Defining the Relationship

Purpose:

The purpose of this activity is to understand the variables that affect the behavior of gases and to understand their relationships. You and your partner will become the experts for the relationship between two or three variables that are related through your assigned demonstration. You and your partner will also have to try to explain the relationship using Kinetic Molecular Theory (KMT).

Introduction:

Much of science is an effort to explain why things behave the way they do. Chemistry models and theories are speculation about what occurs on the atomic or molecular level that causes the macroscopic properties we see. These models and theories are most useful when they not only explain the observed behavior but they can also predict the results of future experiments. Kinetic Molecular Theory (KMT) is used to explain the behavior of ideal gases. There are 4 main ideas in KMT:

1. Gases consist of tiny, indivisible particles that are SO SMALL compared with the distances between them that the volume of these particles is assumed to be negligible. In other words, gas molecules are points in space.
2. Gas particles are in constant, random, straight-line motion. The collisions of the particles with the walls of the container are the cause of the pressure exerted by the gas.
3. Collisions between the particles are completely elastic, and the particles do not experience attractive OR repulsive forces.
4. The average kinetic energy (KE) of the particles is proportional to the temperature of the gas. (KE= ½ mv2  and KE=constant\*T)

There are several variables that affect gases, and these variables are intertwined.

Your task:

Before beginning, watch the introductory video.

Your task today is to watch or perform five of the demonstrations found as videos on PSL or in this document and to determine what is happening on a molecular level. You will need to include a (small) paragraph (using complete sentences) that addresses the following information for each of the five demos:

1. Title of the Demo
2. Which of the gas variables change in the demo (P, V, n, T), and which remain constant?
3. An explanation on a molecular level (using KMT) of what is happening during the demo and demonstrating your understanding of the relationship between the variables in the demo.

You may work (remotely) with another honors chemistry student if you would like and submit one file for the two of you. Make sure both names are on the document!

If you choose to perform at least two demos in your home, you may choose to only explain only four different demos with no penalty. I recommend watching all the videos/trying one or two before deciding which will be the best to explain. Some of these are easier to explain than others, and I will take that into account when grading.

Online DemOs

This is a list of the demos that are available for view on PSL:

1. The Weight of Air
2. The Rigid Sphere of Science
3. You Can Do It!
4. Squeezy the Squid
5. Are You Stronger Than Science?
6. Casper the Bell Jar Ghost
7. Bicycle Built for Science
8. Science Doesn’t Suck
9. Lucky Bird
10. Boiling over with Happiness

DemOs fOr hOme

If you would like, and you have the required materials, these demos may be performed at home, with proper adult supervision! Never perform experiments when you are by yourself. Feel free to record your own version of the demo video.

1. Happy Birthday!

Materials: short candle, kitchen match, a saucer or shallow pan, water, heatproof clear jar Demo Instructions:

* 1. Pour about ¼ cup of water into the saucer.
  2. Place the candle in the center of the saucer and light it.
  3. Turn the jar upside down and carefully place it over the candle on the saucer.
  4. Observe.

1. Floating Card

Materials: A glass with a smooth rim or an empty bottle, water, stiff piece of thin cardboard, like a playing card

Demo Instructions:

* 1. Do this experiment over a sink! Fill the glass or bottle to the brim with water.
  2. Place the piece of cardboard over the opening in the glass.
  3. Holding the cardboard tightly in place, turn the glass upside down.
  4. Remove your hand from the cardboard. What happens?

1. Atomizer

Materials: two straws, glass of water Demo Instructions:

* 1. Hold one straw vertically in a glass of water with one hand. Don’t let the end of the straw touch the bottom of the glass of water (this might block the flow of water).
  2. With your other hand, hold a second straw horizontally. One tip of the horizontal straw should be inserted into your mouth, and the other end should be held adjacent to the tip of the vertical straw to form a 90-degree angle.
  3. Now blow, and blow hard!
  4. If your straws are set up properly, your blowing should raise the liquid up the vertical straw. What happens when the liquid reaches the top? Why?

1. Soda Pop! Straw

Materials: lots of plastic straws, a laboratory assistant Demo Instructions:

1. Taking one end in each hand, tightly pinch both ends of a straw.
2. Twist the straw with a pedaling-type motion.
3. As you twist, the amount of straw between your fingers should bet smaller and smaller.
4. Twist until you can’t twist any more. You should have about an inch of hard, untwisted straw between your fingers.
5. While you keep holding the straw, have your able assistant flick his or her finger at the untwisted portion of the straw. They should hit the straw with their fingernail, and they should flick hard!
6. The straw should make a loud pop. If it doesn’t, flick again or try another straw. This may take a couple tries!

1. Make Your Own Thermometer

Materials: water, food coloring, soft drink bottle, clear plastic straw, modeling clay or play-doh, wax crayons or marking pencils, a pan, warm water, a thermometer

* 1. Color the water with several drops of food coloring.
  2. Mostly fill the soft drink bottle with the colored water.
  3. Mold the clay or play-doh around the straw, about 2 inches from one end.
  4. Insert the straw into the bottle, and mold the clay so that you seal the straw in pace at the top of the bottle. Do not let the end of the straw touch the bottom of the bottle.
  5. The water will rise, probably to about ½ inch above the clay seal. Let the bottle sit at room temperature until the water level stops changing.
  6. Use the crayon or marking pencil to mark the level of the water on the straw. Check the room temperature, either with the thermometer or a thermostat. Using a different color, write that temperature at your mark on the straw.
  7. Fill the pan with warm water. Set the bottle in the pan and wait for the water level to stop rising. Mark the new level on the straw. Label this temperature, too.
  8. Why does this work?

1. Popover for a Look

Materials: 2 eggs, 1 cup milk, 1 tbsp butter, melted, oven, 8 6 oz custard cups, jelly-roll pan, large mixing bowl, whisk, ladle or large spoon Demo Instructions:

* 1. Preheat oven to 425 °F. Butter eight 6-oz. custard cups generously; place on a jelly-roll pan. Place in oven to heat while preparing batter.
  2. Beat eggs in large bowl; add milk and butter. Beat until blended. Add flour and salt; beat until batter is quite smooth. Ladle into prepared cups to fill about half-full.
  3. Bake in preheated oven for 35 minutes. Cut slit in side of each popover to allow steam to escape. Bake for 5 minutes longer or until popovers are a deep brown and very crisp. Serve immediately. Makes 8 popovers.
  4. Observe.

1. Balloon In a Bottle

Materials: glass bottle with narrow neck, water, oven mitts, trivet, party balloon, measuring spoons.

Demo Instructions:

* 1. Pour 1 tablespoon of water into the bottle.
  2. Place the bottle in the microwave and heat for 1 minute. If the bottle is too tall to fit in the microwave, rest it diagonally in another microwave safe bowl and heat it up that way.
  3. The bottle and water will be very hot coming out of the microwave. Use oven mitts to grab the bottle and set it on a trivet on the kitchen counter.
  4. With your oven mitts still on, quickly stretch the balloon over the mouth of the bottle. Make sure the balloon is centered over the mouth and sit back to watch what happens next.

1. Tea Bag Hot Air Balloon

Materials: tea bag with string attached, scissors, mug, glass plate, match Demo Instructions:

* 1. Use scissors to cut the tea bag open on the side attached to the string. Dump the contents into a mug to use later or discard.
  2. Shape the tea bag into a cylinder and stand it up on a glass plate.
  3. Use a match to light the top of the tea bag on fire.
  4. Observe.

1. Egg in a Bottle (Part I)

Materials: hard boiled egg, glass bottle with an opening only a little smaller than the egg, match, piece of paper, lubricant (butter, cooking oil, etc) Demo Instructions:

* 1. Remove the shell from the hard boiled egg.
  2. Rub the lubricant around the mouth of the bottle.
  3. Fold the paper into an accordion. Light the match and set fire to the paper. Immediately put the lit paper into the bottle, and place the egg over the opening. Observe.

1. Now What? (Part II)

Materials: An egg in a bottle (created in demo 19), water

* 1. If the egg remains in one piece, fill the bottle with water. Use your finger to keep the egg away from the mouth of the bottle, and pour out the water and burned paper into the sink.
  2. Turn the bottle upside down so the egg falls into the neck and blocks the opening from the inside.
  3. Continue holding the bottle upside down and blow as hard as you can into the bottle.
  4. Stop. Move your hand to (hopefully) catch the egg.

# Demo 12: Floating Card

This experiment manipulates Pressure. Temperature, volume and number of moles are constants. The card stays in place because air pressure around the glass (or the pressure exerted when the gas molecules bounce off the bottom of the card) is enough to hold the pressure that the water is exerting on the other side of the card.

# Demo 18: Tea Bag Hot Air Balloon

This experiment manipulates Temperature and volume. The pressure and number of moles are constant. The Tea Bag flies upwards because the heat from the flame creates a pocket of hot air that is captured by the remnants of the bag, which become very light as they are now just ash. Because gas molecules move faster the hotter they are, they take up more space at a constant pressure. This hot pocket of air therefore rises in volume while keeping the same mass, meaning that the density decreases dramatically. Because less dense things float in fluids, the hot pocket of air rose, taking the burnt teabag with it.

# Demo 7: Bicycle built for science

This experiment manipulates the number of moles, pressure and volume. The temperature is constant. The sealed syringe decreases in volume as the pressure of the simulated atmosphere increases relative to it. Because there is more gas in every square centimeter of the outer bottle, more gas molecules/atoms bounce off of the syringe plunger. Because there is more force pushing the syringe plunger inwards, it moves inwards which increases the pressure in the syringe by decreasing the volume and increasing the number of times the gas interacts with the plunger. This continues until the pressure is equal on the inner syringe. When the forces (pressures) are in equilibrium, the plunger stops moving.

# Demo 3: You can do it!

This experiment manipulates temperature, pressure and volume. The number of moles is constant. The can gets crushed by the atmospheric pressure. Because the can is placed into the cool water, it creates a seal. The hot water vapor was at atmospheric pressure before being put into the liquid, but because the gas particles were moving quickly, there is only a small amount of vapor particles inside. When the can is placed into the cool water, the vapor quickly cools and decreases in pressure. This pressure is less than the atmospheric pressure, so the force pushing out on the can is quickly overcome and the can crushes inwards. The vapor then becomes liquid again, decreasing pressure again, and this pressure equalizes when the atmospheric pressure pushes water back into the can.