Solar Battery

Overview: This is a favorite experiment of mine, since it really demonstrates the photoelectric effect in a useful way. Here's the deal: electrons can be either free or attached to the atom, and when you hit a metal place with UV light, some of the attached electrons break free and start current flowing in a circuit.

What to Learn: This lesson will help you learn how solar energy reaches the earth in the form of radiation and takes multiple forms, mostly visible light.

Materials

- ½ sq. foot of copper flashing sheet (check the scrap bin at a hardware store)
- Alligator clip leads (RS#278-1156)
- Multimeter (Radio Shack #22-810)
- Electric stove (***not*** gas)
- Large plastic 2L soda bottle
- ¼ cup salt
- Sandpaper & sheet metal shears

Lab Time

1. First, we'll prepare the copper. Use the metal shears to cut the sheet so that it fits on top of the electric burner. Be careful, the edges will be sharp!
2. Wash the sheet very carefully with soap and water on both sides. Once it's dry, use the sandpaper to scrub off any loose particles. Take your time and scrub it all over on both sides.
3. Place the copper on the burner and turn it to the highest setting. Leave it for about a half hour. Watch the copper for the first few minutes. What do you notice?
4. You can prepare your water bottle while the sheet is cooking. Cut the neck off the bottle.
5. After cooking, turn off the burner and allow the copper to cool on the burner for another twenty minutes. It will shrink and you should notice a black layer which may flake off. We want the layer underneath the black layer. Wash the copper to remove any larger black pieces.
6. Cut the sheet in two, and then bend the sheet so that it can fit into the bottle. We want the smoothest side to face outward. Take a fresh, uncooked piece of copper and place it inside. It's important that the two sheets don't touch.
7. Take some salt and pour it in there. Pour water into the bottle, leaving about an inch of air in the top of the bottle. Stir it up with a spoon so that the salt and water form a solution.
8. Turn on your multimeter, and attach the positive side to the uncooked side of copper, and the negative to the cooked side of copper. Set the meter to read amps.
9. Read the meter in both sunlight and shade. What do you notice? Record your data in the worksheet.

Solar Battery Data

Location	**Multimeter Reading (Amps)**
Full Sunlight	
Shade	
Partial sunlight	

We are using the photoelectric effect for this experiment. This cuprous oxide solar cell ejects electrons when placed in UV light – and sunlight has enough UV light to make this solar cell work. Those free electrons are now free to flow – which is exactly what we're measuring with the volt meter.

Semiconductors are the secret to making solar cells. A semiconductor is a material that is part conductor, part insulator, meaning that electricity can flow freely or not, depending on how you structure it. There are lots of different kinds of semiconductors, including copper and silicon.

In semiconductors, there's a gap (called the bandgap) that's like a giant chasm between the *free* electrons (electrons that have been knocked out of its shell) and *bound* electrons (electrons still attached to the atom). Electrons can be either free or attached, but it costs a certain amount of energy to go either way (kind of like a toll booth).

When sunlight hits the semiconductor material in the solar cell, some of the electrons get enough energy to jump the gap and get knocked out of their shell to become free electrons. The free electrons zip through the material and create a flow of electrons. When the sun goes down, there's no source of energy for electrons to get knocked out of orbit, so they stay put until sunrise.

Reading

Solar energy is the kind of energy most people think of when you mention "alternative energy," and for good reason! Without the sun, none of anything you see around you could be here. Plants have known forever how to take the energy and turn it into usable stuff… so why can't we?

The truth is that we can. While normally it takes factories the size of a city block to make a silicon solar cell, we'll be making a copper solar cell after a quick trip to the hardware store. We're going to modify the copper into a form that will allow it to react with sunlight the same way silicon does. The image shown here is the type of copper we're going to make on the stovetop.

This solar cell is a real battery, and you'll find that even in a dark room you'll be able to measure a tiny amount of current. However, even in bright sunlight, you'd need 80 million of these to light a regular incandescent bulb.

Exercises Answer the questions below:

1. The sunlight causes the electrons to flow from the cuprous oxide because of:
    a. Photosynthesis
    b. The electromagnetic spectrum
    c. The photoelectric effect
    d. The photochemical principle
2. What material do most solar cells use instead of copper?

3. What part of the electromagnetic spectrum is most active in this experiment?
    a. Visible Light
    b. Ultraviolet Light
    c. Gamma Rays
    d. Microwaves
4. When you read amps, you read:
    a. Current
    b. Voltage
    c. Power Draw
    d. Work

Answers to Exercises: Solar Battery

1. The sunlight causes the electrons to flow from the cuprous oxide because of the: (photoelectric effect)
2. What material do most solar cells use instead of copper? (silicon)
3. What part of the electromagnetic spectrum is most active in this experiment? (UV light)
4. When you read amps, you read: (current)