Thermos Calorimeter

Grade Level: 3-5

Duration: 45-60 minutes

Classification: Classroom

Subject(s): Thermodynamics, Chemistry

Categories (STEM): Science

Keywords: thermodynamics, temperature, equilibrium

Introduction

- Summary: Students will learn about heat transfer by designing and testing a thermos to insulate water.
- Description: Students will be given a cup of ice water to design and construct an insulating thermos to keep heat from entering the cup of water. They will take temperatures at the beginning and end to compare results.

Online Resource: https://www.learner.org/series/nasas-best-students-k-2/design-a-lunar-thermos/

Vocabulary

- **Thermodynamics -** how thermal energy is converted to and from other forms of energy
- **Thermal equilibrium -** a higher temperature object will transfer heat to the lower temperature object. The objects will approach the same temperature, and they will then maintain a constant temperature. They are then said to be in thermal equilibrium.
- **Calorimeter -** a model that measures the heat involved in a chemical reaction.

Materials

Materials	Quantity	Reusable?
Thermometer	1 per classroom	Yes
Timers	1 per 3 students	Yes
Dixie or clear plastic cups	1 per 3 students	Yes
Bucket or pitcher	1 per classroom	Yes
Ice cubes	1 gallon bag per classroom	No
Scissors	1 per 3 students	Yes
Masking tape	3 rolls per classroom	No
Newspaper or construction paper	2 sheets per 3 students	No
Ziploc sandwich bags	1 per 3 students	Yes
Aluminum foil	1 foot per 3 students	No
Other insulation materials*	N/A	Yes

*****Possible materials could be bubble wrap, Styrofoam, pom pom balls, wax paper, fabric or fleece, etc.

Directions

BEFORE CLASS - fill the bucket/pitcher with water and ice and let sit.

DURING CLASS:

1. Introduce the concepts.
    a. Tell the class about the definition of thermodynamics and thermal equilibrium.
    b. If you set a glass of ice water on the table and came back after one day, what would happen? The ice would melt and the water would reach room temperature (aka thermal equilibrium).
2. How do we keep from losing heat energy?
    a. When we go to the Moon, we will need to protect our bodies from the extreme differences in temperature. In the shadowed areas of the moon, the temperature is –180 ºC (or – 300 ºF), and in the sunlit areas it is about 100 ºC (or 212 ºF), which is the boiling point for water! These are serious extremes for human beings! We want to keep our bodies at a fairly constant temperature.
3. Explain insulation and ask the students to provide examples.
    a. Examples: cooler to chill food and drinks, astronaut suits, house insulation, rubber handle of a frying pan
4. Today, we will be designing and making an insulated thermos to prevent heat transfer. **The challenge is to design a thermos that will keep a cup of ice water cold for 5 minutes**.
5. Pour ice water into a cup and set aside as our control. Make sure there are no ice cubes in the cup.
6. Break up the class into groups of 2-3 students per group and pass out materials.
7. Pour a cup of ice cold water (with no ice cubes) for each team and measure its temperature with the thermometer. This is our starting temperature. Write this measurement on the board.
8. Give students 10 minutes to design and construct their thermos. When they are done designing, instruct them to set their timer for 5 minutes while they clean up their work stations.
9. After 5 minutes have passed, use the thermometer to measure the temperature again and write it on the board for each team. Also measure our control cup again and see how much that water has warmed up.
10. The team with the coldest cup at the end of the challenge wins. Discuss which design ideas were the most successful and why.

Activity Extension

Add a price to each material they use. The team with the coldest cup and the cheapest thermos is the new winner.

After testing, encourage the students to go back to the drawing board and redesign their thermos to be even better.

Discussion Questions

- How much did the temperature of the water change in your thermos?
- How does your experiment's data compare to the control experiment your SRM conducted at the front of the room?
- During this session, you explored designing insulation to reduce temperature changes, much like protecting humans from the extreme temperature swings on the Moon's surface. What if you needed to capture heat energy instead? How would you do that?
    - Solar panels capture energy from the sun to use for heat.
- How would the material of the cup change the thermos?
    - A glass cup insulates the liquid better than a paper cup.

What is happening?

- Air around the cup of water is warmer than the water. Heat transfers to the water in the cup and heats it to an equilibrium temperature.
- As heat is added to the liquid water, there is greater kinetic energy of the molecules because water molecules move and vibrate more.

Applications:

- Majors
    - Chemistry, Biochemistry, Biology
    - Chemical, mechanical, materials engineering
    - Packaging engineering
- Jobs
    - Scientist, engineer, astronaut, packaging engineer
- Hobbies
    - Cooking, studying weather and space
- Real-World applications
    - Cooler to chill food and drinks, astronaut suits, house insulation, rubber handle of a frying pan
    - Calorimetry (styrofoam)
    - Isothermal Calorimetry(ITC) measures the affinity of a protein and ligand binding
    - Shipping research materials in styrofoam to keep cold
    - House insulation \