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Teacher Notes

Decaying Batteries Introduction

This activity will engage students in investigating electricity by:

1. observing batteries being "used up" as a result of being placed in a circuit. Many students will have had experiences with batteries in flashlights, portable stereos, calculators, and electronic toys "going dead". The students will be using a multimeter to make it possible for students to measure and graph this phenomenon, thereby gaining a graphic image of the process.

2. observing that different types of cells are used in various electrical devices.

This activity is designed to follow investigations in which students have developed the concept of flow of electric current through a complete circuit.

The use of a multimeter is meant to extend the students power of observation. It allows the students to do this in two ways:

- by measuring quantitatively a phenomenon, battery decay that students can only observe indirectly. The decay of a D-Cell in a 30-minute period is not noticeable in the brightness of a bulb, but it can be dramatically demonstrated with the multimeter and software.

- by graphing this data comparatively for different kinds of cells make it possible for students to gain a clearer picture on which to construct their ideas about electricity.

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mobile inquiry technology
Decaying Batteries Teacher Notes

Discussion Guide

Prior to this activity ask the students to collect data about kinds of cells in battery powered devices a home and in school. They should make a list that includes the type of cell, its voltage rating, the number of cells in the device, and the kind of device.

Begin the activity with a discussion with the students, asking them to think about electrical devices, such as their laptop computers, that can operate with either a battery or connected to a wall socket. You can prompt their reflection by asking some of the following questions:

- What have you noticed about devices that run on either battery power or plugged into a wall socket?
- What happens to battery powered devices if you leave them on continuously? Will the same thing happen if they are plugged into a wall socket? What do you think explains this difference?

As a result of this discussion the class should develop a "working hypothesis" that the energy in a battery is "used up", while the wall socket offers a continuous supply. Challenge the class to propose a method for measuring this process.

If they have yet to use a multimeter, demonstrate the voltmeter as a device used to measure electric voltage. Pass out a variety of AAA-, AA-, C-, and D-cells to students. Ask them to report back on the voltage rating of the cells. Tell the students that volts are one of many measures related to electric current. Tell the students that voltage is a measure of the "push" of an electric current.

Since electrical terms and circuits are often difficult for students to understand, propose this analogy to the students: An electrical circuit is much like water running through a hose from a faucet. In this model the water represents the current (I) flowing through the hose that represents the wire. The resistance (R) to flow is dependent on the length or the narrowness of the hose. If you turn the faucet on full, the pressure needed to push the water through the hose is at maximum. The pressure need to push the water represents the voltage (V). Power (P) is the rate of flow of the water in the hose.

Students may question why different size batteries have the same voltage. Propose an addition to the analogy: Let's suppose you are watering a garden with your hose. Instead of connecting your hose to a faucet (which implies a non-ending source), you have the option of drawing water from two different ponds. One pond is twice the size of the other and of equal depth. Both ponds rest on a hill equal distance from the garden. If you place the hose at the bottom of either of the ponds, the water will flow at equal pressure (representing the voltage drop) through the hose. Ask the students which pond they would use during a drought if they needed more water for their garden? The larger pond is like the bigger battery. The large pond stores more water. The larger battery stores more chemicals.

Direct the students to go to "Thinking About the Question". After they have had an opportunity to read and discuss the question within groups and as a class, distribute different kinds of cells to each group.

After the students have completed Question 1 in the "Analysis", hold a class discussion about their findings. The next step before they move on will be to combine data from each group using different kinds of 1.5-volt cells. During the "Analysis", students from each group will be asked to share their data with students in other groups with different types of batteries. If you do not want students sharing computer disks, the teacher can transfer the data by computer disk to one computer for student observation. This data could then be shared on a computer in an easily accessible part of the room or by using a projection system. Once a graph is obtained of data from the entire class, focus the students on the differing rate of decay between one type of battery and another.

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Additional Teacher Background

Electric cells generate current because of the potential energy inherent in the chemical reactions between the different chemicals at the negative and positive pole. When that reaction is "used up" the potential energy that causes the "pressure" of the current is diminished. The unit of measure that represents that **potential pressure** is a **volt**. A complete circuit induces the chemical reaction to occur. Eventually that chemical reaction slows down and current required to power the device exceeds the available energy of the cell. We then say the cell is "dead". The cells in this activity are all carefully engineered to deliver the same "pressure" of 1.5 volts. Essentially larger size cells have more chemicals and can either carry on the reaction longer or deliver more current in the same period of time.

Another property of materials is their **capacity to conduct** an electric current. This is called **resistance**. A number of factors affect resistance in a circuit, including the material that components are made of, the length, and diameter of components such as wires.

Batteries are often taken for granted by students to run their WalkMan or to operate a remote control, yet they do not have a sense of the science behind a battery.

The following information about how the battery works might even surprise you. Every battery has two terminals that are also called electrodes. The "ode" is from the Greek for path, and so, as you would guess, the electrodes are pathways for electricity. Each of the electrodes are made of different materials. One of the electrodes is usually made of metal. It is called the anode and it is marked with a minus sign. The other electrode, marked with a plus sign, is called the cathode. It is generally made from carbon and a metallic oxide. "Oxide" means combined with oxygen, so a metallic oxide is a metal-oxygen chemical compound. The two electrodes are surrounded and separated by a chemical called an electrolyte. Some batteries differ by the materials used for electrodes. Different batteries can have different metal or carbon electrodes. These different electrode materials give the battery its generic name. For instance, a nickel-cadmium (NiCd) battery has one terminal of the metal nickel and one of cadmium.

If you could cut open a D-cell, you would see a number of components that work together to produce an electric current.

So how does a battery actually work? When you connect the anode and the cathode, some of the oxygen that was combined with the metal in the cathode moves into the electrolyte. The oxygen carries with it electrically charged particles called electrons. The electrolyte transfers the electrons to the anode. When the metal in the anode becomes oxidized, electrons are released and move through the connection to the cathode. This movement of electrons is an electric current, and can be used to do something. For instance, the electrons can run through the thin wire filament of a light bulb. Since the filament resists the flow of electrons, as they force their way through, the filament heats up and glows. This "force" or "pressure" is referred to as voltage and can be measured by connecting the battery to voltage leads.

There are two basic kinds of batteries that store electricity. Primary batteries are non-rechargeable and include alkaline magnesium dioxide, lithium magnesium dioxide, and silver oxide batteries that operate everything from high tech portable computers and cellular phones to everyday flashlights, radios and toys. The second basic kind of battery, like that in their computer, is rechargeable. Nickel-cadmium and lithium ion rechargeable batteries are alternatives to primary batteries and are most appropriate for devices requiring consistent, high power output.

The energy in nature can never be destroyed, it is only converted to another form. Every time one type of energy is converted to another, some of the energy is lost as useless heat. There are many different forms of energy that can be changed into other forms. For example, a chemical reaction such as burning can provide both heat and light energy. Heat, in turn, makes steam, and mechanical energy from a steam engine can be used to make electricity. All of the forms can be converted into other forms. A good example is the radiant energy from the sun can be converted into electricity with a solar cell.

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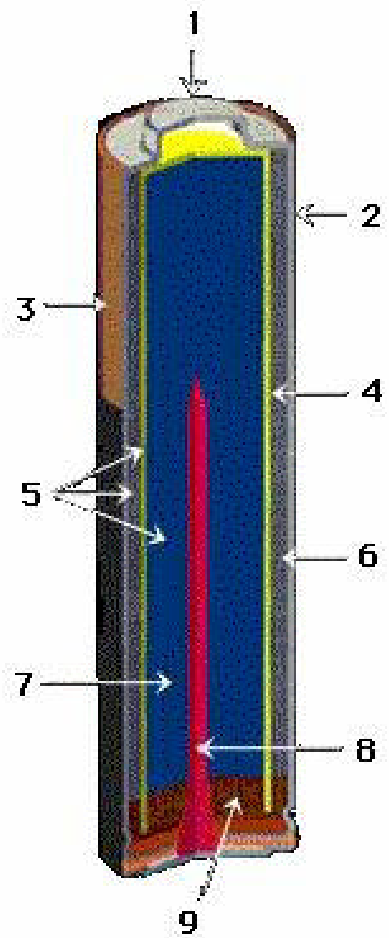
mobile inquiry technology
Decaying Batteries Teacher Notes

Additional Teacher Background (D-cell cut-away)

If you could cut open a D-cell, you would see a number of components that work together to produce an electric current.



1. Positive Pip: A protrusion formed in the bottom of the battery can that identifies it as the positive terminal.

2. Steel Can: Nickel-plated steel which is formed into a container to hold chemicals; serves as the positive collector.

3. Outer Jacket: A plastic sleeve containing decorative print that identifies the cell type and size.

4. Separator: Porous non-woven fibrous material which separates electrodes; holds electrolyte between electrodes.

5. Electrolyte: A solution of potassium hydroxide in water that carries the ionic current

inside the battery.

6. Cathode: Manganese dioxide and graphite that take up electrons from the external circuits.

7. Anode: Powdered zinc metal that serves as the source of electrons.

8. Anode Collector: Tin-plated brass that serves as a path for the electrons from the anode to the external circuit.

9. Seal/Vent: Molded plastic disc that holds internal components inside the cell and releases internal pressure when battery is abused.

(Battery drawing and description obtained from http://www.duracell.com/OEM/index.html)

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Decaying Batteries Suggested Timeline

The amount of time you spend on introductory discussions, data collection, and analysis, will determine your overall timeline. The following represents a possible timeline.

- One class period - Introductory Discussion
- One class period - Investigation I: Making a circuit and spreadsheet
- One class period - Investigation II: Investigating the decay of a battery
- One class period - Investigation III: Investigating the decay of different types of batteries
- One class period - Analysis

Additional days can be used for further investigations.

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