Name: _____

Lab Partner's Name: _____

Battery Lab

Clean Up

At the end of the lab you must clean up your own mess failure to do this will result in the loss of 10 points on your lab.

1. Throw away your lemons, aluminum foil, paper towels, and used carbon.
2. Wash/dry and retie your leads
3. Wash metal pieces.
4. Put all materials in the marked area.
5. Wipe down your table

Summary

In this lab, we will be exploring the properties of batteries by constructing simple examples of each technology using household items. We will construct two different types of batteries and test the performance of each battery by using a multi-meter; in addition, you will attempt to light a red LED with your battery.

Supplies

Each group is provided with the following items:

- 4 lemons
- 4 zinc bars
- 4 copper bars
- 1 aluminum washer
- 1 nail (iron)
- 5 pieces aluminum foil
- 5 paper towels
- activated carbon
- 1 red LED
- 10 electrical leads
- 1 portable digital multi-meter
- cup with salt water
- 1 spoon

Measuring Voltage and Current

Voltage

Batteries produce direct current (DC), so we will measure DC voltage (marked $V^{\text{---}}$). The batteries should not produce more than 20 volts, so you should measure using the setting '20.' To measure the voltage, touch the materials of interest. If the voltage is negative reverse the leads. If the black lead is plugged into the "com" on the multi-meter and the red is plugged into the "VΩmA" and the voltage is positive, the **black lead** will be on the **anode** and the **red lead** will be on the **cathode**.

Current

To measure current, we will use the section marked A⎓. Depending on the battery, you will need to use different settings in this section. The 2000µ setting will measure up to 2000 microamps (1000 microamps = 1 milliamp). The 20m setting will register current up to 20 milliamps. The 200m setting will register up to 200 milliamps (1000 milliamps = 1 amp). The 10A setting will register up to 10 amps. If you need to make a measurement using this setting, make sure to move the red lead to the hole marked '10A.' The units of the measurement are the same as the setting that you are on. If you choose a setting that is too high or too low, the meter will read '- 000.' Adjust the setting until you get a reading that makes sense. In order to measure the current you must insert the multi-meter into the circuit. This is done by connecting the wire coming off of the anode to the red lead on the voltmeter and connecting the black lead on the voltmeter to cathode.

Procedure

I. The Lemon Battery

A lemon battery is made using a lemon and two metallic electrodes. The juice in the lemon is the electrolyte in the battery. When the electrodes are connected by a wire, a chemical reaction occurs at each electrode. Electrons are produced by the reaction at the negative electrode, or *anode*, and flow through the wire to the positive electrode, or *cathode*. This flow of electrons per time is the *current* through the wire.

To make a lemon battery:

First, soften the lemon by rolling it around on a table while pressing down with your palm.

Next, select two electrodes. There are four electrode choices: copper, zinc, aluminum (washer), and iron (nail). If the electrode material appears corroded, use the sandpaper to gently remove the corrosion.

Insert the electrodes through the lemon skin, the electrodes should be close together but should not touch. Attach an electric lead to each of the electrodes. If the voltage is a negative number switch the leads. When you get a positive voltage, the **red** lead will be on the **cathode** and the **black** lead will be on the **anode**.

1. With one lemon, try different combinations of materials for the electrodes. Measure the current and voltage for each pair you try, and then record the results in the chart below. Make sure that you correctly identify which material is the cathode and which material is the anode. Also make sure to **include the correct units** for each measurement. (3 pts)

Cathode	Anode	Voltage	Current

2. Two lemon battery cells can be connected to form a bigger battery. (4 pts)

   a. Using the zinc and the copper try to hook 2 lemons up in different ways to get two distinct batteries (different voltages and currents).

      Draw a picture of the two batteries below:

      Battery 1:

      CURRENT: _____ VOLTAGE: _____

      Battery 2:

      CURRENT: _____ VOLTAGE: _____

b. **Show you picture to Darby or Ali and they will give you the definition of parallel and series** (1 pt)

Series: _____

_____

Battery _____ is wired in series.

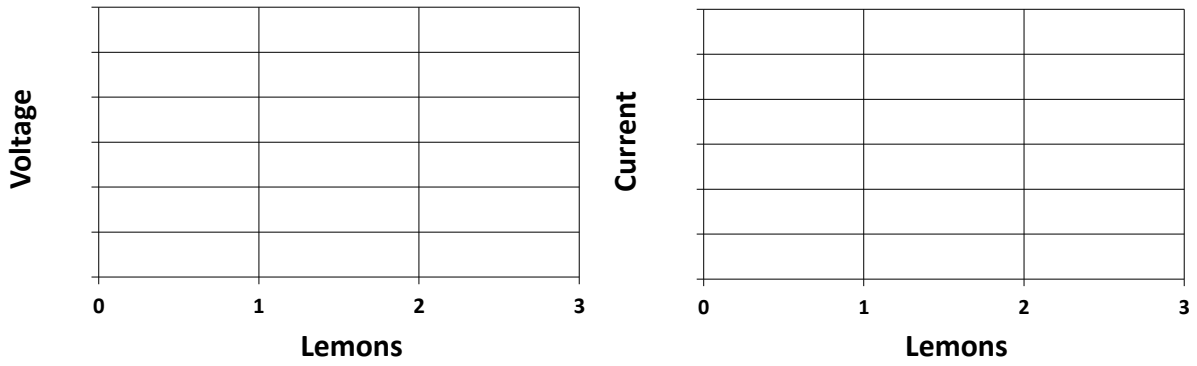
Parallel: _____

_____

Battery _____ is wired in parallel.

c. Using the zinc/copper lemon batteries, create a battery by connecting the lemons in series. When you add each lemon (up to 3 lemons) measure the voltage and current produced in the resulting battery and show the results. You have already measured the voltage for 1 and 2 lemons in part 1 and 2. (2 pts)

Number of Lemons	Voltage	Current
1		
2		
3		



Make sure that you label the vertical axes with the appropriate scale and units.

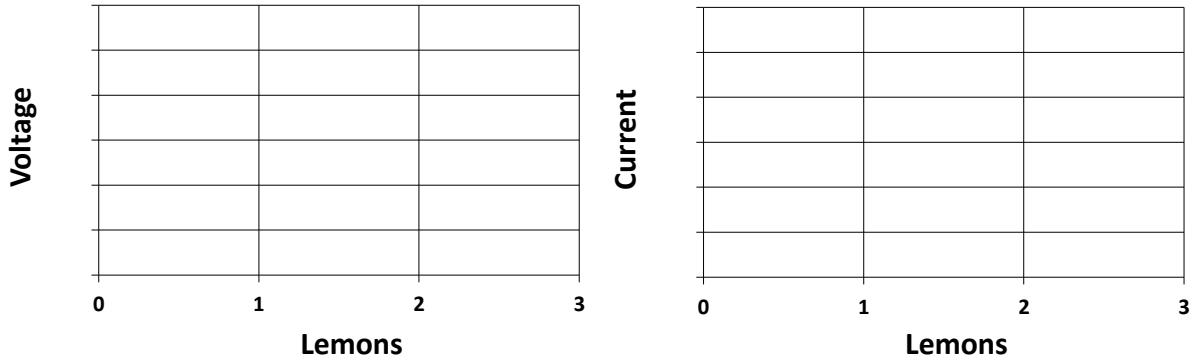
What is the relationship between the number of lemons and the voltage/current? (1 pt)

_____

_____

d. Using the zinc/copper lemon battery, create a battery by connecting the lemons in parallel. When you add each lemon, up to 3 lemons, measure the voltage and current produced in the resulting battery and show the results. You have already measured the voltage for 1 and 2 lemons in part 1 and 2. (2 pts)

Number of Lemons	Voltage	Current
1		
2		
3		



Make sure that you label the vertical axes with the appropriate scale and units.

What is the relationship between the number of lemons and the voltage/current? (1 pt)

_____

_____

3. Show your results from parts 2c and 2d to Darby or Ali and they will give you the answers to the next two questions.

a. In an ideal situation what happens to the voltage and the current when batteries are wired in series? (0.5 pts)

_____

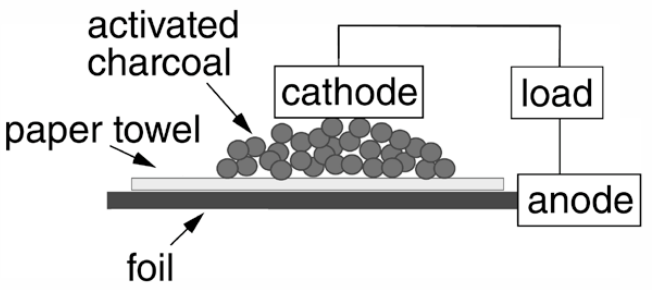
_____

b. In an ideal situation what happens to the voltage and the current when batteries are wired in parallel? (0.5 pts)

_____

_____

II. The Aluminum-Air Battery



The lemon battery uses two electrodes that react with the electrolyte in the lemon. However, metals are not the only option for electrodes. It is also possible to build a battery that uses the following reactions: (1) a reaction with aluminum that generates electrons at one electrode, and (2) a reaction with oxygen that uses electrons at the other electrode. To help the battery get access to the oxygen in the air, you can make the second electrode out of something that can conduct electricity but is non-reactive, like carbon. Activated carbon is highly porous, and these pores result in a large surface area that is exposed to the atmosphere. One gram of activated carbon can have more surface area than an entire basketball court. In this activity, you will construct a battery that uses these two reactions to produce current.

1. Get a square of aluminum foil that is approximately 15 cm • 15 cm.

2. Prepare a saturated saltwater solution: mix salt in a small cup of water until some dissolved salt remains on the bottom of the cup. Fold a paper towel into half and wet it in the saltwater solution, and place the towel on the foil.

3. Add a ¾ of a spoonful of activated carbon on top of the paper towel. Try to keep the carbon only one layer thick. Pour a few spoonful's of the saltwater solution on the carbon to moisten it. Be sure that the carbon is wet throughout, but does not touch the foil directly. You should have three layers, like a sandwich (see picture above).

1. Measure the voltage and current produced by the battery by connecting the **black** lead from the multi-meter to the **aluminum** foil and firmly pressing the **red** lead from the multi-meter into the **carbon**. What is the voltage and current produced by your battery? (2 pts)

   VOLTAGE: _____ CURRENT: _____

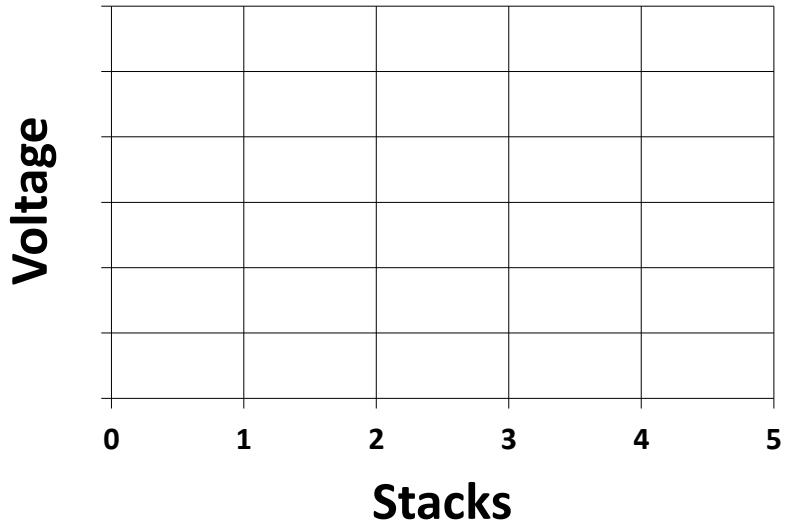
   How does this compare with the single cell lemon batteries? (0.5 pts)

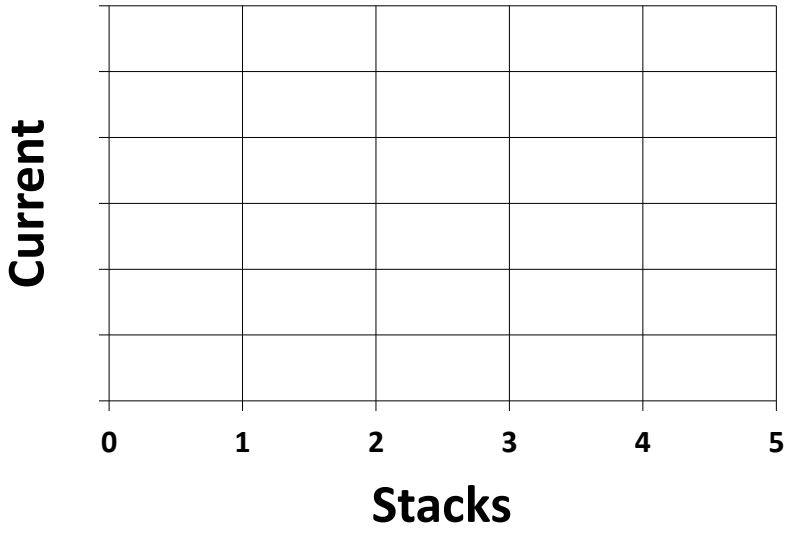
   _____

   _____

2. The first modern electric battery was made of a series of electrochemical cells, called a voltaic pile. Repeat steps 1–3 to construct additional aluminum–air cells. Stack the aluminum–air cells on top of each other to see if you can make a more powerful battery. Clip the black lead to the bottom piece of foil, and place the red lead on the top carbon pile. Press down firmly on the pile to reduce the internal resistance of the battery, but make sure that the foil pieces don't touch each other. Add one layer at a time, and measure voltage and current after each addition. (3 pts)

Number of Stacks	Voltage	Current
1		
2		
3		
4		
5		





What is the relationship between the number of layers and the voltage/current? (1 pts)

_____

_____

Is this battery wired in parallel or series? (0.5 pts) _____

Based on your measurements for 1 aluminum/air battery, what is the ideal voltage and current for a five-stack aluminum/air battery? (1 pts)

VOLTAGE: _____ CURRENT: _____

3. What are some possible reasons that your ideal and your measured voltage/current are different? Make sure to back up your claim with evidence. (1 pts)

_____

_____

_____

4. Construct a voltaic pile that can light the LED (2.6 V, 28 mA). Hook the long end of the LED to the carbon and the short leg of the LED to the aluminum. What is the minimum number of layers that it took? What was the voltage/current? (2 pts)

NUMBER OF LAYERS: _____

VOLTAGE: _____ CURRENT: _____

5. When constructing a voltaic pile out of several aluminum-air cells, why is it important to make sure the foil pieces don't touch? (2 pts)

_____

_____

_____

_____

Additional Questions

1. Based on your observations of the lemon batteries, answer TRUE or FALSE for the following statements. (1 pts)

   Electrodes in the lemon battery must be made of a material that conducts electricity.

   TRUE FALSE

   Two electrodes of the same metal can be used to make a lemon battery.

   TRUE FALSE

2. What factors affect the voltage of a battery? (2 pts)

   _____

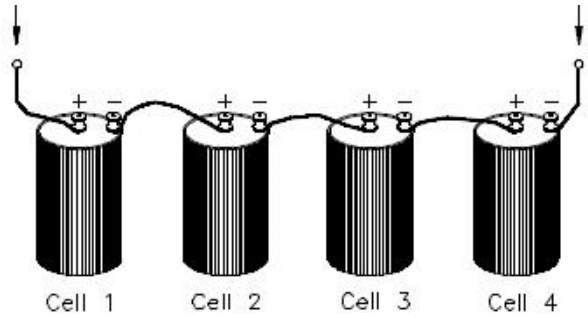
   _____

3. What factors affect the current of a battery? (2 pts)

   _____

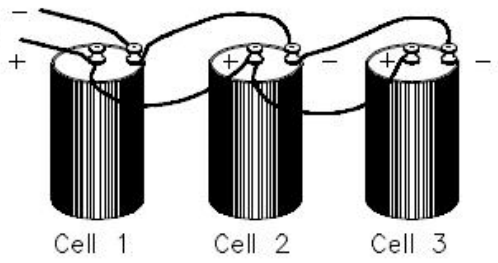
   _____

4. What is the ideal current and voltage for the following system? A single battery has a voltage of 1.5 V and 1.0 A. (1 pts)



VOLTAGE: _____ CURRENT: _____

5. What is the ideal current and voltage for the following system? A single battery has a voltage of 1.5 V and 1.0 A. (1 pts)



VOLTAGE: _____ CURRENT: _____

6. Draw a picture of a zinc/copper battery (made from a combination of zinc/copper batteries) that is made from no more than 4 lemons and produces at least 0.70 mA and 1.6 volts. Assume that one zinc/copper lemon battery produces 0.9 V and 0.5 mA (3 pts)

What is the ideal voltage and current of your new battery?

VOLTAGE: _____ CURRENT: _____

7. Based on your measurements for a single cell zinc/copper battery and a single cell aluminum/air battery which one has lower internal resistance. You must show you calculations for the internal resistance of each. Assume the internal resistance in the multi-meter and wires are 0 Ω. (hint: remember V=IR) (2 pts)

Using some (not all) of your answers from above write a 1-page report summarizing what you have learned about batteries. This should be in paragraph form and not a list of questions and answers. You do not need to include all of the questions above. Make sure that you include data (graphs etc.) that back up what you are saying. Your grade is based on if you can use evidence to back up what you are saying. (10 pts)