**Lesson Topic:** Effects of Temperature and Pressure on State

**Objective:**
Students will be able to:

1. Describe how changes in thermal energy cause changes in state.
2. Explain how pressure changes can affect changes in state.
3. Discuss changes in particle motion leading up to changes in state.

**Time Required:** 75 minutes

**Materials Needed:**

- Cold water (approximately 6 cups)
- Ice (1 to 2 cups)
- Large bowl
- Tongs
- Hot plate or similar heating source
- Empty soda can
- Tablespoon
- Goggles
- Teacher computer with internet access
- Projector/interactive whiteboard
- 1 computer/laptop/iPad per student with internet access
- Effects of Temperature and Pressure on State 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 – Effects of Temperature and Pressure on State
- Assign a Legends of Learning Content Review Quick Play playlist for the day(s) you will be teaching the lesson.
    - Content Review – Middle School – Effects of Temperature and Pressure on State
- Make copies of Effects of Temperature and Pressure on State Worksheet (1 per student)

**Engage (10 minutes):**

1. Explain to students that they will observe water changing state inside of a soda can.
2. Begin by adding two tablespoons of room temperature water to the empty soda can.
3. Add ice to the large bowl filled with cold water.
4. Explain to the students that the soda can will be submerged into the ice bath later in the demonstration.
5. Place the soda can on the heat source until the water begins to boil. (approximately 30 seconds)
6. Point out that water vapor is released from the can.
7. Explain that the thermal energy from the heat source is causing the liquid water to change state and become a gas.

8. The change in state from liquid to water vapor (evaporation), pushes out most of the air from the can.
9. Use the tongs to quickly invert the can into the ice bath, allowing the pressure difference to crush the can.
10. Explain to the students that the ice bath quickly cooled the water vapor inside of the can, causing another change in state. In this case, the remaining water vapor condensed into liquid.
11. Explain to students that increasing or decreasing pressure can also help a substance to change state. Initially, pressure in the can is low, which, along with the input of thermal energy, makes the particles' escape from the liquid state a bit easier.
12. Ask students to keep this demonstration in mind as they learn more about the effect of temperature and pressure on state during the lesson.

**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 Effects of Temperature and Pressure on State 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 answers to the Effects of Temperature and Pressure on State Worksheet by taking a class poll about which pot of water, the class thinks will boil faster. Explain the difference in pressure at high and low altitudes and the effect of pressure on the boiling point of water.
2. Review part 2 of the worksheet, by asking students to stand to acknowledge agreement as each statement is read to the class.
3. Relate student knowledge to the demonstration at the beginning of the lesson.
    a. What caused the change in state to occur inside of the soda can? (addition of thermal energy)
    b. What might have been different in the demonstration if it had been conducted at a higher altitude? (water would have boiled quicker; evaporation would have happened faster)
    c. What were the two changes in state observed in the demonstration? (evaporation where liquid becomes gas; condensation when the gas becomes a liquid)
    d. How would you describe the kinetic energy and particle movement in the can when it is on the heat source just before the change in state? (high KE; particles are moving rapidly)
    e. How would you describe the kinetic energy and particle movement in the can as it contacts the ice bath before the next change in state? (lower KE; particles are slowing down)

**Elaborate (5 minutes):**

1. Explain to students that the rates of changes in states can be controlled by the addition or removal of thermal energy and changes in pressure.

2. Show students this video of ice changing state: Houdini State Change
3. Ask students to describe the changes of state they see in the video and how they could speed up or slow down the process.
    a. Answer: The ice is melting from solid to liquid. Evaporation is occurring, changing the liquid water to gas. Adding thermal energy would speed up the process while removing thermal energy would slow down the process.

**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.

# Effects of Temperature & Pressure on State

Name:_____

**Directions**. While playing the games in Legends of Learning, use what you learn to answer the questions below.

**Part 1.** You and a friend are boiling water to cook pasta. Your friend lives in the mountains, and you live at sea level. Which pot of water will begin to boil first? Explain your answer in the box below.

**Part 2. Agree or Disagree.** On the line next to the statement, place an **A** if you **agree** with the statement or a **D** if you **disagree** with the statement.

_____ Some liquids become solids quicker when pressure is increased.

_____ Increases in thermal energy cannot cause a change in state.

_____ Particles are spaced farther apart in a gas.

_____ A decrease in thermal energy can cause condensation to occur.

_____ Decreases in pressure can decrease the amount of thermal energy needed to melt a substance.

_____ Particle movement in a gas is slower than in a liquid.

_____ Evaporation is the change from a solid to a liquid.

# Effects of Temperature & Pressure on State

Name:____*KEY*_____

**Directions**. While playing the games in Legends of Learning, use what you learn to answer the questions below.

**Part 1.** You and a friend are boiling water to cook pasta. Your friend lives in the mountains, and you live at sea level. Which pot of water will begin to boil first? Explain your answer in the box below.

*The water at higher altitude is under less pressure, which makes the boiling point lower. The water at higher altitude will boil faster. The lower pressure makes it easier for the water particles to escape from the liquid phase.*

*The water at sea level is under higher pressure, which makes the boiling point higher. The water at lower altitude will boil slower. The high pressure holds the water molecules in the liquid phase, requiring more energy to escape as a gas.*

**Part 2. Agree or Disagree.** On the line next to the statement, place an **A** if you **agree** with the statement or a **D** if you **disagree** with the statement.

___*A*___ Some liquids become solids quicker when pressure is increased.

___*D*___ Increases in thermal energy cannot cause a change in state.

___*A*___ Particles are spaced farther apart in a gas.

___*A*___ Decrease in thermal energy can cause condensation to occur.

___*A*___ Decreases in pressure can decrease the amount of thermal energy needed to melt a substance.

___*D*___ Particle movement in a gas is slower than in a liquid.

___*D*___ Evaporation is the change from a solid to a liquid.