HOW LOW CAN YOU GO?

STEM CATEGORY

Science

CAREER PATH

Energy

TOPIC

Thermal Energy

OVERVIEW

In this activity, students will investigate factors that influence the temperature of an isolated system and relate this to average kinetic energy and thermodynamic properties. Then, students will conduct experiments in which salt is used to lower the temperature of an ice-water mixture by the greatest amount. Lastly, students will account for errors and describe modifications that can be made to achieve an even lower temperature.

STEM LESSON FOCUS

Engineering Design Cycle	**21st Century Skills**
• Refine or Improve	• Collaboration

OBJECTIVES

Students will be able to:

- Investigate factors that influence the temperature of an isolated system.
- Experiment to achieve the lowest temperature of a mixture.

MATERIALS

- Copies of the Student Handout and Exit Ticket (optional), one per student
- Styrofoam™ cups (small and large sizes)

HOW LOW CAN YOU GO?

- Balance
- Plastic spoons
- Sand
- Sodium chloride or rock salt
- Ice
- Long stem thermometers/temperature

HAVE YOU EVER WONDERED…

Why we pour salt on the roads in the winter? Or what the difference is between heat and temperature and how we affect temperature?

MAKE CONNECTIONS!

How does this connect to students?	How does this connect to careers?	How does this connect to our world?
When your school calls a "snow day," often it's because the roads couldn't be treated well enough to maintain a safe temperature to prevent icy, dangerous driving conditions.	**Food Scientists / Safety Experts** improve methods of processing, canning, freezing, storing, packaging, and distributing food. **Chemical Engineers** transform processes developed in the lab into practical applications for production of goods. **Thermodynamics / Automotive Engineers** design and improve systems to regulate the heating and cooling of engines.	Rising ocean temperatures and salinity, as well as the warming of the Earth, all represent challenges for the current and future generations to manage effectively.

HOW LOW CAN YOU GO?

BLUEPRINT FOR DISCOVERY

Activator: How High Can You Go?
The following can be completed as a whole-class teacher demonstration, with students assisting in the shaking and temperature reading steps, or students can complete the demonstration themselves in small groups. Adjust the materials accordingly.

Procedure:

1. Fill the larger Styrofoam cup halfway with sand and invert the smaller Styrofoam on top to make a tight seal. Then tape the two cups together so they do not come apart.
2. Poke a hole in the bottom of the smaller inverted cup and insert the thermometer or temperature probe so that it's in the middle of the sand.
3. Measure and record the initial temperature of the sand to the nearest 0.1°C.
4. Shake vigorously for 3 full minutes.
5. Measure the final temperature of the sand. Record to the nearest 0.1°C.
6. Repeat the procedure for a second trial and calculate an average change in temperature.
7. Direct students to complete the data sheet with their temperature readings and answer the questions. Ensure that students understand that energy is transformed within the isolated system (cup with sand) from potential (stored) energy to kinetic energy (energy of motion). On average, the particles of sand have a higher kinetic energy than they did originally, and therefore, a higher temperature. Relate this to rubbing your hands together to create warmth.

Inquiry Investigation: How Low Can You Go?
Direct students complete the following procedure in small groups:

1. Place a specific amount of ice (don't forget to record the mass) into the beaker and record the initial temperature using the temperature probe or thermometer.
2. Experiment with adding different amounts of salt to the beaker and recording the resulting temperature. Record the lowest temperature reached in the data table on your handout.
3. Also try adding different amounts of ice. The goal is to achieve the lowest possible temperature. Complete three different trials.
4. Direct students to record their data and answer the discussion questions on the Student Handout.
5. Ensure that students understand that there is a dynamic equilibrium (balance) between the freezing and melting of ice/water. Salt (the solute) disrupts this equilibrium by slowing down the rate of freezing without impacting the melting rate. Therefore, melting occurs faster than freezing when salt is introduced.
6. Use the optional Exit Ticket to review vocabulary that students applied during the lesson (assuming that the vocabulary has been explicitly introduced).

HOW LOW CAN YOU GO?

TAKE ACTION!

Let's make ice cream! In this activity, you will use the lowered freezing point of water when adding salt to chill another mixture (ice cream) to the solid state. Visit www.teachnlearnchem.com/Solutions/PDF/Ice%20Cream%20Lab.pdf for materials, procedure, and discussion questions.

NATIONAL STANDARDS

Science	Next Generation Science Standards **HS-PS3-4.** Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Name:_____ Date:_____

SIEMENS STEM DAY–HOW LOW CAN YOU GO? STUDENT HANDOUT

Activator: How High Can You Go?

Data Table

Trial #	Initial Temperature (°C)	Final Temperature (°C)	Change in Temperature (°C)
1			
2			
Average			

Questions

1. Were you surprised by the change in temperature? Why or why not?

2. What type of energy does the sand have sitting on the desk in the Styrofoam cup?

3. What type of energy does the sand have when it is being shaken?

4. Is energy created in this lab? Why or Why not?

5. If the temperature of an object increases, what is happening to its particles?

6. What would happen if the cup were shaken for ten minutes?

7. What is the difference between heat and temperature?

Name:_____ Date:_____

Inquiry Investigation: How Low Can You Go?

Data Table

Trial #	Mass of Ice (grams)	Initial Temperature (°C)	Mass of Salt Added (grams)	Final Temperature of Ice/Salt Mixture (°C)
1				
2				
3				

Discussion Questions

1. What was the lowest temperature that you were able to achieve?

2. Describe the conditions of the experimental trial you used in order to obtain this temperature.

3. What modifications would you make to your experimental set-up if you were going to run the experiment again to get an even lower temperature?

4. Why do you think the temperature changed when salt was added to the ice?

Name:_____ Date:_____

Exit Ticket: Vocabulary Review

Instructions: Use the terms in the word bank to complete the statements below.

Kinetic energy	Solute	Freezing point
Temperature	Heat	Potential energy

1. A measure of the average kinetic energy of the particles in a sample of matter is called the _____.

2. The energy of motion is called _____.

3. Any substance that gets dissolved in a mixture is referred to as the _____.

4. The energy that something has because of its position or the way its parts are arranged is called _____.

5. The temperature at which a liquid turns into a solid when cooled is called the _____.

6. Energy that spontaneously flows between a system and its surroundings from a hotter to a colder body is _____.

Name:_____ Date:_____

Exit Ticket: Vocabulary Review (KEY)

Instructions: Use the terms in the word bank to complete the statements below.

Kinetic energy	Solute	Freezing point
Temperature	Heat	Potential energy

1. A measure of the average kinetic energy of the particles in a sample of matter is called the _____temperature_____.

2. The energy of motion is called _____kinetic energy_____.

3. Any substance that gets dissolved in a mixture is referred to as the _____solute_____.

4. The energy that something has because of its position or the way its parts are arranged is called _____potential energy_____.

5. The temperature at which a liquid turns into a solid when cooled is called the _____freezing point_____.

6. Energy that spontaneously flows between a system and its surroundings from a hotter to a colder body is _____heat_____.