NAME

SECTION DATE

STEM ACTIVITY 4 BUILD A BETTER THERMOS

USING INSULATION TO SLOW TEMPERATURE CHANGE

What materials or arrangement of materials effectively insulate a hot or cold liquid?

Have you ever thought about how people design houses to survive in the frigid arctic or the sweltering desert? The challenge to this sort of architecture is preventing rapid loss (arctic) or gain (desert) of thermal energy. These designs succeed by using insulators.

Most of us don't live in such extreme temperature regions, but we understand thermal insulation as it applies to thermos bottles. Very few people like lukewarm beverages; most would prefer that hot liquids stay hot and cold liquids stay cold. So how does a thermos keep temperature from changing as quickly? Is it the materials that surround the liquid, or is it a lack of materials? Can we improve the design of the thermos? The main idea is to interfere with the transfer into or out of the liquid. In this project, you will study heat transfer and design the functional part of a thermos. You will then test your design to determine how efficiently it slows the transfer of heat from a hot liquid or into a cold liquid.

Key Questions ?

- What materials effectively slow heat transfer?
- Can the same materials keep something hot as well as keep something cool?

Equipment E

Soda bottles, 16 oz and 2 L
Materials that may insulate
Tape
Hot glue gun
Funnel
PVC pipe, ½ in. diameter and 2 in. long
Beaker, 500 mL
Heat source such as Bunsen burner or hot plate
Water
Ice
Lab thermometer, temperature probe, or wireless sensor with data-gathering software.
Hand heat protector mitts (2)

DESIGN PARAMETERS

Note: Record all notes, designs, data, calculations, analyses, and conclusions in a project log.

As you design your insulating layers, you must consider both the materials used and the space available for insulation. Your design parameters are as follows:

1. Your teacher will tell you the types of materials that you may use in the design of your insulating material.
2. Your teacher will allow you to see and measure the container that you will use for testing. This will allow you to understand any space limitations you have.
3. The insulating material must fit entirely within the test container taping or must not interfere with the external bottle closing.

PROCEDURE

Planning the Design

1. Research heat—flow of thermal energy—and the factors that can affect it.
2. Research various insulation materials and effective insulating measures.
3. Review the construction materials available and design the parameters, then discuss design ideas with your team members.
4. Draw a diagram of your own design.

5. Experiment with the materials and modify your design as needed.
6. Discuss your findings on insulation material with your team members. As a team, reach a consensus on the materials and design that your team will use. Draw a diagram of the team design. Construct your insulation.

Testing the Design

1. Using a hot plate or a Bunsen burner, heat 450 mL of water to a little more than 50 °C.
2. Turn off the heat source and, using the hand heat protector mitts, pour the water into the inner container of the thermos (water temperature should be approximately 50 °C).
3. If available, use a temperature probe with data-gathering software to record your data. If data-gathering software is not available, use a thermometer to measure and record the temperature of the water every 2 minutes for 16 minutes.
4. Empty the container.
5. Using ice, cool 425 mL of water to approximately 5 °C. Once cooled pour the water into the inner container of the thermos.
6. If available, use a temperature probe with data-gathering software to record your data. If data-gathering software is not available, use a thermometer to measure and record the temperature of the water every 2 minutes for 16 minutes.
7. Plot temperature vs. time on graph paper or by using a computer program (data-collecting software, Excel, Sheets, etc.) for each of the two tests.
8. Analyze the graphs of both tests and determine the slope of the best-fit line for each graph.
9. Record the materials used and the slopes for each of the other teams and compare results. Draw conclusions regarding the effectiveness of each thermos design. Include factors that increased or decreased the rate of thermal energy transfer in the devices. Hypothesize what could improve the design further.
10. Modify your design and retest by repeating the testing procedures.

Figure 1
Completed thermos ready for testing

NAME

Individual Trials Data Table

Warm Water		Cold Water	
Time (min)	Temperature (°C)	Time (min)	Temperature (°C)

Group Data Table

Material	Warm Water Slope (°C/min)	Cold Water Slope (°C/min)	Notes