5TH GRADE 4-H

THE CLASSIC VINEGAR AND BAKING SODA EXPERIMENT

Conservation of Mass as a New Substance is Formed

Materials Needed: goggles, grill lighter or long wooden matches, scale/balance, 2-liter plastic bottle, balloon, graduated cylinder or tablespoon, vinegar (4%-7%) acetic acid, sodium bicarbonate--baking soda capsules, small hose, and a 2-liter bottle lid valve.

Procedure: First allow the students to observe the liquid without telling them what it is. Via the smell, they will likely be able to make the identification. As for the baking soda, have them observe it's color and consistency. They may guess its identity, or not. If not, don't tell them until the end of the experiment. Light the long grill lighter or a long match. Relatively quickly place the flame end into the bottle...don't stay so long that you damage the bottle. The students will need to understand, that a flame can burn in the bottle, under normal conditions.

SAFETY WARNING: Under no circumstances use more baking soda than 16 grams (10 pills). Due to the fact that the bottle may be used multiple times, and weaken, 8 pills (12.8 grams) of baking soda is recommended for this experiment. Extra baking soda will make extra gas. Typical 2-liter bottles are pressurized by soda at 45-100 psi (depending on temperature). Largely dependent on temperature, this experiment will produce a psi in the upper 40s.

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Increasing pressure by using more baking soda makes this experiment more likely to burst the bottle; or, with enough baking soda and vinegar, cause an explosion. Keep it safe! Limiting the baking soda also acts as limiting factor in this experiment, in case someone accidentally uses a concentrated vinegar, with over 7% acetic acid. PUT ON YOUR GOGGLES!

Measure 225 ml (approximately 15 tablespoons) of household vinegar (5% acetic acid) into the bottom of a clean plastic 2-liter bottle.

Weigh the bottle with vinegar, 8 of the 1.6 g. baking soda capsules, the bottle top/stop, hose and attached (with a rubber band) deflated balloon. If you have a old-fashioned beam scale, have a volunteer come up and help them read the weight. Record the weight for the class. Check the top/stop valve and make sure it is already closed. The valve opens or closes with a slight twist. Dump the 8 capsules into the bottle and seal it with the top/stop. No rush, the capsules will buy you about 10 minutes before they are ready to do much.

At this point, show the video "Vacation or Conservation of Mass: Crash Course Kids #23.1" https://www.youtube.com/watch?v=3lHHOiTdmK4 As the speaker moves fairly quickly, stop the video and reiterate the important concepts of "Conservation of Mass."

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EA/EOU

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Remember, you want to use about 10 minutes presenting this short video. At the end of the video, ask the kids to make a prediction. "We are about to have a chemical reaction, will the mass (which we are weighing) change during the reaction?"

As the capsules dissolve, show the class the reaction and the bubbles of some "unknown gas" being produced. Feel free to swirl and shake the solution until all, or most of the baking soda has reacted. (If you would like more detail on this reaction, look at page 3.) Place the closed bottle and attachments back on the scale. You should have the same weight as you had before the reaction. So, a chemical reaction has occurred; however, we still have the same weight. Tell the students that during the chemical reaction, a new gas was produced and it is "squeezed" into the bottle, causing pressure inside the bottle similar to the pressure in a car tire. Pick up the bottle and slowly open the valve, allowing the balloon to blow up with the new gas we have produced. Close the valve once the balloon has filled sufficiently.

Now to prove that you have made something other than "air," (approximately 78% nitrogen, 21% oxygen, 1% Argon, and then trace amounts of other gases). Unscrew the bottle valve cap and place your hand over the opening. Ask students to predict what will happen if you put the lighter or match down in the bottle again. Go ahead and light the lighter/match and try to put the lit end in the bottle. It should go out quickly. So, apparently, our gas will not allow things to burn...interesting. Ask students, "Would this have happened with normal air?" "What is missing from this clear gas?" Hopefully, students will jump to oxygen being missing; however, you may need to lead them somewhat. (FYI: Most oxygen is attached to carbon; thus, there is little "free" oxygen to allow the fire to burn).

Go ahead and weigh the bottle with the attachments, and deflated balloon. We should have lost weight; because most of our gas is not out in the room...not in the bottle.

This is a great time to talk about atoms being in everything that we commonly experience on the surface of earth, including a gas. The gas had weight and it exerted force on the bottle and the balloon. Thus, it must have been made from something.

PURDUE UNIVERSITY
Extension

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If you have time, have students use their computers to look up which gases will not support fire. This is likely to be a long list. Then, have them add that the gas was invisible, heavier than air, and resulted from mixing vinegar and a white powder (unless they already guessed the power was baking soda). They should be able to come up with carbon dioxide gas fairly quickly. (One atom of carbon combined with two atoms of oxygen.)

Indiana Standards: 5-PS1-1, 5-PS1-2, 5-PS1-3, 5-PS1-4

Down In The Weeds Of This Chemical Reaction

Baking Soda/Sodium Bicarbonate ($NaHCO_3$) reacts with acetic acid (CH_3COOH) to form sodium acetate (CH_3COONa) water (H_2O) and carbon dioxide (CO_2). All of the resultant combinations are liquid except the CO_2 , which is gaseous.

How much CO_2 will 16 grams of baking soda make? About 4.25 liters (if all of the soda is used in the reaction).

1 mole of acetic acid (60 grams) will react with 1 mole of sodium bicarbonate (84 grams) to produce 1 mole of CO_2. A mole of CO_2 will have a volume of about 22.4 liters. If that were squeezed into the 1.5 liter space we are using (2-liter bottle less liquid), the pressure would be over 245 psi (assuming a temperature of 85 degrees Fahrenheit). This would be an explosive pressure for the bottle. Thus the reason for the warning at the beginning of this experiment.

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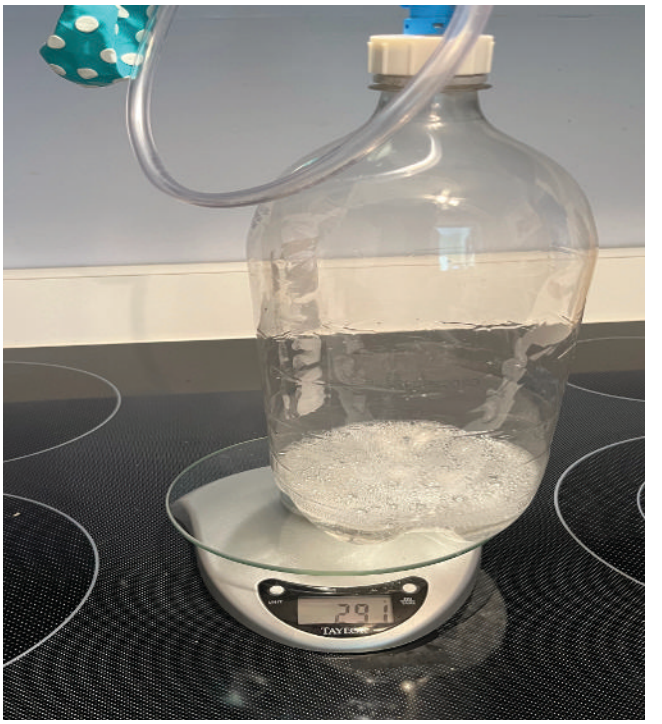
Conversions for differing vinegar concentrations:

4% acetic acid vinegar: increase to 286 ml (19 tablespoons)
6% acetic acid vinegar: decrease to 190 ml (13 tablespoons)
7% acetic acid vinegar: decrease to 163 ml (11 tablespoons)

Use of vinegar with above 7% acetic acid is not recommended for safety considerations. DO NOT CHANGE THE AMOUNT OF BAKING SODA!!!!!



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