Demonstration: Investigating Gas Density

Summary
In this demonstration, students will observe a reaction between baking soda and vinegar in the presence of a burning candle. The initial environment has plenty of oxygen present in order to sustain the candle’s flame; however the reaction will produce carbon dioxide which will cause the lit candle to extinguish. Students will analyze the outcome and compare the presence of the gases in the container and make determinations about the densities of each.

Grade Level
Elementary and Middle school

NGSS Alignment
This demonstration will help prepare your students to meet the performance expectations in the following standards:

- **MS-PS1-2**: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
- **5-PS1-4**: Conduct an investigation to determine whether the mixing of two or more substances results in new substances.
- **Scientific and Engineering Practices**:
  - Asking Questions and Defining Problems
  - Analyzing and Interpreting Data

Objectives
By the end of this demonstration, students should be able to

- Compare the density of gases based on their behavior and observations.
- Understand that oxygen is necessary to sustain burning.

Chemistry Topics
This demonstration supports students’ understanding of

- Density of gases
- Chemical reactions
- Observations

Time
**Teacher Preparation**: 10 minutes
**Lesson**: 15-20 minutes

Materials

- Large glass or plastic bowl/container
- 1 candle (2-3 inches in height is best)
- 1 **long reach lighter**
- ½ cup (~120ml) of Vinegar
- 1 tbsp (~16 grams) Baking Soda

Safety
- Always use caution around open flames. Keep flames away from flammable substances.
- Always wear safety goggles when handling chemicals in the lab.
• Vinegar vapors can be irritating. Work in a well-ventilated area. In the event of eye contact, flush with water.
• The concentration of acetic acid in this experiment does not present any significant hazards. Always use caution around open flames. Keep flames away from flammable substances.
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• 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.
• An operational fire extinguisher should be in the classroom.
• Students should wear proper safety gear during chemistry demonstrations. Safety goggles and lab apron are required.

Teacher Notes
• This demonstration was inspired by and adapted from Fish Tank CO₂ and Comparing Gas Density. Both suitable for older students.
• Procedure:
  1. Measure 1 tbsp of baking soda, and distribute it in the bottom of the container in a circular pattern.
  2. Place the candle in the center of the container.
  3. Measure ½ cup (~120ml) of vinegar.
  4. Light the candle in the container.
  5. Carefully pour the ½ cup of vinegar slowly down the side of the container. Move the measuring cup around, or rotate the container so that the vinegar reacts with as much of the baking soda as possible (you may need assistance from a second person for this).
  6. The reaction will begin immediately. The flame should go out within a few seconds of the reaction occurring.
• Watch the video to see the demonstration in action.
• Key discussion points and explanations for this demonstration:
  o What is vinegar? What is baking soda?
  o How do you know a chemical reaction is taking place?
  o Reaction: NaHCO₃ + HC₂H₃O₂ → NaC₂H₃O₂ + H₂O + CO₂
  o Note that one of the products of this chemical reaction is carbon dioxide (CO₂)
  o Which has a higher density – CO₂ or air?
  o Students should observe closely (the candles will go out after the reaction has occurred for a few seconds. There will be fizzing/gas produced indicating a reaction is taking place.
  o Why do you think the candles went out? CO₂ is forming from the reaction in the bottom of the tank, and since it is denser than the oxygen in the container, the oxygen is getting pushed up higher/out of the container. Without oxygen the flame is not sustainable.
  o What reactants are needed for combustion? Both oxygen and a fuel (the candle) are needed for the combustion reaction to take place. Since CO₂ has a higher density than oxygen, it builds up in the bottom of the tank, replacing the oxygen.