CAN YOU POUR A GAS??

DESCRIPTION: This is an eye-opener demonstration that shows a dense gas (CO_2) being poured from one container into another to extinguish a candle.

PURPOSE: When most hear the word fluid they automatically think of liquids - something that flows with no rigid shape of its own, something that can be poured from one container into another.

MATERIALS:
- vinegar, 200 mL (approximately 5% acetic acid)
- deflagration spoon or bent stiff wire
- 2 1 Liter beakers or 2 2-L plastic soda bottles (colorless with the tops cut off)
- baking soda, $NaHCO_3$ - approximately 10 grams
- candle that fits in the deflagration spoon
- matches

PROCEDURE:
1. Prepare the 2 Liters by cutting off the tops leaving the sides curved in a bit at the top.
2. Melt some wax in the spoon and adhere the candle to the spoon.
3. Ask the students what they think is in the two beakers. Light the candle and dip it into the two beakers to show that the candle burns (oxygen is present).
4. Place two teaspoons of baking soda in the bottom of one beaker and add 1 cup of vinegar. Ask the students what they observe (a chemical reaction, bubbles, gas is being produced). Ask them if they know what gas is being produced? (CO_2).
5. Ask them if they know what Carbon dioxide is used for (fire extinguishers).
6. Light the candle and ask what enables it to burn (air - or more precisely, the oxygen in the air). Have them predict what will happen when the candle is lowered into the unused beaker, still

presumably filled with air. Carefully lower the candle into the beaker and observe that the candle continues to burn. This serves as a control to confirm that the act of lowering the candle into a beaker does not put out a flame.

7. Next, lower the candle into the beaker in which the chemical reaction took place and observe that the candle extinguishes (note that if the candle is lowered slowly enough, the flame will get "lifted" off the wick - sometimes by as much as 1 - 2 cm).
8. Once it has been established that the CO_2 gas is dense enough to stay in the bottom of the beaker (as though it were a liquid), ask the question: "Do you think that the CO_2 can be poured like a liquid from one container into another?"
9. Place the candle aside and slowly pour the CO_2 from the reaction beaker into the other one. Since there is virtually (if there is residual smoke from extinguishing the candle, you may see the smoke as it is carried with the CO_2) no evidence that the gas is being poured from one beaker to the other, the students will think you have lost your mind. It is very funny if you say things like, "I've got to be careful not to spill any" or "Oops, some just fell on the floor - I'll clean it up later!"
10. Relight the candle, then prove that the CO_2 has indeed been transferred by lowering the lit candle into the original reaction beaker and observe as it continues to burn. Students will then demand better proof than that, so next lower the candle into the other beaker and observe that it is extinguished.

EXPLANATION: The nice thing about this demo of the invisible pourability of carbon dioxide is that it illustrates quite a few physical properties of the molecule:

a. CO_2 is a gas at room temperature
b. it is clear and colorless
c. since it is a gas, it has low viscosity

d. it is more dense than air

CO_2 = 44 g/mole
O_2 = 32 g/mole
N_2 = 28 g/mole

e. Due to Brownian movement, it eventually diffuses out of the container in all directions to occupy the entire space around it

Avogadro's Law states that gases with the same number of particles will have the same volume at the same temperature and pressure. Because of this law, one can simply use the molar masses of gaseous substances to predict their relative densities. For example, under the same conditions, we would expect neon gas (formula weight = 20.2 g/mole) to be about five (5) times more dense than helium (molar mass = 4.0 g/mole). Likewise, we would expect CO_2 with a formula weight of 44 g/mole to be about 50% denser than air.

DISPOSAL: No special safety precautions are needed for disposal. All material may be washed down the sink.

REFERENCES: Mr. Bob Becker, Kirkwood High School, Kirkwood, MO,. First presented this at "An Incredible Evening of Chemistry: 20 Demos to Knock Your Socks Off!" in New Orleans at the NSTA Convention in 1997.

TOPICS: Density, phases of matter, chemical reactions, combustion (O_2 dependent), fire extinguishers.