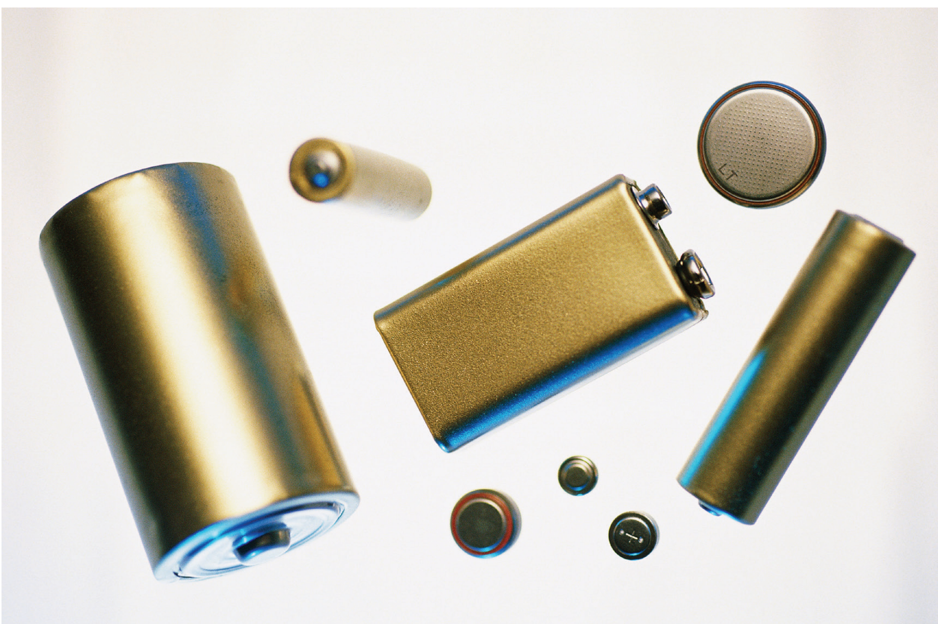
8 Chemical Batteries

INVESTIGATION

So far, you have been learning how chemical reactions can be used to make new substances or products. During a chemical reaction, the atoms in each substance are rearranged to form new substances. You have observed that some chemical reactions also release energy as heat or light. Scientists and engineers are able to use some of these energy-releasing reactions to obtain useful energy. In this activity, you will design a chemical battery to investigate how energy from chemical reactions can be transformed into electrical energy.

First, you will build a chemical battery prototype. A **prototype** is an early model of a product being designed. A prototype provides a way for new ideas to be tested, evaluated, and then used to improve a design. Like an engineer, you will test your prototype to see how well it works. If you imagine a battery, it is likely a cylindrical or rectangular object, like the ones pictured below. You cannot see inside of these batteries. The prototype you will make will use substitute materials that will allow you to see how the parts are interacting. Based on how the prototype functions, you will generate ideas for how to further test, evaluate, and improve your design.



Chemical reactions occur inside these batteries to release electricity.

GUIDING QUESTION

How can we improve the design of a chemical battery?

MATERIALS

For each group of four students

1 dropper bottle of 3% hydrogen peroxide solution
1 small piece of sandpaper

For each pair of students

1 SEPUP wet cell chamber
1 strip of copper
1 strip of iron
1 strip of magnesium
1 strip of zinc
5 packages of table salt
1 plastic spoon
1 graduated cylinder (50-mL)
2 wire leads: 1 red and 1 black, with clips
1 plastic cup (9-ounce)
1 electric motor
masking tape
paper towels

For each student

1 pair of chemical splash goggles
1 Student Sheet 8.1, "Chemical Battery Designs"

SAFETY

Wear chemical splash goggles at all times during this lab. Do not allow the solutions to touch your skin or clothing. Clean up any spills immediately. If accidental contact occurs, inform your teacher and rinse exposed areas. Be sure to wash your hands thoroughly with soap and water after you finish the activity.

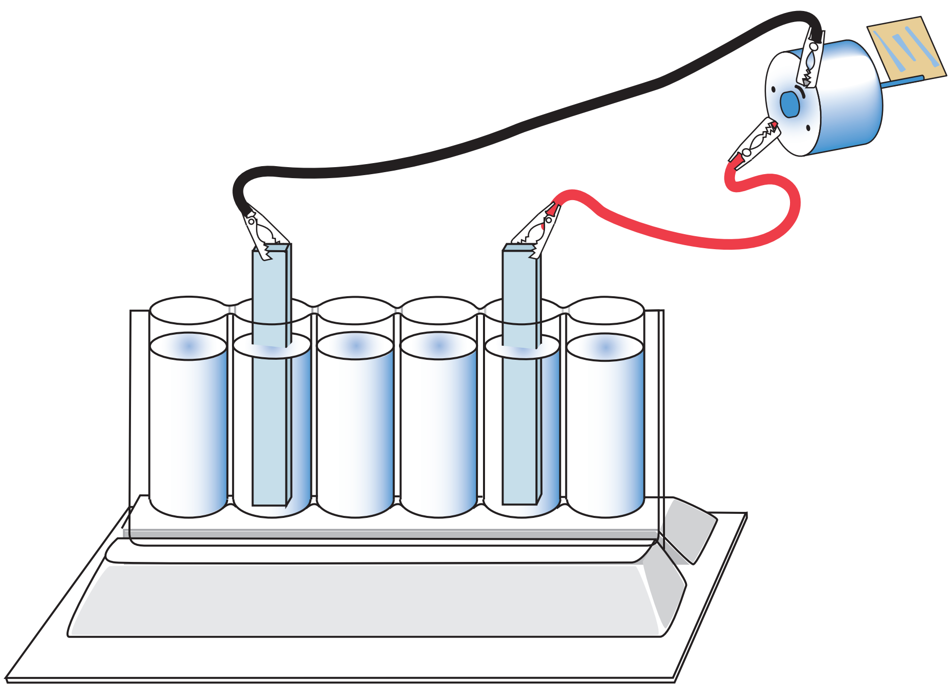
PROCEDURE

Part A: Build and Test a Chemical Battery Prototype

1. Prepare the battery's electrolyte—the liquid that will conduct the electricity released by the battery.
   a. Use the graduated cylinder to put 25 mL of water into the plastic cup.
   b. Add 5 packages of table salt.

   c. Add 25 drops of hydrogen peroxide.
   d. Stir until all of the salt is dissolved.
   e. Carefully pour the mixture into the SEPUP wet cell.

2. Attach a small piece of masking tape to the motor shaft to make a flag. This will allow you to see when the spindle on the motor is turning.
3. Clip one wire lead onto the zinc strip and another wire lead onto the magnesium strip. Clip the other ends to the motor.
4. Lower the zinc and magnesium strips into the second and fifth slots of the SEPUP wet cell as shown below. There should be a small amount of metal sticking out of the cells.



5. Observe the motor spinning.

   Hint: If the motor doesn't spin, try giving the flag a small push with your finger to start it. If it still does not spin, let your teacher know.

6. Once the motor spins, disconnect the wire leads from the metal strips. Remove the two metal pieces. Dry them, and then shine them with a piece of sandpaper. It is extremely important to completely dry the metals on a paper towel and clean both sides with the sandpaper!

Part B: Optimizing the Battery Design

7. In Part A, you built an initial prototype of a chemical battery. You saw how two metals—zinc and magnesium—along with the electrolyte transformed chemical energy into electrical energy. Now you and your partner will brainstorm, design, build, and test battery designs to make a better battery. Your new design must meet the following design **criteria** (minimum requirements for how the design must function; singular **criterion**) and **constraints** (something that limits or restricts the design, such as the availability of particular materials or limits on the size or final cost of the design).

   Design Criteria

   The design must

   - be able to make the motor spindle turn as fast as possible.
   - power the motor for at least 5 min.

   Design Constraints

   The design is limited by

   - using only the materials provided.
   - using the original electrolyte solution prepared in Part A.

8. With your partner, discuss different ways that you could modify the original chemical battery design to meet the criteria within the constraints above.

   Hint: For each idea, limit your modifications to one change at a time.

9. On Student Sheet 8.1, "Chemical Battery Designs," draw and label diagrams of your designs. If you are adjusting the volume of electrolyte in the wet cell or the amount of metal submerged, be sure to indicate specific measurements on your drawings.

10. Build prototypes to test your designs. Be sure to make and record your observations on your Student Sheet.

11. Discuss with the other pair in your group which of your designs best met the design criteria and constraints. As a group, determine if a better design could be made from combining parts of the prototypes already built and tested.

ANALYSIS

1. Did a chemical change take place in your wet cell? Use evidence from your investigation to support your answer.
2. Which of your design ideas
   a. made the motor spin the fastest?
   b. made the motor spin the slowest?
3. Why do you think the motor spun the fastest in the design you described in Analysis item 2a?
4. When designing your prototypes, you made one modification at a time. Based on the designs from all of your classmates, which types of modifications most improved the chemical battery's performance?

Name____ Date____________

STUDENT SHEET 8.1

CHEMICAL BATTERY DESIGNS

Draw and label your preliminary designs.

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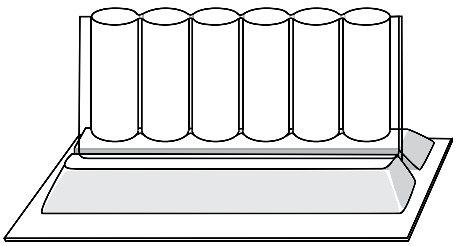
<tr>
<td>Design 1

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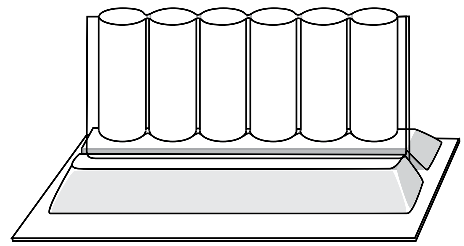
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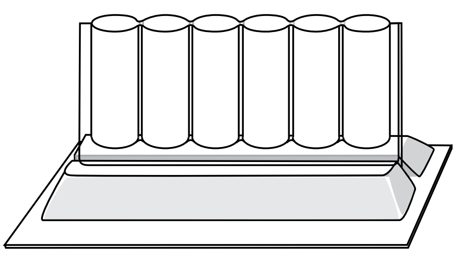
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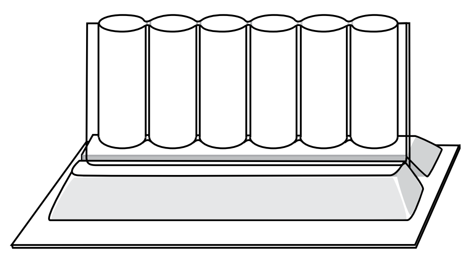
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