Magnesium				

Notes: U.S. pennies, minted after 1983 are composed of a thin layer of copper over a core of zinc. These coins will react as if they were made of pure copper.
U.S. nickels are an alloy of 75% copper and 25% nickel.
Canadian nickels minted before 1983 are composed of pure nickel.
U.S. quarters and dimes, minted after 1965, are composed of 75% copper and 25% nickel with a copper core, the same material as a U.S. nickel.

II. The Electrochemical Cell

Materials Needed:

Electrochemical cell holder with beaker OR 100-mL beaker and two large paper clips
Strips of copper, iron, zinc, aluminum, and lead
Voltmeter or multimeter
Test leads (with alligator clip connectors)
Steel wool, extra fine
Sulfuric acid, 1M
Motor
Light bulb and socket assembly

Safety Precautions

Wear safety goggles at all times in the laboratory

Sulfuric acid is corrosive. In the event of skin contact, rinse the sulfuric acid from the affected area with cold water. If any redness or blistering occurs, seek medical assistance.

Disposal

Used sulfuric acid solution should be disposed of in the proper laboratory waste container.

All metal strips can be reused. They should be rinsed with water, dried, and placed in the proper containers in the lab.

Procedure:

Obtain two different metal strips. Clean the metal strips with fine steel wool.

Construct cells using two different metal strips. If an electrochemical cell holder is not available, the metal strips can be held in place by two large paper clips.

Have the voltmeter and test leads ready to for measuring. Add approximately 40 mL of 1 M H_2SO_4 to the beaker. (Note: the sulfuric acid will react with some of the metals)

Record the voltage of the cell in the table which follows.

Can you use the cell to power a small motor?

Can you use the voltaic cell to light a small light bulb or LED?

You may need to connect cells in series. Work with other groups. How many cells are needed?

Repeat the procedure using two different metal strips. Try all combinations of the available metals.

Cell Voltages

Metals used			
Aluminum	Aluminum		
Iron		Iron	
Copper			Copper
Zinc			

III. The Lemon Cell

Have you seen the potato clock? There are kits on the market that allow you to power a small clock using potatos, apples, oranges or other fruits. Based on your observations and results from the electrochemical cell section of this experiment, you should now be able to determine how these devices work.

Materials Needed

A Lemon
Metal strips, 1 each, zinc and copper
Knife
Test leads (with alligator clip connectors, if available)
Steel wool, extra fine
Voltmeter or multimeter
Motor
Light bulb and socket assembly

Safety Precautions

Wear safety goggles at all times in the laboratory

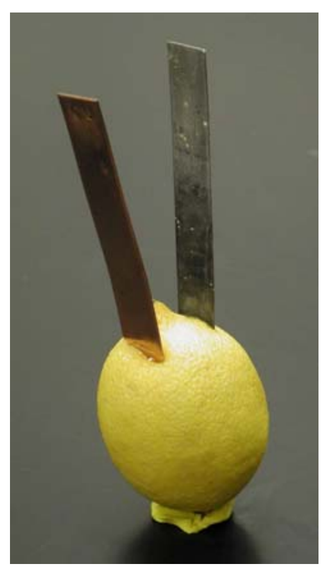
There are no safety hazards with the materials in this part of the experiment.

Disposal

Used lemons should be disposed of in the proper laboratory waste container.

All metal strips can be reused. They should be rinsed with water, dried, and placed in the proper storage containers in the lab.

Procedure:



Obtain two metal strips, one zinc and one copper. Clean the metal strips with fine steel wool.

Obtain a lemon. Roll it on the bench top to break some of the internal membranes in the lemon.

Using a knife, make two small slits on one end of the lemon.

Insert a copper strip into one of the slits and a zinc strip into the second slit.

Record the voltage of the cell.

Voltage = ___________________

Can you use the lemon cell to power a small motor?

Can you use the lemon cell to light a small light bulb or LED?

You may need to connect cells in series. Work with other groups. How many cells are needed?

IV. The Storage Cell

Materials Needed:

Electrochemical cell holder with beaker OR 100-mL beaker and two large paper clips
Lead strips, 2
Voltmeter or multimeter
Test leads (with alligator clip connectors)
Steel wool, extra fine
Sulfuric acid, 1M
Small automotive battery charger or power supply
Motor
Light bulb and socket assembly

Safety Precautions

Wear safety goggles at all times in the laboratory

Sulfuric acid is corrosive. In the event of skin contact, rinse the sulfuric acid from the affected area with cold water. If any redness or blistering occurs, seek medical assistance.

Take care when working with the battery charger or power supply. Always make sure that the charger is turned OFF before touching the electrodes. Most power supplies cannot function with the short circuit that is the storage cell and will often blow their fuse.

Disposal

Used sulfuric acid solution should be disposed of in the proper laboratory waste container.

The lead metal strips can be reused. They should be rinsed with water, dried, and placed in the proper storage containers in the lab.

Procedure:

Obtain two lead strips. Clean the metal strips with fine steel wool.

Construct cells using the two lead strips. If an electrochemical cell holder is not available, the metal strips can be held in place by two large paper clips. (This is similar to the cell constructed in Part III of this experiment.)

Attach leads from the battery charger or power supply. Set all voltages and settings on the power supply to zero. The setting should be at 6 Volts (or the closest value to 6 volts on the power supply). Turn on the power supply.

Charge the cell for about 3 minutes.

Describe any changes taking place in the cell as it is charging.

Do you observe any changes within the solution?

Turn off the power supply. Disconnect the power supply

Measure the voltage of the freshly charged cell.

Voltage = ________________

Can you use the cell to power a small motor?

Can you use the cell to light a small light bulb or LED?

You may need to connect cells in series. Work with other groups. How many cells are needed?

V. Construct a Dry Cell Battery

Dry cell batteries, in their various forms, are probably one of the most common power sources used for flashlights, toys, and today's portable electronic devices. Through modern engineering, these devices are highly dependable, having long shelf lives, and extended use lives. Most of the batteries available, today, are alkaline batteries, replacing the older carbon-zinc dry cell battery. The electrolyte in alkaline batteries is potassium hydroxide, which is corrosive and difficult to work with in the laboratory..

In this part of the experiment, you will construct a zinc-carbon dry cell battery.

Materials Needed:

IASCO Science demonstration dry cell kit consisting of 2 zinc cans, 2 label tubes, 2 plastic seal caps, 2 capped graphite rods, 2 sheets of separator paper, 2 bottom liners, 1 plastic knife, 1 plastic spoon, and 1 package of electrolyte mix.
Scissors
Voltmeter or multimeter
Test leads (with alligator clip connectors)
Battery holder
Motor
Light bulb and socket assembly

Safety Precautions

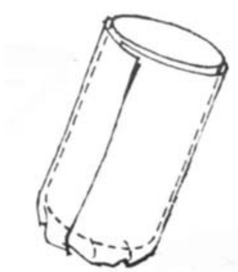
Wear safety goggles at all times in the laboratory

Zinc chloride, contained in the battery mix, can cause skin and eye irritations. In the event of skin or eye contact, rinse the affected area with cold water. If any redness or irritation occurs, seek medical assistance.

Disposal

Excess battery mix should be disposed of in the proper laboratory waste container.

Procedure:



Each battery kit contains materials to construct two dry cell batteries. These should be shared between separate groups of two people.

Take one sheet of the separator paper and roll it around the outside of the zinc can. Position the paper to extend ¼ inch (6 mm) beyond the bottom of the can. Holding the paper in place, fold the bottom of the paper over the bottom of the zinc can.

Remove the cylinder of separator paper from the outside of the zinc can, roll it a little tighter, and slide it into the inside of the zinc can. Push it to the bottom of the can so that the folded bottom of the paper is flat on the bottom of the can.

Take the bottom liner circle and gently fold up the outer edge slightly so it is shaped like a small pie pan.

Place the bottom liner inside the zinc can and push it to the bottom of the can using the eraser end of a pencil or a rounded end stirring rod. Take care not to tear or poke any holes in the paper.

Make sure the bottom liner lies flat on the bottom of the can. No zinc metal should be visible through the sides or bottom of the liner paper and bottom liner.

Obtain the plastic bag of electrolyte mix. This material must be handled with the plastic utensils only. It will be ruined by contact with any metals.

Use the plastic knife to open the electrolyte mix package. Place it on a piece of paper towel on the bench top.

Carefully add about ½ a spoonful of the mix to the zinc can. Pack it in place using the flat, **uncapped** end of the graphite rod. Continue to add electrolyte mix, one spoonful at a time, to the zinc metal can. Use the **uncapped** end of the graphite rod to pack the material after each addition.

Continue to add electrolyte mix until the level of the packed mix is about ½ inch (13 mm) below the top of the zinc can.

Use a scissors to cut off any excess separator paper that extends above the top of the zinc can.

Fold the upper portion of the separator paper onto the top of the packed electrolyte mix. It should cover most, if not all, of the top of the mix.

Insert the plastic seal cap onto the top of the zinc can. You may have to push the seal cap into place by pushing it against the side of the lab bench. DO NOT hit the zinc can or bag it against the table, this can loosen the electrolyte mix.

Use a piece of paper towel to wide any electrolyte mix off of the graphite rod.

Push the graphite rod through the hole in the seal cap.

Continue to push the graphite rod into the battery assembly, taking care to keep the carbon rod straight, until the capped end of the rod rests against the seal cap. If necessary, you may have to position the battery assembly against the side of the lab bench and gently, but firmly, push the graphite rod into place.

Finish the battery by sliding the label tube over the zinc can.

Measure the voltage of the battery using the voltmeter.

Voltage = _______________

Although the battery may record a voltage, it will not be able to power any devices for at least 12 hours, and preferably 24 to 48 hours, as it takes time for the moisture in the electrolyte mix to penetrate the liner paper to conduct the electrical charge to the outside of the zinc can.

You will continue to work with this battery in your next class or laboratory class.

As a **homework assignment**, look up the construction of a typical dry cell or alkaline battery, a lead storage battery, a silver oxide battery, and any other types of batteries you can find in a book or on the Internet. Print out any diagrams you find and bring them to the next class.

Next lab or class period, Measure the voltage of the battery.

Voltage = _______________

Is there any change in the voltage from the last lab or class period?

Place your battery into a battery holder. Use lead wires with alligator clips on the ends to connect the battery to a small motor and a light bulb assembly.

Can you use the battery to power the small motor?

Can you use the battery to light a small light bulb or LED?

You may need to connect cells in series. Work with other groups. How many cells are needed?

Summary

1. What is the maximum voltage you could obtain from any of your cells in this experiment? Which cells and/or metals were the most effective?

2. Can you observe similarities between your cells in this experiment and the dry cell battery and lead storage battery in any diagrams you found?

3. Why is it important that the electrolyte material, in the dry cell construction project (Part V), not come in contact with the zinc can? What would happen?

4. Summarize your finding about cells and batteries.