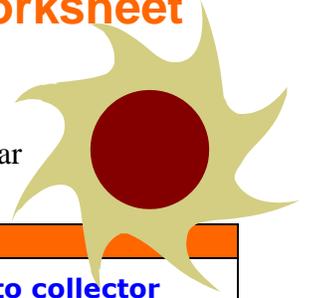


Group name: _____ Date: _____

Team members: _____

Solar Water Heater Design and Analysis Worksheet Answers



Part 1 — Design

Under the constraints of the materials listed below, design a device that uses solar energy to heat water. As you do this, describe the function of each specific part.

| Material | Function |
|---------------------------|---|
| plastic tubing (2 ft) | Transports water from water tank to collector |
| soft copper tubing (3 ft) | Absorbs heat from the sun and transfers it to water passing through |
| water container | Holds the water |
| insulation | Prevents loss of heat within the system |
| aluminum foil | Reflects solar radiation onto the absorbing surface |
| cardboard | Contains the individual components of heater |
| plastic sheet | Provides a barrier that permits radiation to enter and also traps heat inside |

Sketch:

Sketches will vary by team.

Briefly explain how your device works to accomplish its task. Provide additional sketches if necessary.

Descriptions and sketches will vary by team.

Part 2 — Build

Part 3 — Test

Procedure:

1. Measure 1 liter of water and pour it into your water container. Either plug the outflow of the system or hold it above the tank to prevent water loss. Obtain four Styrofoam cups to collect the water after it has been heated and minimize its heat loss. To maximize their insulating ability, use one cup inside another (double up).
2. Prepare to circulate water through the system. Set the system on a chair to provide room below to catch the water coming out of the copper tube.
3. Start timing as soon as you start the water circulating. As your cup fills with water, exchange it with an empty one and pour the water back into the water tank. Try not to let any water escape. Have one group member record in the table below the tank water temperature every five minutes. **Results will vary by team; see example answers in table below.**

| State | Elapsed Time (mins.) | Temperature (°C) | Change in temperature (Δ°C) |
|----------------|-----------------------------|-------------------------|------------------------------------|
| Initial | 0 | 23.0 | none |
| 1 | 5 | 23.7 | 0.7 |
| 2 | 10 | 24.4 | 0.7 |
| 3 | 15 | 25.0 | 0.6 |
| Final | 20 | 25.5 | 0.5 |

Calculations

- Convert the initial volume of water to mass using the density of water (1g/mL).

$$\text{mass} = \text{volume} * \text{density}$$

$$m_{\text{water}} = (1000\text{mL}) * \left(\frac{1\text{g}}{1\text{mL}}\right) = 1000\text{g} = 1\text{kg}$$

- Calculate the heat gained by the water using the equation below:
Show your work and remember to label the units correctly!

$$Q = mC_w\Delta T \quad \text{Given: } C_w = 4.186 \frac{\text{Joules}}{\text{gram} * \text{K}}$$

Example:

$$m_{\text{water}} = 1\text{kg}$$

$$\Delta T = T_{\text{final}} - T_{\text{initial}} = (25.5^\circ\text{C} - 23.0^\circ\text{C})$$

$$Q = (1000\text{g}) \left(4.186 \frac{\text{J}}{\text{g} * ^\circ\text{C}}\right) (25.5^\circ\text{C} - 23.0^\circ\text{C}) = 10,465\text{J} = 10.465 \text{kJ}$$

Your design's heat gain:

Example: 10.465 KJ
Results will vary by team.

Part 4 - Evaluate

Compare your value to those obtained by three different teams. Also, record notes about each group's design in the table below.

| Team | Their Heat Gain | Design Notes |
|------|-----------------|-----------------------------------|
| | | Results will vary by team. |
| | | Results will vary by team. |
| | | Results will vary by team. |

Identify reasons for differences in values obtained for your device compared to those of the other groups.

Reasons will vary by team.

Identify any sources of error in the model solar water heater experiment.

**Heat loss to surrounding air
Inaccuracy of measuring equipment**

Provide reasons for using solar energy rather than some other energy source (such as coal, natural gas, electricity).

Solar energy is a renewable source that costs nothing, and does not harm the environment at all. Energy sources such as coal, natural gas, and electricity all harm the environment in one form or another, and are all expensive.

What kind of effect would using a solar water heating system in your house have on the environment? On your utility bill?

Using a solar water heating system would have a very positive effect on the environment because it eliminates pollutants that would have otherwise been emitted during the combustion of fossil fuels. And, it also significantly reduces the cost of your utility bill.