Experimenting with Solar Heaters Part 1: Making the Standard Solar Heater

AUTHOR: Nathan Franck

DESCRIPTION: In part one of the activity students will be asked to create a simple solar heater, measure the temperature change in a vial of water, then calculate the heat energy transferred to a vial of water. Students will construct the solar heater, place a set amount of water into a vial in the collector and place it in direct sunlight. After a set time students will measure the final temperature of the water and calculate the heat energy transferred to the water from the sun.

GRADE LEVEL(S): 6, 7, 8

SUBJECT AREA(S): Physical science

ACTIVITY LENGTH: 1 hour, 30 minutes

LEARNING GOAL(S): In this activity students will learn that sunlight energy can be transformed into other forms of energy and that the amount of sunlight energy captured by an object can be quantified and measured.

STANDARDS MET:

Next Generation Science Standards:

- MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed
- MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
- MS-PS3-5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
  - *MS-PS3-5 (Crosscutting Concepts). Energy may take different forms*

……

Student Background:

Students should already be familiar with the ideas of energy transfer and energy transformation. They should be familiar with the concept that the kinetic energy of an object changes as energy is transferred to or from an object and that temperature readings represent the average thermal

kinetic energy of an object. Students should also be familiar with the concept that energy can take different forms and that it can be transformed from one form of energy to another.

Educator Background:

Educators should be comfortable with the ideas of energy transfer, energy transformation and kinetic energy. Educators should also be familiar with how solar heaters work.

Other Materials List:

1 set per class:

- 2-3 liters of room temperature water
- Several graduated cylinders or syringes for measuring 30ml of water
- Multiple colors of construction paper
- Rolls of aluminum foil
- Tape/glue
- A sunny day

1 set per group of 2-4 students:

- “Directions for Solar Heater” student handout
- Part 1 “Student Worksheet”
- 2 vials - clear 12 dram vials work
- 2 thermometers
- 2 Styrofoam plates
- 1 piece 30cm x 30cm piece of aluminum foil
- 1 soup bowl to be used as the solar heater mold

Vocabulary:

- Solar heater
- Heat transfer
- Kinetic energy
- Temperature
- Energy transformation

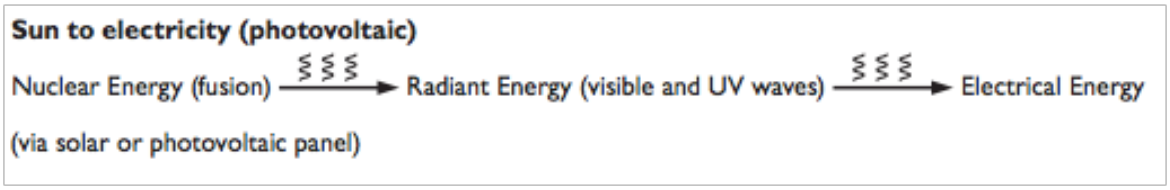
……

Lesson Details:

This is a detailed, step-by-step guide to the lesson. Feel free to make it your own in order to better match the needs of your students.

Review:

1. Review concepts of energy transfer and energy transformation if needed.
2. Create an energy transformation diagram of sun to electricity, this one is from KidWind:



3. Have students create an energy transformation diagram for a solar heater starting with the sun (i.e. where nuclear energy is transformed to radiant energy and then into thermal energy).

Part 1:

1. Focus Question: What is a solar heater and how does it work?

2. Inform students that today in class they will make a solar heater. Ask them to discuss what they could measure to determine the effectiveness of a solar heater. After hearing several ideas suggest using temperature change, T_f-T_i=ΔT.

3. If you will be using joules to calculate Heat Energy Transferred, teach students the equation: q=mcΔT where q=energy transferred in joules; m=the mass of the water; c=the specific heat of water; and ΔT=the change in temperature of the water.

4. Give students Solar Heater Directions and Handout Part 1

5. Question #1: Give groups five-ten minutes to brainstorm a controlled experiment that could be used to determine the effectiveness of a solar heater.

6. After discussing possible controlled experiments, guide the class to first construct a standard solar heater, test it and then make incremental changes one variable at a time.

7. Construct solar heaters using the Solar Heater Directions Sheet. (Save one standard solar heater for use as the control during parts two and three of the experiment.)

8. When constructed, place solar heaters in the sun outside for at least 10-15 minutes, though longer is better. *Note: If there is no sun, shop lights or clamp lamps will also work. Fluorescent lights will not work for this activity.*

9. Guide students through the worksheet and data collection and analysis. Some parts may be completed as homework at your discretion.

10. For question #7, you may want them to graph either ΔT or the Joules of heat energy transferred.

11. Have students complete this statement "This graph shows…" citing specific data points and trends.

12. Possible extension questions:

    a. What does your above graph show? Briefly describe the graph you made discussing specific data and trends.
    b. What was the purpose of the vial 1 in this experiment?
    c. About how much radiant solar energy from the sun was transformed into thermal energy in vial 1? Vial 2?
    d. What other sources of energy might have heated the water in vials 1 and 2?
    e. Which design was most effective for collecting solar energy? What do you think made this design most effective?
    f. Use what you know about the characteristic properties of electromagnetic waves to create the two diagrams below.
        i. Make a labeled diagram showing how electromagnetic rays travel from the sun to vial 1.
        ii. Make a labeled diagram showing how electromagnetic rays travel from the sun to vial 2.