Solar Education for NY
SchoolPower...Naturally

Solar Kit Lesson #3
Parts of a Solar Panel – Part I

TEACHER INFORMATION

LEARNING OUTCOME
After examining electrical contacts and the use of solar cells and rechargeable batteries to power electric motors, students are able to describe how a solar cell is similar to and different from a rechargeable battery as a way to explain to others how a solar cell works.

LESSON OVERVIEW
Students use observation, critical thinking, and deductive and inductive reasoning to compare and contrast the characteristics of a solar cell to a rechargeable battery. By comparing and contrasting a solar cell to the more familiar rechargeable household battery, students discover a simple analogy to help them understand and explain to others how a solar cell works: similar to a rechargeable battery, a solar cell can be energized to provide a circuit with direct current. It is unlike a rechargeable battery in that it is energized by a different form of energy (light as opposed to electricity) and it can be energized instantly but it cannot store energy so it instantly becomes "dead" when that energy source is removed.

GRADE-LEVEL APPROPRIATENESS
This Level I and II Physical Setting, physical science and technology education lesson is intended for use in grades 4–6.

MATERIALS
Per work group
- student handout
- one rechargeable AA battery
- one AA battery holder
- one mini–solar panel*
- one piece of solar cell*
- gooseneck lamp with 150-watt incandescent bulb
- small project-motor (almost any small motor will work, but test your selection before using it in class to make sure it works with the low voltages of one AA battery and the mini–solar panel)

*Available in the provided Solar Education Kit; other materials are to be supplied by the teacher

SAFETY
Broken pieces of solar cell have sharp edges. Tell students to handle the small pieces as they would any sharp object, such as a piece of broken glass. Light bulbs get hot enough to burn. Instruct students not to touch the light bulb.

TEACHING THE LESSON

Students should already be familiar with recharging and using rechargeable batteries prior to this lesson. Have students work in teams of two.

Show students a piece of a solar cell and identify it. Tell students that a solar cell acts in some ways like a rechargeable battery; sometimes the cell is "dead" and sometimes it is energized and can provide electric power. Reveal that they are to investigate and report on how a solar cell is similar to and different from a rechargeable battery.

For each team, hand out an energized (charged) rechargeable AA battery. Show students that the battery's two ends are covered with a metal contact. Discuss why this is necessary for the battery to be usable.

Distribute pieces of solar cells to student teams. Caution them that solar cells have sharp edges and are very fragile. Instruct students to hold the cells so that they are flat and not to bend them. They need to handle them as they would any sharp object, such as a piece of glass.

Point out that solar cells as well as batteries need metal contacts in order to be usable. Have students examine the cells and determine which parts of the cell they think are the metal contacts. Discuss with the class how one side of the cell is covered with a metal and the other side has a grid of metal lines.

Ask students to speculate why solar cells are made this way. Discuss how solar cells need to let as much light as possible into the cell and how they need to allow as much electricity as possible flow in or out of the top and bottom of the cell.

Distribute the student handout and have students complete the drawings called for in parts a and b of step 1.

Collect the solar cells. Now show students a mini–solar panel and identify it as a package of solar cells. Give each team one mini–solar panel and one AA battery holder. Tell students that, because solar cells are fragile, they are packaged in protective containers with wires that are brought to the outside and connected to the cell's electrical contacts. Have them identify which metal contact on the batteries and which wire on a solar panel are marked with a positive (+) symbol. Do the same for the negative terminal. (Note: Many batteries only identify the positive terminal.)

Have students complete all parts of step 1 of the handout. As each team completes step 1, provide them with a small project-motor and, if no bright direct sunlight is available, a gooseneck lamp having a 150-watt incandescent bulb. Have them complete the rest of the handout.

Extension activity: Have students compose in writing a description of how a solar cell works, comparing and contrasting it to a battery. Have students orally describe to another person or to the group how a solar cell works as compared to a rechargeable battery.

ACCEPTABLE RESPONSES FOR DEVELOP YOUR UNDERSTANDING SECTION

1a) Accurate drawing of a battery with the two ends labeled as having metal contacts.

1b) Accurate drawings of both sides of a solar cell with the metal contacts properly labeled.

1c) Accurate drawing of a mini–solar panel with the colors of the wire leads identified and the wire leads identified with a plus (+) or a minus (-) sign.

1d) Accurate drawing of a battery in a battery pack with the colors of the wire leads identified. Also, the wire leads should be identified with a plus (+) or a minus (-) sign.

1e) Answers may vary. A typical response might be that both have wires that are used as metal contacts.

2a) Electrical

2b) Students should describe recharging the battery with a battery charger on a regular basis.

2c) Light

2d) The solar panel is energized whenever it is exposed to a light source of sufficient energy. It acts like a "dead" battery when it is not exposed to the light source.

2e) Keep the solar panel exposed to a light source whenever it is needed to run the motor.

Venn Diagram:
List electrical characteristics of a rechargeable battery that are different from those of a solar cell.

Answers will vary. More complete answers might include such observations as:

(1) Rechargeable batteries are energized, or charged, using electricity as a source of power.

(2) It takes time to energize or charge a battery.

(3) Rechargeable batteries can store energy.

(4) Batteries discharge, or become dead, slowly.

List electrical characteristics that a solar cell and a battery have in common.

Answers will vary. More complete answers will include such observations as:

(1) Both have positive and negative metal contacts.

(2) Both can supply electric power (can be used to run a motor).

(3) Both can be energized by an external source of energy.

List electrical characteristics of a solar cell that are different from those of a rechargeable battery.

Answers will vary. More complete answers might include such observations as:

(1) Solar cells are energized using light as an energy source.

(2) Solar cells become instantly energized when exposed to light.

(3) Solar cells cannot store energy and they instantly become "dead" when the light source is removed.

ADDITIONAL SUPPORT FOR TEACHERS

SOURCE FOR THIS ACTIVITY

This is not an adapted lesson..

BACKGROUND INFORMATION

By placing metal contacts on the top and bottom of a photovoltaic cell (solar cell) and connecting these to an electric circuit, we can draw electrons off the top of the cell to form a current that can be used externally. Electrons from the top of the cell move through the electric circuit to replace the missing electrons in the bottom of the cell. This movement will continue as long as the cell is exposed to light having photons that have sufficient energy to excite the photovoltaic crystal's electrons.

When a solar cell is exposed to such a light source, almost instantly it moves negatively charged electrons to the top of the cell, leaving behind a crystal lattice of silicon atoms that have more positively charged protons than electrons on the bottom of the cell. This movement quickly reaches an internal state of equilibrium at which time the solar cell exhibits a voltage difference of about 0.5 volts between the top and bottom of the cell.

In this lesson, we refer to this condition as an "energized" solar panel. The solar cell is now able to provide a direct electric current to a circuit. In this way, a solar cell works like a rechargeable battery: it can be energized by an external energy source. The solar cell is unlike a rechargeable battery in that the solar cell cannot store energy and so becomes "dead" as soon as the energy source is removed. It is also different from a rechargeable battery in that the solar cell uses a different form of energy, light as opposed to electrical energy, to become energized.

Parts of a PV Cell

The top of a PV cell contains a grid of metal contacts. The metal contacts must be

- thick enough and close enough together (low resistance) to allow for the required current to flow through them, yet
- thin enough and spaced far enough apart to let sufficient light into the cell.

The cell is covered with an antireflective coating that enables maximum penetration of light into the cell. This is necessary because silicon crystals are highly reflective.

The bottom of a PV cell is covered with a metal plate that allows electrons to move back into the cell with minimum resistance. The metal plate also acts to reflect light back through the cell.

PV cells are packaged in panels covered by protective glass or other transparent material and encased in a protective receptacle.

REFERENCES FOR BACKGROUND INFORMATION

Richard Komp, Ph.D., *Practical Photovoltaics: Electricity from Solar Cells*, aatec Publications, 2002.

Chris Mason of the Northeast Sustainable Energy Association provided the analogy of a solar cell as a rechargeable battery.

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www.nyserda.ny.gov

(STUDENT HANDOUT SECTION FOLLOWS)

Names _____

_____

Date _____

How Is a Solar Cell Like a Rechargeable Battery?

1) Electrical connections:
   a) Draw and label a battery. Describe each metal contact.

   b) Draw and label both sides of a solar cell. Describe the metal contacts.

   c) Draw and label a solar panel including both wires. Describe both wires.

   d) Insert the battery into the battery holder. Draw and label the system. Describe the relationship of the wires to the rest of the system.

   e) Describe one or more ways that a battery in a battery holder is like a solar cell in a solar panel.

2) **Electrical power:** Connect the battery to the motor in a variety of ways, and observe and record what happens. Connect the solar panel to the motor in different ways and observe and record what happens. Expose the solar panel to bright sunlight or a lamp provided by your teacher and observe and record what happens. ***Caution: Do not place the solar panel closer than six inches to a bright light bulb; the heat of the bulb might melt the panel's protective cover.***

Use what you know about rechargeable batteries and what you observed to answer the following questions. Then fill out the Venn diagram on the next page.

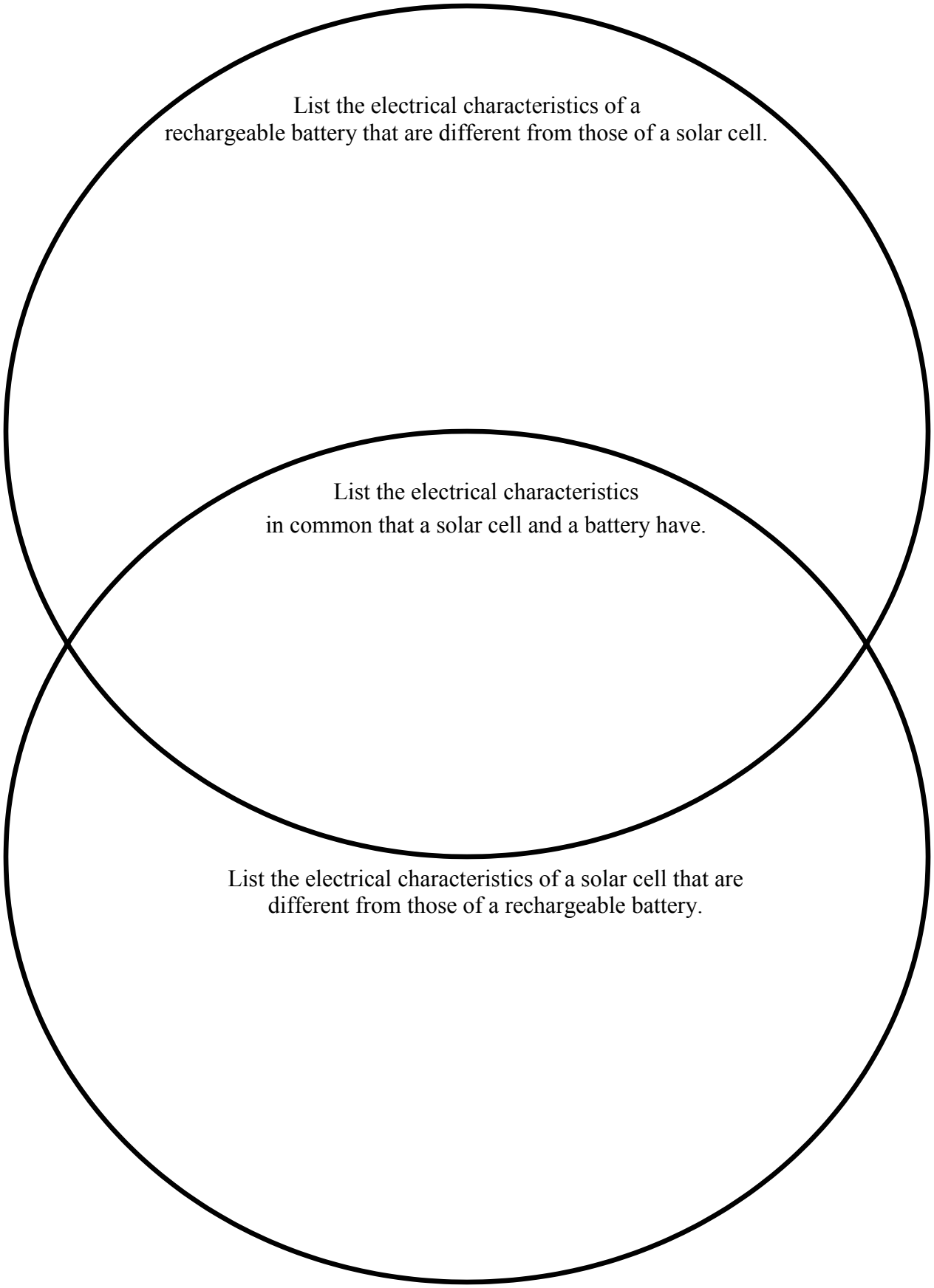
a) From your knowledge of rechargeable batteries, what form of energy is used to charge a rechargeable battery? Circle one.
   i) light
   ii) electrical
   iii) heat
   iv) mechanical

b) Using your knowledge of rechargeable batteries, what would you need to do if you wanted to run the motor every day for a long period of time?

c) What form of energy is used to energize a solar panel? Circle one.
   i) light
   ii) electrical
   iii) heat
   iv) mechanical

d) Describe the condition present when the solar panel is energized. Describe the condition present when the solar panel is "dead."

e) From what you observed, what would you have to do to use this solar panel to run this motor every day for a long period of time?


List the electrical characteristics of a rechargeable battery that are different from those of a solar cell.
List the electrical characteristics in common that a solar cell and a battery have.
List the electrical characteristics of a solar cell that are different from those of a rechargeable battery.