Investigation: BYOB (Build Your Own Battery)

Introduction

As we have covered in a previous investigation, chemical energy is energy released during a chemical reaction. A chemical reaction of particular note is one that occurs between two elements when one loses electrons and the other gains those electrons. These are called reduction-oxidation or redox reactions. The discipline of chemistry regarding these energy changes is called electrochemistry. In this investigation, we will see how this form of chemical energy can be harnessed into electrical energy, and in fact redox reactions contribute to electric potential (or voltage) in the circuit.

What parts of a battery determine its voltage?

Hypothesis: State your hypothesis to the above question and explain your reasoning.

_____

_____

Procedure:

Materials:

- 2 wires with alligator clips at both ends
- Resistor
- Voltmeter (a tool that measures the voltage *difference* between two points)
- Electrolytes:
  - Potato
  - Lemon
  - Pickle
  - Salt Water
- Metals:
  - Machined bolt (galvanized)
  - Old (before 1982)/new (after 1982) penny, sanded down
  - Soda can, sanded down

1. Your group will choose one combination of metals to use. You must pick a different combination of metals from the other groups if such is available (there are 6 possible combinations). Write the metals you use in the provided blanks.
2. Assemble the battery. Insert both metals into one of the electrolytes, connect one wire from a metal to the resistor, and then the other wire from the other end of the resistor to the other metal.
3. Measure the voltage of the battery. Put one probe of the voltmeter on one side of the battery and the other probe on the other side. The circuit must be completed in order to not damage the voltmeter. If you put the probes on the same side of the battery, the voltage will not register. If the voltage is negative, switch the positions of the probes. Record this voltage in the blank box below the electrolyte you're using.

4. Repeat for all four electrolytes. Then record the average voltage. Inform the instructor when you are finished, then answer the questions below the Observations section.

Observations:

Metals: _____ & _____

Electrolyte	Potato (H_3PO_4)	Lemon ($C_6H_8O_7$)	Pickle (CH_3COOH)	Salt Water ($NaCl_{(aq)}$)
Voltage (V)				

Average Voltage (V): _____

Questions:

1. Does the electrolyte affect the voltage significantly?

2. Why do you think the electrolyte is important? (Hint: it has to do with the compound name given in the table above! Start by identifying some of those compounds via the internet.)

3. Ask another table about their average voltage. Did they get a different voltage from your group?

4. Evaluate your earlier hypothesis. Was it correct or incorrect?

5. What do you think would happen if we used two of the same metal? (This configuration is useful in electronics when the electrolyte is removed and replaced with an insulator of some type, and it has a particular name. Do you know what it is?)

6. Each of the metals used in this experiment correspond to a different element on the periodic table. Give your best guess as to which elements were used in your experiment. This will be important in a future lesson.

Investigation: Resistance is Futile

Introduction

Now that we have an idea of where voltage comes from, we will investigate how to use electric potential in circuits. For the purposes of energy consumption, any electronic device can be effectively reduced to three basic circuit components: capacitors, inductors, and resistors. Today, we will just be looking at purely resistive circuits, that can be approximated by resistors only. Resistance determines how quickly electrons flow in the circuit, called current, governed by a well-known relationship:

What is the mathematical relationship between voltage, current, and resistance in a circuit?

Hypothesis: State your hypothesis to the above question and explain your reasoning.

_____

_____

Procedure:

1. Open the computer simulation. Familiarize yourself with the toolbox: take note of the battery, wire, resistor, ammeter (a tool that measures current), and voltmeter. You will need to use all of these tools.
2. Assemble a simple resistive circuit with the appropriate tools. Place a battery, wire, ammeter, and resistor together, connected end-to-end so the circuit is complete. The blue dots on the parts should begin to move. These simulate electron flow in the circuit. Note: the ammeter needs to be placed inside the circuit in order to function, unlike the voltmeter. The ammeter must be in series with the circuit, while the voltmeter must be in parallel.
3. Pull out the voltmeter and attach the probe ends to opposite sides of the resistor (or battery). Record the voltage (the readout from the voltmeter) and current (the readout from the ammeter). Open up the menu on the resistor and record its resistance.
4. Change the voltage and resistance many times. In the same menu that you recorded the resistance, change the value as you see fit. Additionally, open up the menu on the battery and change the voltage as you see fit. Then record the current. Repeat the recording process until you have ten (10) combinations of voltages, currents, and resistances. (Hint: make the numbers easy to multiply and divide together).
5. Answer question #1 and inform the instructor, who will check your answer. Then proceed to answering the other questions once your answer to #1 is correct.

Observations:

#	Voltage (V)	Resistance (Ω)	Current (A)
1			
2			
3			
4			
5			

Questions:

1. Using the variable names V for voltage, I for current, and R for resistance, write the mathematical relationship you observe in this data.

2. Evaluate your earlier hypothesis. Was it correct or incorrect?

3. Replace the resistor in your circuit with a light bulb. Using the voltage and current in the new circuit, calculate the effective resistance of the light bulb.

4. Put two resistors one right after the other in your circuit. These resistors are in series. Record the values of the resistance of each. Using the voltage and current, calculate the effective resistance of the two resistors together. How did the resistors combine mathematically?

5. Put two resistors in your circuit so that the blue dots branch out from one of the wires, some through one resistor and the rest through the other, then rejoin the two ends and continue the circuit. If these instructions are unclear, ask the instructor. These resistors are in parallel. Record the values of the resistance of each. Using the voltage and current, calculate the effective resistance of the two resistors together. How did the resistors combine mathematically (Hint: make one of the resistors twice the resistance of the other)?