Name ______________________________________ Date ______________ Period _______

Lab: Photovoltaic Cells

CONCEPTUAL PHYSICS: UNIT 6

BACKGROUND: How much energy can we get from the Sun? Solar power is amazing. On average, every square meter of Earth's surface receives 164 watts of solar energy. In other words, you could stand a really powerful (150 watt) table lamp on every square meter of Earth's surface and light up the whole planet with the Sun's energy! Or, to put it another way, if we covered just one percent of the Sahara desert with solar panels, we could generate enough electricity to power the whole world. That's the good thing about solar power: there's an awful lot of it—much more than we could ever use.

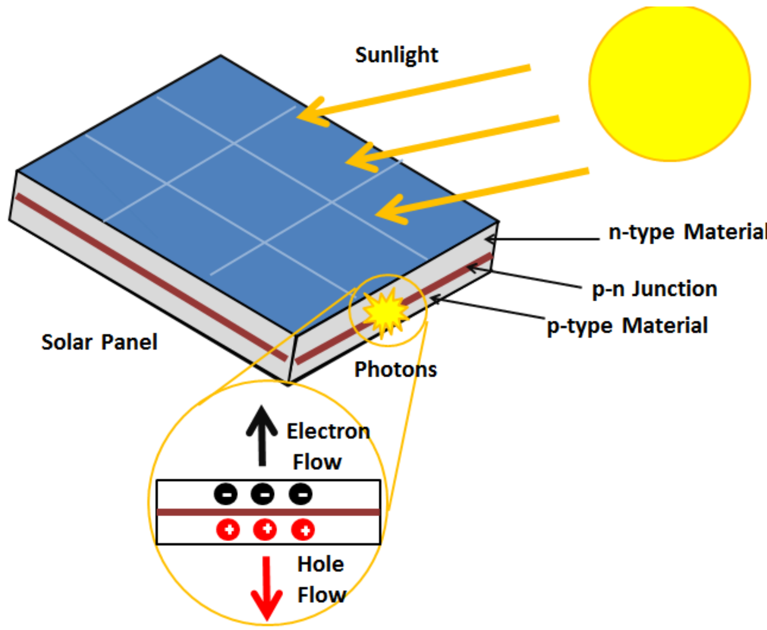
But there's a downside too. The energy the Sun sends out arrives on Earth as a mixture of light and heat. Both of these are incredibly important—the light makes plants grow, providing us with food, while the heat keeps us warm enough to survive—but we can't use either the Sun's light or heat directly to run a television or a car. We have to find some way of converting solar energy into other forms of energy we can use more easily, such as electricity. And that's exactly what solar cells do.

What are Solar Cells? A ***solar cell*** is an electronic device that catches sunlight and turns it directly into electricity. It's about the size of an adult's palm, octagonal in shape, and colored bluish black. Solar cells are often bundled together to make larger units called solar modules, themselves coupled into even bigger units known as solar panels (the black- or blue-tinted slabs you see on people's homes—typically with several hundred individual solar cells per roof) or chopped into chips (to provide power for small gadgets like pocket calculators and digital watches).

Just like the cells in a battery, the cells in a solar panel are designed to generate electricity; but where a battery's cells make electricity from chemicals, a solar panel's cells generate power by capturing sunlight instead. They are sometimes called ***photovoltaic (PV) cells*** because they use sunlight ("photo" comes from the Greek word for light) to make electricity (the word "voltaic" is a reference to Italian electricity pioneer Alessandro Volta, 1745–1827).

We can think of light as being made of tiny particles called ***photons***, so a beam of sunlight is like a bright yellow fire hose shooting trillions upon trillions of photons our way. Stick a solar cell in its path and it catches these energetic photons and converts them into a flow of electrons—an electric current. Each cell generates a few volts of electricity, so a solar panel's job is to combine the energy produced by many cells to make a useful amount of electric current and voltage. Virtually all of today's solar cells are made from slices of silicon (one of the most common chemical elements on Earth, found in sand), although as we'll see shortly, a variety of other materials can be used as well (or instead). When sunlight shines on a solar cell, the energy it carries blasts electrons out of the silicon. These can be forced to flow around an electric circuit and power anything that runs on electricity.

How are solar cells made? ***Silicon*** is the stuff from which the transistors (tiny switches) in microchips are made—and solar cells work in a similar way. Silicon is a type of material called a ***semiconductor***. Some materials, notably metals, allow electricity to flow through them very easily; they are called ***conductors***. Other materials, such as plastics and wood, don't really let electricity flow through them at all; they are called ***insulators***. Semiconductors like silicon are neither conductors nor insulators: they don't normally conduct electricity, but under certain circumstances we can make them do so.



A solar cell is a sandwich of two different layers of silicon that have been specially treated or doped so they will let electricity flow through them in a particular way. The lower layer is doped so it has slightly too few electrons. It's called ***p-type*** or positive-type silicon (because electrons are negatively charged and this layer has too few of them). The upper layer is doped the opposite way to give it slightly too many electrons. It's called ***n-type*** or negative-type silicon.

When we place a layer of n-type silicon on a layer of p-type silicon, a barrier is created at the junction of the two materials (the all-important border where the two kinds of silicon meet up). No electrons can cross the barrier so, even if we connect this silicon sandwich to a flashlight, no current will flow: the bulb will not light up. But if we shine light onto the sandwich, something remarkable happens. We can think of the light as a stream of energetic "light particles" called ***photons***. As photons enter our sandwich, they give up their energy to the atoms in the silicon. The incoming energy knocks electrons out of the lower, p-type layer so they jump across the barrier to the n-type layer above and flow out around the circuit. The more light that shines, the more electrons jump up and the more current flows. This is what we mean by ***photovoltaic***—light making voltage—and it's one kind of what scientists call the ***photoelectric effect***. *(taken from http://www.explainthatstuff.com/solarcells.html)*

PROCEEDURE:

1. Obtain video worksheet ***"How do solar cells work?"*** and complete worksheet while watching YouTube video (https://www.youtube.com/watch?v=xKxrkht7CpY) on a Chromebook before conducting the following steps.

2. Form groups of 3-4 students each.

3. Obtain one solar powered cockroach from your teacher.

4. Place your solar powered cockroaches under each of the following light sources and determine whether or not your solar cell in developing an electrical current. (Answer **Yes** or **No** for each)

- Incandescent light bulb:
- Fluorescent light bulb:

- LED Grow Light:
- How could you explain why these light sources did not develop an electrical current? (*What are these light sources not producing?*)

5. Quietly walk outside and put your solar powered cockroach under sunlight.

- Does the solar cell produce an electric current? (**Yes** or **No**)
- How can you tell?
- How long did it take to start vibrating when you put it under sunlight?
- Put your hand over the cockroach and cast a shadow over your cockroach. How long does it take for the vibration to stop?
- Do you think the solar powered cockroach would still work when it is overcast? (**Yes** or **No**)

5. Turn the solar powered cockroach onto its back and carefully inspect the underside.

- What is producing the vibratory motion when it is exposed to sunlight?
- What other common electronic device you know of utilizes this type of vibratory motor?
- Is the electrical current produced **AC** or **DC**? (circle one)

6. Return your solar powered cockroach to your teacher and obtain a **miniature solar powered car**.

7. Quietly take your solar powered car outside and place it under direct sunlight.

- How quickly does the car respond (begin to move) when you put it under sunlight?

- How quickly does it stop when it reaches a shady area?
- Do you think your solar powered car produce more or less power than your solar powered cockroach? How did you determine this?

- If a full size solar powered car was developed, what do you think would limit its usefulness?
    - How could you solve this problem so the car could function at nighttime?

CONCLUSION QUESTIONS:

1. How large of a solar cell would be required to power a 150W lightbulb?

2. What is the name of the **light particles** that power a solar cell?

3. What type of material (**element**) is utilized to **make photovoltaic cells**?

4. What is a **semiconductor**?

5. What is the difference between a **conductor** and an **insulator**?

6. What makes up the two <u>layers</u> of a **silicon solar cell** and how do they differ?

7. What other electronic devices have you used that contain a **photovoltaic cell**?