Lesson Topic: Temperature, Thermal Energy, and Particle Motion

Objective:
Students will be able to:

1. Understand the relationship between particle motion and energy in a system.
2. Describe temperature as the average kinetic energy of a particle or particles in a system.
3. Explain how adding or removing thermal energy affects kinetic energy and changes in state.
4. Recognize that particle motion differs depending on the state of matter (solid, liquid, or gas).

Time Required: 75 minutes

Materials Needed:

- Beaker (500 mL or larger, or other heat-safe glass container)
- Ice cubes
- Hot plate or heating source
- Water (room temperature, 150 mL)
- Goggles
- Thermometer
- Teacher computer with internet access
- Projector/interactive whiteboard or Smartboard
- 1 computer/laptop/iPad per student with internet access
- Temperature, Thermal Energy, and Particle Motion Worksheet (attached)

Teacher Preparation:

- Assign a Legends of Learning Instructional Quick Play playlist for the day(s) you will be teaching the lesson.
    - Instructional - Middle School - Temperature, Thermal Energy, and Particle Motion
- Assign a Legends of Learning Content Review Quick Play playlist for the day(s) you will be teaching the lesson.
    - Content Review - Middle School - Temperature, Thermal Energy, and Particle Motion
- Make copies of Temperature, Thermal Energy, and Particle Motion Worksheet (1 per student)
- Draw or display Particle Arrangement: States of Matter illustration on whiteboard or using Smartboard (see attached)

Engage (10 minutes):

1. Ask students to recall three states of matter.
    a. Answer: Solid, liquid, and gas. Some students may wish to add plasma, but for this lesson, the focus will be on solids, liquids, and gases.

2. Hold up the beaker with water for the class and ask them to describe the arrangement of the particles inside – closer together, far apart, in between?
    a. Answer: In between
3. Present the Particle Arrangement: States of Matter illustration on the whiteboard or using Smartboard and help students clarify their descriptions.
4. Explain to students that the particles in a liquid state are loosely interacting. They can flow and move, but they are connected and not free to escape like the particles in the gaseous state.
5. Take the temperature of the water in the beaker. Record it on the board.
6. Turn on the heating element.
7. Show students the ice. Ask them to describe the arrangement of the particles as you add ice to the beaker and place it on the heating element.
    a. Answer: The particles are closer together.
8. Explain to students that particles in the solid state are vibrating about fixed positions, meaning they are moving, but have very little freedom, which is why solids have fixed shapes like the ice cubes.
9. Explain to students that the heating source is adding energy to the beaker of ice and water.
10. Ask students to name the energy added from the heating source.
    a. Answer: Thermal energy
11. Ask students to predict what the addition of thermal energy will do the contents of the beaker.
    a. Answer: It will cause the water to boil, the ice will melt, steam will form, and water will evaporate.
12. Ask students to describe the arrangement of the water vapor particles that forms as water evaporates and becomes a gas.
    a. Answer: The particles are spread far apart.
13. Ask the students to describe the movement of the water vapor particles compared to the particles in the remaining ice cubes.
    a. Answer: The particles in the water vapor are moving faster.
14. As the water is boiling, take and record the temperature of the water.
15. Explain to the students that the addition of thermal energy is transferring energy to the particles inside the beaker that results in increased particle movement, which increases temperature.
16. Ask students to give the name for the energy of motion.
    a. Answer: Kinetic energy
17. Explain to students that the temperature is a measure of the average kinetic energy of the particles in a system.
18. Ask students to describe how the kinetic energy of the beaker has changed since the demonstration started, and what is responsible for the change.
    a. Answer: Kinetic energy has increased, and the addition of thermal energy is responsible for the change.

Explore (30 minutes):

1. Have your students sign in to Legends of Learning. Instruct students to complete the

Instructional playlist.
2. As students complete the assigned games, students will complete the Temperature, Thermal Energy, and Particle Motion Worksheet.
3. Circulate as students work through the playlist and complete the handout. Listen for evidence of understanding and use this opportunity to correct any misconceptions.

Explain (20 minutes):

1. Review the answers to Temperature, Thermal Energy, and Particle Motion Worksheet by writing the terms on the whiteboard or interactive whiteboard. Ask for student volunteers to help connect the words and fill in phrases on the connecting lines.
    a. Use this opportunity for formative assessment to gauge understanding and address any misconceptions.
2. Relate student knowledge to the demonstration at the beginning of the lesson.
    a. Which state of matter are particles moving the slowest? (solid)
    b. How does the addition of thermal energy affect the system? (It causes the ice to melt, the water to boil, and evaporate)
    c. What effect does the addition of thermal energy have on particle motion? (it increases particle motion)
    d. If thermal energy is removed from a system, what changes would occur? (water vapor would condense, temperature would drop, particle motion would slow down)
    e. How do thermal energy and particle motion relate to temperature? (thermal energy causes the particle motion to increase, which means the particles gain kinetic energy, and the temperature is a measure of the average kinetic energy in a system.

Elaborate (5 minutes):

1. Explain to students that thermal energy and its effects on particle motion and temperature are found all over our world and in some fun ways that can take us literally to new heights.
2. Show this video of how a hot air balloon works: How a Hot Air Balloon Works
3. Ask students what they learned about the particle space inside the balloon and how thermal energy plays a role in adjusting altitude.
    a. Answer: The particles are spaced far apart, so the balloon becomes less dense than air. The propane burners provide thermal energy that allows the particles to spread farther apart, which further decreases the density of the balloon compared to the surrounding air, allowing the balloon to fly higher.

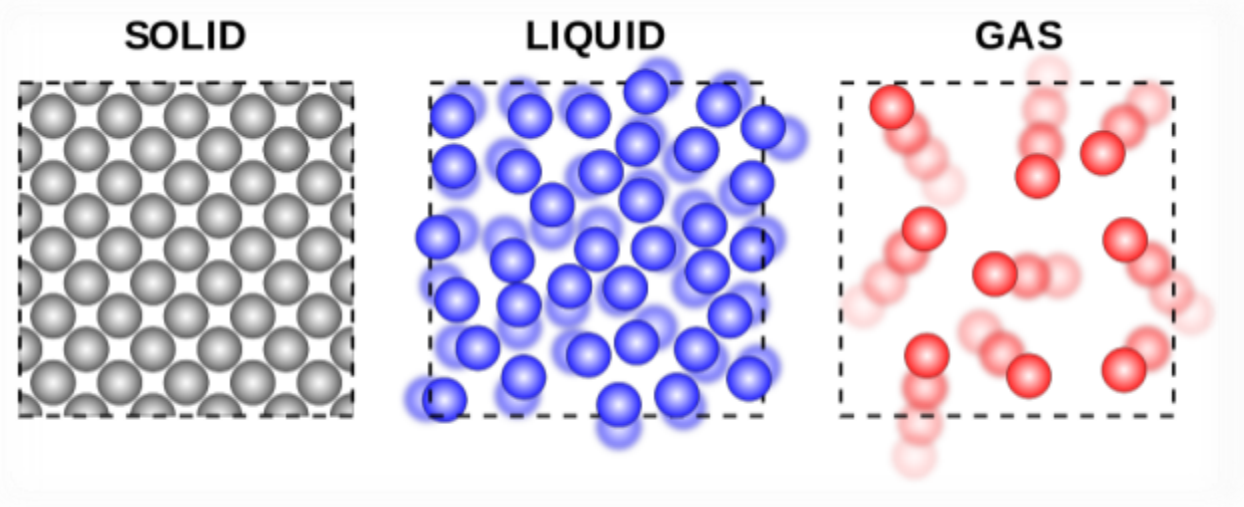
Evaluate (10 minutes):

1. Have your students sign in to Legends of Learning. Instruct students to complete the Content Review playlist.
2. Analyze student results to determine what concepts need to be a focus for reteaching.

Additional Lesson Strategies:

- To use Legends for additional instruction, create a custom playlist with an instructional game and pre and post assessment.
- To use Legends for a quick formative assessment, create a 5-question assessment in a playlist.
- To use Legends for a student-directed experience, create a targeted freeplay playlist.
- Encourage students to play on their own at home in Legends of Learning: Awakening for a student-driven experience including avatars, battling, and quests all centered around topics they are covering in class.

Particle Arrangement: States of Matter



This Photo by Unknown Author is licensed under CC BY-SA

Temperature, Thermal Energy, & Particle Motion: Wordsplash

Name:_____

Directions: While playing the games in Legends of Learning, use what you learn and draw lines connecting the related words, then write a short phrase on top of the line that describes how they relate.

Temperature

Kinetic Energy

Color

Liquid

Gas

Atoms

Thermal Energy

Particle Motion

Solid

Temperature, Thermal Energy, & Particle Motion: Wordsplash

Name:_____*KEY_(Sample)*_____

Directions: While playing the games in Legends of Learning, use what you learn and draw lines connecting the related words, then write a short phrase on top of the line that describes how they relate.