COOL AS ICE

Written by Amy Rowley and Jeremy Peacock

Annotation

In this demonstration, students will explore the principles of operation of a microwave oven in relation to molecular motion.

Primary Learning Outcomes:

Students will be able to describe the principles of operation of a microwave oven.

Students will be able to compare and contrast the molecular motion of solids and liquids.

Students will be able to relate molecular motion to temperature.

Georgia Performance Standards:

Characteristics of Science

SCSh2. Students will use standard safety practices for all classroom laboratory and field investigations.

SCSh3. Students will identify and investigate problems scientifically.

SCSh8. Students will understand important features of the process of scientific inquiry.

Physical Science Content

SPS2. Students will explore the nature of matter, its classifications, and its system for naming types of matter.

Chemistry Content

SC6. Students will understand the effects of motion of atoms and molecules in chemical and physical processes.

Physics Content

SP4. Students will analyze the properties and applications of waves.

Duration:

Preparation: 5 minutes
Introduction: 5 minutes
Demonstration: 10 minutes
Conclusion: 10 minutes
Total Class Time: 25 minutes

Materials and Equipment:
For Teacher Preparation:

1. Microwave
2. 2 Plastic drinking cups
3. Ice
4. Water
5. Thermometer

Safety:
The heated water produced during the demonstration should be handled with care to prevent burns.

Technology Connection:
Not applicable.

Procedures:
Teacher Preparation:
At time of demonstration, obtain ice directly from the freezer. *(Note: Ice that is allowed to sit out may not behave properly in the demonstration.)*

Introduction:
The microwave has changed the way we cook and eat many of our meals. From snacks like popcorn and mini pizzas to complete frozen dinners, microwaveable foods are fast and easy. But have you ever wondered exactly how a microwave works? Why does our popcorn pop and our soup boil, while a little aluminum foil sends sparks flying? In this activity, you will explore the physical principles behind our favorite appliance.

Explain to students that you will conduct an experiment that will demonstrate how a microwave cooks. Students should carefully observe the experiment. Following the experiment, students will interpret their observations to explain the operation of the microwave.

Demonstration:
Review the materials and procedure with students. Ask them to predict the outcome of the experiment and to write a one-minute paper that describes their predictions. Will the ice melt? How will the temperature of the water change? Students should also write a brief explanation, to the best of their knowledge, of how a microwave heats substances and cooks food. After students have completed this task, perform the demonstration.

Procedure:

1. Fill one plastic cup with ice cubes fresh from the freezer.
2. Measure and record the temperature of the ice.
3. Place the cup in the microwave and microwave on high power for 90 s.
4. Remove and observe the ice cubes. (*Note: The ice cubes should remain unchanged.*)
5. Measure and record the temperature of the ice.

6. Fill a second plastic cup half-full with tap water.
7. Measure and record the temperature of the water.
8. Place the cup in the microwave and microwave on high power for 90 s.
9. Carefully remove water and observe the water. (*Note: The water should be very hot and steaming or boiling.*)
10. Measure and record the temperature of the water.

Conclusion:

Ask students to use their observations of the demonstration to revise their one-minute paper to explain the results of the experiment and to update their explanation of how the microwave cooks food. Students should have observed during the demonstration that the solid ice did not melt while the liquid water was heated quickly. Ask students to consider what role the physical state (solid vs. liquid) of the water had in the effects of microwaving. What might this tell us about how a microwave cooks food?

A microwave oven does not contain a heat source. Instead, it contains a microwave tube that generates microwaves by passing an electron stream across metal cavities. Although these microwaves are a form of electromagnetic radiation, this should not be confused with the radiation mode of heat transfer. When microwaves interact with water molecules in food, the water molecules vibrate at a higher rate than normal. This increased vibration (*i.e.* molecular motion) produces heat and raises the temperature of the food. Therefore, water content is a very important consideration when developing microwaveable foods. If we place a cup of liquid water in the microwave, the process is the same and the water quickly heats up. Ice, however, behaves differently. The solid crystalline structure of ice binds the water molecules in place and does not allow them to vibrate. Therefore, the ice does not heat up and melt. It is important to use ice fresh from the freezer, though. If we allow the ice to sit at room temperature for any significant time, a thin layer of water will form on the ice as it begins to melt. This layer of water would be susceptible to microwave heating and would cause the ice to melt.

Assessment:

Assessment should be based on completion and revision of the *Cool As Ice* one-minute paper.