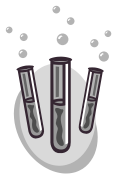


A Liquid Battery

Valeria Alston

Topic

Electric current in an electrochemical cell

Time

45 minutes to 1 hour

Safety

Please click on the safety icon to view the safety precautions. Adult supervision is required. Magnesium burns with intense light and heat. *Make sure no flames are in the area*. Be careful when handling the knife. Dispose of all liquids in the sink or toilet.

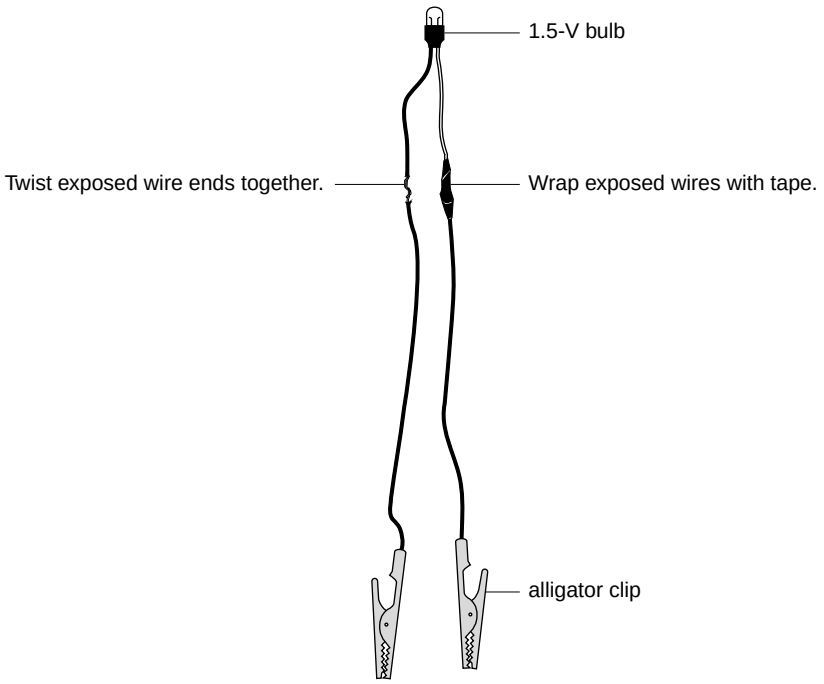
Materials

1.5-V bulb (Radio Shack #272-1139)
two copper pennies
two alligator clips or one test cable (Radio Shack #278-1156A)
24 cm magnesium ribbon
26 oz table salt
250 mL vinegar
250 mL water
250 mL cola
250 mL lemon juice
four beakers or ceramic or Pyrex™ cups, at least 250-mL capacity
ceramic or Pyrex™ saucepan
bell wire
matte knife
solder and soldering iron
hot plate or other heat source
hot glove
electrical tape
pencil

Procedure

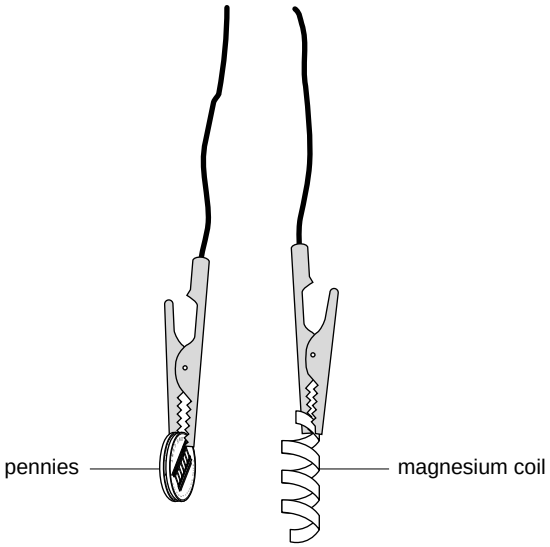
1. If you use the test cable, cut it into two halves, and remove the insulation from the cut ends. If you use the wire and alligator clips, cut two equal lengths of wire 15 cm long. Remove 2 cm insulation from each end, and on one end of each wire attach and solder an alligator clip.
2. Using the matte knife, remove 1 cm insulation from the ends of the wires leading from the bulb. Be careful not to cut the wires; they are very fragile.
3. Connect the bulb to the wires leading to the alligator clips by wrapping the exposed ends around each other, one to one. Using electrical tape, wrap the connections (see figure 1).

Figure 1



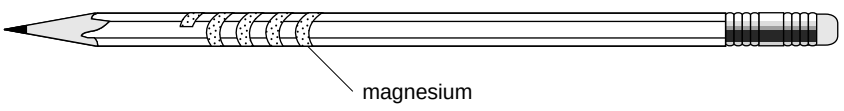
4. Clip the two pennies in one of the alligator clips (see figure 2).

Figure 2



5. Cut a piece of magnesium ribbon 6 cm long, and wrap it around a pencil (see figure 3). Attach the magnesium coil to the other alligator clip (see figure 2).

Figure 3



6. Set out the four beakers or cups; fill one with 250 mL (1 cup) water. Fill the second with the same amount of vinegar, the third with the same amount of lemon juice, and the fourth with the same amount of cola.
7. Place the electrodes (the pennies and the magnesium) into the cup of water, being careful that they don't touch each other. Note on your data table what happens. Is any gas released? Does the bulb light? Do you see or smell anything else?
8. Pour the water into the saucepan, and heat it until just below the simmering point. Reduce or turn off the heat. Being careful not to burn yourself with the hot liquid, insert the electrodes. Record your observations on the data table. Carefully pour the liquid back into the cup and set it aside. Wash the saucepan.

DATA TABLE

Substance tested	Observations		
	Gas forms (how much?)	Bulb glows (how much?)	Other
Water			
Water, heated			
Vinegar			
Vinegar, heated			
Lemon juice			
Lemon juice, heated			
Cola			
Cola, heated			
Water and salt			
Vinegar and salt			
Lemon juice and salt			
Cola and salt			
Vinegar and salt, heated			

9. Repeat steps 7 and 8 for each liquid, rinsing the electrodes in water before proceeding to the next liquid. Note the results on the data table. If the magnesium coil shows signs of wear, replace it with a new one.
10. Allow the water to cool to room temperature. Then add 3 tbs salt to it, and stir to dissolve the salt. Test the solution and record your results on the data table.
11. Repeat step 10 for the rest of the liquids. Replace the magnesium coil if it seems to be wearing out.

12. Pour the vinegar and salt solution into the saucepan and heat it. Leaving the heat on low, add more salt, 1 tbs at a time, to the solution as you test it. Keep heating it and adding salt, leaving the electrodes in the solution. After about 2 min, remove the electrodes. Record your observations.
13. Does water contain electrolytes? How do you know?
14. Is salt an electrolyte? Does lemon juice contain electrolytes?
15. Why do gas bubbles appear, and why does the bulb glow in some liquids and not in others?
16. What effect does adding more of an electrolyte have on the amount of electric current produced? How do you know?
17. What effect does heating the electrolyte solution have on the amount of current produced, and how do you know?

What's Going On

Water does not contain electrolytes. When you insert the metal electrodes in the water, there is no observable reaction. No gas bubbles appear, and the bulb does not light. This does not change when the water is heated.

Salt is an electrolyte, and lemon juice contains electrolytes. When you use salt-water, gas bubbles appear and the bulb glows, showing that an electric current is moving through the wires. When the metal strips are inserted in the lemon juice, which does contain electrolytes, gas bubbles appear. The bulb may glow faintly when you use cold lemon juice, or it may not. When the lemon juice is heated, the gas bubbles increase and the bulb glows. You will also notice a smell from the gas being released. When the solution contains an electrolyte, the chemical reaction occurs that causes a gas to form bubbles.

The bulb will glow only when the liquid contains an electrolyte. Sometimes, even in an electrolytic solution, the reaction is not strong enough to cause the bulb to light because there is not enough of the electrolyte present. Adding more of an electrolyte (the salt in this experiment) increases the amount of current produced, so the bulb glows more brightly (or just glows, when before only bubbles indicated the presence of a reaction). Heating the electrolytic solutions speeds up the chemical reactions, so more energy is released and the bulb glows more brightly. More gas bubbles also form, and you may smell the gas being released.

Connections

An *electrochemical cell* transforms chemical energy into electrical energy. The combination of the right materials placed in the proper solution will create a chemical reaction that will cause electrons to flow through a conductor, producing an electric current. For the cell to work, the solution must contain a substance called an *electrolyte*, which, when dissolved in water, separates into charged atoms that conduct electricity through the liquid.

In this experiment you tested some different liquids to see if they contain electrolytes and you observed an electrochemical cell in action.

Safety Precautions

READ AND COPY BEFORE STARTING ANY EXPERIMENT

Experimental science can be dangerous. Events can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. Basic safety procedures help prevent serious accidents. Be sure to follow additional safety precautions and adult supervision requirements for each experiment. If you are working in a lab or in the field, do not work alone.

This book assumes that you will read the safety precautions that follow, as well as those at the start of each experiment you perform, and that you will *remember* them. These precautions will not always be repeated in the instructions for the procedures. It is up to you to use good judgment and pay attention when performing potentially dangerous procedures. Just because the book does not always say "be careful with hot liquids" or "don't cut yourself with the knife" does not mean that you should be careless when simmering water or stripping an electrical wire. It *does* mean that when you see a special note to be careful, it is extremely important that you pay attention to it. If you ever have a question about whether a procedure or material is dangerous, stop to find out for sure that it is safe before continuing the experiment. To avoid accidents, always pay close attention to your work, take your time, and practice the general safety procedures listed below.

PREPARE

- Clear all surfaces before beginning work.
- Read through the whole experiment before you start.
- Identify hazardous procedures and anticipate dangers.

PROTECT YOURSELF

- Follow all directions step by step; do only one procedure at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure that there is adequate ventilation.
- Do not horseplay.
- Wear an apron and goggles.
- Do not wear contact lenses, open shoes, and loose clothing; do not wear your hair loose.
- Keep floor and work space neat, clean, and dry.
- Clean up spills immediately.
- Never eat, drink, or smoke in the laboratory or near the work space.
- Do not taste any substances tested unless expressly permitted to do so by a science teacher in charge.

USE EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives and other sharp or pointed instruments with caution; always cut away from yourself and others.
- Pull plugs, not cords, when inserting and removing electrical plugs.
- Don't use your mouth to pipette; use a suction bulb.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.
- Clean up broken glassware immediately.

- Do not use reflected sunlight to illuminate your microscope.
- Do not touch metal conductors.
- Use only low-voltage and low-current materials.
- Be careful when using stepstools, chairs, and ladders.

USING CHEMICALS

- Never taste or inhale chemicals.
- Label all bottles and apparatus containing chemicals.
- Read all labels carefully.
- Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves).
- Do not touch chemical solutions.
- Wash hands before and after using solutions.
- Wipe up spills thoroughly.

HEATING INSTRUCTIONS

- Use goggles, apron, and gloves when boiling liquids.
- Keep your face away from test tubes and beakers.
- Never leave heating apparatus unattended.
- Use safety tongs and heat-resistant mittens.
- Turn off hot plates, bunsen burners, and gas when you are done.
- Keep flammable substances away from heat.
- Have a fire extinguisher on hand.

WORKING WITH MICROORGANISMS

- Assume that all microorganisms are infectious; handle them with care.
- Sterilize all equipment being used to handle microorganisms.

GOING ON FIELD TRIPS

- Do not go on a field trip by yourself.
- Tell a responsible adult where you are going, and maintain that route.
- Know the area and its potential hazards, such as poisonous plants, deep water, and rapids.
- Dress for terrain and weather conditions (prepare for exposure to sun as well as to cold).
- Bring along a first-aid kit.
- Do not drink water or eat plants found in the wild.
- Use the buddy system; do not experiment outdoors alone.

FINISHING UP

- Thoroughly clean your work area and glassware.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Don't dispose of materials in the sink unless instructed to do so.
- Wash your hands thoroughly.
- Clean up all residue, and containerize it for proper disposal.
- Dispose of all chemicals according to local, state, and federal laws.

BE SAFETY-CONSCIOUS AT ALL TIMES