

Student Worksheet

Name: _____ Date: _____ Class: _____

Student Worksheet

Silicon solar cell efficiency: Comparing input power to output power of a silicon photovoltaic cell.

Safety

DO NOT TOUCH PLUGGED IN LIGHT BULBS WITH YOUR BARE HANDS. Use a heat-proof glove to handle hot light bulbs. Replace the light bulb into its original box immediately after use.



Introduction:

What do nanotechnology and solar power have in common? To answer this question let's think of an electron as the ultimate currency of modern society and technology. The electrons which might power your cell phone and make tweeting during class possible reside in nano-environments. These nano-environments made up of different atoms and molecules can influence electron behavior as much as our environment influences us. Scientists believe that through studying these tiny environments we can come up with better ways of collecting, storing, and transporting energy. In a typical solar cell, electrons flow creating electric current as a result of sunlight striking the surface of a silicon semiconductor. In this lab you will compare the electrical power in watts that a silicon solar cell generates to the power given off by a light bulb with a given power rating. You will also research some other possible photovoltaic materials and compare them to silicon.

Materials per lab group of 3-4 students:

- 1 Photovoltaic cell
- clamp-on lamp with reflector
- 5 incandescent light bulbs with different light output (same glass and type):
 - 15 watts
 - 40 watts
 - 60 watts
 - 75 watts



National Nanotechnology Infrastructure Network

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- 100 watts
- 1 Vernier current probe
- 1 Vernier voltage probe
- 1 Vernier Go!Link Interface
- Computer with Vernier Logger Pro software and a spreadsheet program (Excel etc.) and Internet access
- 1 breadboard
- Jumper wires (2)
- LED
- Heat-proof gloves or hot hands
- 2 alligator clip leads
- metric ruler
- Scientific calculator



Question: Is silicon a good material to use in solar cells?

Make a Prediction (Predict the efficiency of your solar cell as a percentage)

Procedure

1. Turn on the computer and open the Logger Pro software.

Part 1. Measuring Voltage

2. Connect the Vernier Go!Link Interface to the Voltage probe and plug it into your computer's USB drive.
3. Plug the LED into a breadboard and use jumper wires to connect the LED in series with the solar cell terminals. *Hint: In general the longer end acts as a positive electrode, thus the shorter end is negative.*
4. Install the 100 W light bulb in the clamp-on lamp. Turn it on, and place it in 25 cm away from the solar cell.
5. Connect the alligator leads from the Voltage probe to the LED to measure voltage making sure you do not short-circuit the LED.
6. Record the voltage reading from Logger Pro in the table below.
7. Turn off the lamp, unplug it, and USING A HEAT GLOVE replace the 100 W bulb with the 75 W bulb and repeat steps 4–6. Repeat this procedure for the 60 W, 40 W, and 15 W bulbs.

Part 2. Measuring Current

8. Connect the Vernier Go!Link Interface to the current probe and plug it into your computer's USB drive.
9. Connect the alligator clip leads to the current probe.
10. Install the 100 W light bulb in the clamp-on lamp. Turn it on, and place it in 25 cm away from the solar cell.
11. Measure the current by plugging the current probe into the circuit (in series). This involves temporarily breaking the circuit to connect the alligator clip leads from the current probe. Make sure to match the correct electrodes (+ to +, - to -).
12. Record the current reading from Logger Pro in the table below.
13. Turn off the lamp, unplug it, and USING A HEAT GLOVE replace the 100 W bulb with the 75 W bulb and repeat steps 10-12. Repeat this procedure for the 60 W, 40 W, and 15 W bulbs.

Analyze the Results

1. Calculate the power generated by the solar cell for each light bulb using the formula: $P = VI$. Record as Output Power in Table 1.
2. Use the spreadsheet program to make a bar graph (Graph 1) of light bulb power (x-axis) vs. solar cell output power (y-axis). Make sure to tile the graph and label both axes. PRINT IT.
3. Each light bulb has a power rating (100 W, 75 W, 60 W etc.) which represents the amount of electrical power it consumes, and not the amount of light power it emits, which we will call "input power". In order to calculate the input power of each light bulb you will have to first calculate its light intensity using the formula:

$$\frac{P}{4\pi r^2}$$

where P is the light bulb power in watts, and r is the distance between the solar cell and the light bulb in meters. Record in Table 1.

4. Next, calculate the absorption area of the solar cell in m^2 . Record here:

Finally, use the calculated area and the light intensity to calculate input power. Record in Table 1.

5. Calculate the efficiency by dividing output power by input power and multiplying by 100. Record in Table 1.

- Once again, use the spreadsheet software to make a bar graph (Graph 2) of the efficiencies of all the light bulbs used in the experiment. Make sure to title the graph and label both axes. PRINT IT.

Table 1. Solar Cell Output Voltage, Current, and Power

Light bulb power (W)	Voltage (V)	Current (A)	Output Power (W)	Light Intensity (W/m ²)	Input Power (W)	Efficiency (%)
100 W						
75 W						
60 W						
40 W						
15 W						

Draw Conclusions

- In your opinion, is silicon an efficient material for use in photovoltaics? Use your data to explain your answer.
- Does solar cell efficiency increase or decrease as the input power increases? Use your data to explain the correlation.
- What happens to the remaining power produced by the light bulb if not all of it is used by the solar cell?
- Research two alternative solar cell materials, describe their pros and cons, and compare them to silicon. Provide the source of your information.