Demonstration: Candle Mystery

Summary
In this demonstration, students will observe and analyze how the change in temperature of a gas can affect the volume of a gas.

Grade Level
Elementary and Middle School

Objectives
By the end of this demonstration, students should be able to
• Describe the relationship between temperature and volume of a gas.
• Apply their analysis to real-world scenarios that involve the movement of gases (ex: warm air rises due to expansion of the volume of gas, cool air sinks due to contraction of the volume of gas)

Chemistry Topics
This demonstration supports students’ understanding of
• Gases
• Temperature
• Volume
• Gas Laws

Time
Teacher Preparation: 15 minutes
Lesson: 30 minutes

Materials
• 1 glass container (You can use various sizes for demonstration if desired. Small mouth long neck bottles work best for dramatic demonstration) I usually use a long neck wine bottle.
• 1 Candle (Offertory Candles work best, and can be cut in half to make shorter for best results)
• Small lump of Clay or Plasticine (to hold the candle in place on plate)
• 1 small saucer or plate
• 1 cup of water (all may not be used)
• Food Coloring
• 1 lighter

Safety
• Students should wear proper safety gear during chemistry demonstrations. Safety goggles and lab apron are required. Always use caution around open flames. Keep flames away from flammable substances.
• Always be aware of an open flame. Do not reach over it, tie back hair, and secure loose clothing
• Open flames can cause burns. Liquid wax is hot and can burn the skin.
• Exercise caution when using a heat source.
• When lighting the match and wooden splint, be cautious with the flame.
• An operational fire extinguisher should be in the classroom.

Teacher Notes
• Give students time to answer all of the pre-lab questions before beginning the demonstration.
• Discuss answers to questions.
• Please try this experiment several times with the bottle of your choice before demonstrating in
front of the class, as to work out any kinks beforehand.

- **Demonstration Procedure:**
  - Use the clay to secure the candle to the plate. (The plasticine clay is a little firmer, and can withstand water in the saucer for the small amount of time that it takes for the experiment.)
  - Measure one cup of water.
  - Add a few drops of food coloring to the water.
  - Pour the water onto the plate with the mounted candle.
  - Use enough water to fill the plate to the rim.
  - Ask students anticipation questions like: What do you think is going to happen if I light the candle? What is going to happen to the water when I place the bottle over the candle and set it in the water?
  - With caution, use the lighter and light the candle.
  - Next, using the bottle of your choice, carefully cover the lit candle with the opening of the bottle. Don’t press the bottle onto the plate, but do make sure the bottle opening is submerged slightly in the water.
  - Long neck bottles draw the water up quicker than a wide mouth bottle, however any type bottle will work just fine.
  - Ask students: What do you think will happen to the flame while in this bottle?
  - The flame will slowly fade. While the flame is fading, stop to quickly infer what they think is happening.
  - Ask students why they think the flame is not as bright as before you placed the bottle on top of it?
  - When the candle is burning inside the bottle, the temperature of the gas inside the bottle is increasing, and the students will see that this results in some of the air being forced out of the bottle. Bubbles will form at the base of the candle and neck of the bottle. Remember: air expands when it is heated. You may even hear the bubbles gurgling at the base of the candle.
  - Ask students to describe to you what they think is happening at this point? When the air is forced out you can see that it has nowhere else to go but out through the bottle opening and into the water.
  - The candle flame will go out after a few seconds! The remaining air in the bottle will cool down, and therefore the gas particles will move closer together (decrease in volume). The contraction of the air inside the bottle is the main effect of this experiment. When this cooling happens, empty space is the bottle, so the water will begin to move into the empty space.
  - The height of the amount of water that gets into the bottle will depend on how skinny of a neck your bottle has and the room the water has to travel. Too much or too wide of a bottle, the effects may not be as dramatic.
  - This demo may be repeated several times in front of the students for their greater understanding and ability to accurately answer the questions.

- Final note: Most candles in a larger bottle will burn longer because it can hold more oxygen. Birthday candles are usually best to use in a larger mouth bottle because the water does not rise as high as in a narrow neck bottle.
- A similar demonstration that also includes a video, plans for the candle to move into the bottle as well as the water can be found on the AACT website: Make the Water Rise.
FOR THE STUDENT
Lesson

Candle Mystery

Pre-lab Questions
1. Do you think that you can shrink a gas? How?

2. When a flame is burning, does it heat up the gas around it and make the gas hot? How do you know?

3. Have you ever seen a hot air balloon in the sky before? Explain how you think the balloon actually gets lifted off of the ground:

Procedure
Your teacher will demonstrate a burning candle inside of a bottle. During the demonstration, write your observations for each scenario in the data table below. The demonstration will be shown more than once, but pay close attention, as it happens quickly!

Data

<table>
<thead>
<tr>
<th>Step/situation</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>The bottle is placed over the candle</td>
<td></td>
</tr>
<tr>
<td>The candle flame goes out</td>
<td></td>
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</tbody>
</table>

Conclusion
Explain how temperature affected volume of the gas during this demonstration: