

Potato Power

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 Subject: Chemistry
 Level: Middle School
 Standards: *New York State-Physical Setting/Chemistry* (www.emsc.nysed.gov)
 Standard 1- Analysis, Inquiry and Design
 Standard 4 - The Physical Setting
 Standard 6 - Interconnectedness: Common Themes
 Standard 7- Interdisciplinary Problem Solving

Schedule: One 60 minute period

Objectives:

Understand what an electrochemical cell is and how it can be used to power a small device.

Students will:

- Build a voltaic cell using a potato to power a small device.
- Compare the effectiveness of various types of fruits and vegetables in powering a small device.

Vocabulary:

Voltaic cell
Oxidation
Reduction

Cathode
Anode

Materials:

For Each Group:

Covered wire with alligator clips at both ends.
 Potatoes, apples, oranges, etc, for students to try
 Zinc strips or galvanized nails
 Copper strips or copper pennies
 Device to be powered

For Class:

Voltmeter (optional)

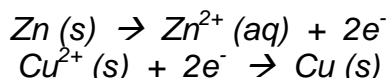
Safety:

This activity does not contain any safety concerns.

Science Content for the Teacher:

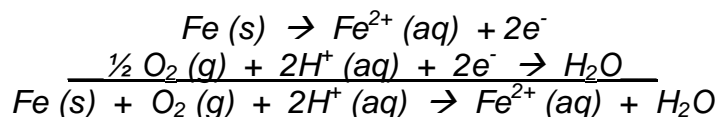
This lesson is based off of the concepts surrounding an electrochemical cell. There is an anode and a cathode that is separated by an electrolyte, and are connected by an electrically conducting wire. At the cathode, reduction occurs and at the anode, oxidation occurs. To determine the flow of electrons, the mnemonic device “LEO the lion goes GER” can be used. LEO means “loses electrons oxidized” and GER means “gains electrons reduction.” Therefore electrons are flowing from the anode to the cathode. Most general chemistry text books have very nice figures to demonstrate these concepts. For more information and pictures, visit <http://mooni.fccj.org/~ethall/2046/ch18/galvanic.htm>

A common galvanic cell uses zinc and copper as the electrodes, which are the metals the students will use this project. The half reactions that occur are shown below. The zinc is oxidized to form zinc ions and copper ions are reduced by the electrons that come through the circuit from the zinc anode. The potato serves as the salt bridge, or electrolyte, to complete the circuit.



These same principals apply to disposable batteries. There is an anode and a cathode separated by an electrolyte (often potassium hydroxide). When you put a battery into a device, that completes the circuit and allows the reactions to proceed, thus producing power to run that device. When the batteries are not in a device, the reaction cannot proceed, so the energy is stored.

Rusting is an example of an electrochemical cell. It is a spontaneous reaction that costs billions of dollars annually. For rusting to occur, both water and oxygen have to be present. The water serves as the electrolyte and the metal surface serves as the connecting wire from the anode to the cathode. The two half cell reactions are listed below, along with the overall reaction:



The resulting Fe^{2+} can react with oxygen to form iron oxides, ($\text{Fe}_2\text{O}_3 \cdot n\text{H}_2\text{O}$) which is the rust that we see on the surfaces of metals. Students should be able to say which reaction is the anode, which is the cathode, and where oxidation and reduction is occurring.



Preparation:

- Cut a series of different numbered plastics into pieces.

Classroom Procedure:

Engage (Time: 10 mins)

- Ask students what they know about electrochemistry, specifically in terms of cells, anodes, cathodes, and oxidation-reduction reactions. Discuss information in the Science Content section and review electrochemistry.

Explore (Time: 35 mins)

- Insert the copper and zinc electrodes into the potato about one inch apart. Do this for three potatoes. Connect the zinc electrode of one potato to the copper electrode of another potato using the wires with alligator clips. Connect the copper electrode of one end potato to the device. The assembled potatoes, wires, and device should form a completed circle. Connect the zinc electrode of the other end potato to the device. Check to see if the device is working. If not, try switching the wires connected to the device because polarity matters. If it still doesn't work, try a device that draws less current. Hooking the potatoes up in one big circle like this is considered to be connected in series. It increases the voltage of the overall cell.
- Have the students try using different types of fruits and vegetables in place of the potato. Using a voltmeter, quantitatively observe how it impacts the voltage.

Explain (Time: 15 mins)

- As a class, have student groups present their findings with the various fruits and vegetables. If a voltmeter was used, have them present their data as well.



Assessment:

The following rubric can be used to assess students during each part of the activity. The term “expectations” here refers to the content, process and attitudinal goals for this activity. Evidence for understanding may be in the form of oral as well as written communication, both with the teacher as well as observed communication with other students. Specifics are listed in the table below.

- 1= exceeds expectations
- 2= meets expectations consistently
- 3= meets expectations occasionally
- 4= not meeting expectations

	Engage	Explore	Explain
1	Shows leadership in the discussion and reflects a good understanding of electrochemistry	Completes work accurately while providing an explanation for what is observed. Works very well with group.	Provides an in-depth explanation of findings, making good use of vocabulary terms.
2	Participates in the discussion and shows an understanding of electrochemistry.	Completes work accurately, works cooperatively with group.	Provides clear explanation of findings and uses vocabulary words.
3	Contributes to the discussion, but shows little understanding of electrochemistry.	Works cooperatively with group, but makes some mistakes with the procedure.	Provides a limited explanation of findings, struggles to use vocabulary words.
4	Does not participate in discussion. Shows no understanding of electrochemistry.	Has trouble working with group. Does little to complete the procedure.	Is not clear in explanation of findings. Does not use vocabulary words.

Safety:

- This activity does not contain any safety concerns.

