Crushing Can

Recommended Grade Level(s):

Appropriate for: Middle school and High school

Time Requirements:

Activity Time: 25 minutes

Teaching Topics & Concepts:

- To illustrate the presence of atmospheric pressure.
- Pressure & Gas Volume Relationship
- Relationship between gas pressure and temperature.
- State change
- Kinetic molecular theory

Background:

Understanding how gases behave in real life helps students connect to scientific principles.

Everybody has a general idea of what a gas is, especially the oxygen and nitrogen mixture we breathe in every day. Or the 14.7 pounds of pressure the atmosphere exerts on every square inch of our bodies. But how do gases behave when you change the temperature, pressure, or volume?

For every action, there is an equal and opposite reaction (Newton's Third Law). Pressure is the measure of how much pushing force something is putting on another object. In a gas, this is usually the gas pushing on the object's container or, if the gas is heavy, something inside the gas. Newton's third law helps explain the changes in the gas pressure when we put force on the object containing it. These concepts help us understand why our ears soda going up in an elevator or on an airplane or changes that happen underwater for scuba divers? By observing a spectacular demonstration of atmospheric pressure crushing a can in your science lab, students can see these principles in action.

Safety

- When working with the Bunsen burner or boiling water
  – Adult supervision is required.
  – Wear safety glasses, gloves, and a lab coat.

Materials:

- Empty soda can (or large metal container with a lid)
- Aluminum pie plate
- Hot plate or Bunsen burner
- Wire gauze square held by a support ring and stand
- Beaker tongs
- Water

(***Tip:*** Add ice to your water for an even more astounding result.)

Procedure:

1. Add water to an empty soda can until the bottom is covered to a depth of~1 cm.
2. Using a hot plate, heat the can to the point that steam is visible from the opening. A Bunsen burner can be used to heat the can but do not heat the can directly with the flame. Place the can on a wire gauze square that is held by a support ring and stand.
3. Continue heating for a minute. Then, using beaker tongs, carefully and quickly invert the can in an aluminum pie plate containing water (or a plastic dish tub half-filled with water).

Expected Results:

When the can is inserted into the liquid, it is crushed in a spectacular demonstration of atmospheric pressure.

Students will be amazed to see that a small amount of water boiled inside a soda can cause it to implode instantly when submerged into cold water! The generation of steam pushes air out of the can. Upon inversion in the cold water, the steam condenses back to liquid water, causing a decrease in pressure relative to its surroundings. The atmospheric pressure crushes the can as a result.

Follow up:

- **What's happening:**
    1. What is happening as you heat the water? (water boils)
    2. What is coming out of the top of the can? (water vapor)
    3. What happened to the can? (it was crushed)
    4. Why was the can crushed?
- **Predictions:**
    1. What will happen when I turn the can over and immerse it in cold water?
    2. What would happen if the can was empty?
    3. What would happen if the water was heated but not boiled?
- After students have made their predictions, repeat the experiment using the different variables mentioned in the above questions. Have students observe and then explain the repeated experiments.
- Ask students to use the principles in this activity to explain why it's dangerous to heat or compact Aerosol cans. What causes those pressurized cans to explode, and what happens to the propellant inside?
- Atmospheric pressure, changes of state. Help students visualize the changes in the particles both inside and outside the can before and after heating.

Teaching notes:

The imploding can demonstrates several scientific concepts:

- Water is a liquid below 212°F (1000C) and a gas (steam, water vapor) above 212°F (i.e., the boiling point of water).
- Water expands to approximately 600 times its liquid volume when heated above 212°F.
- The hot water vapor produced displaces almost all the air inside the soft drink can.
- The hot gas molecules are the same pressure as the air outside the can. Hot water vapor condenses into liquid water when cooled.
- The condensed water volume is approximately 600 times less than the previous hot water vapor volume (i.e., there are fewer molecules of water in the gas phase inside the can).
- Cold water cools any remaining gas molecules, decreasing their kinetic energy and therefore decreases the number of collisions with the walls of the can.
- These factors decrease the pressure inside the can. Atmospheric pressure outside is now much greater and immediately squashes the can while simultaneously forcing water into it.

Disposal/Clean-Up:

The soda can may be recycled.

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