**The Pressure’s Mounting: Gas Law Activities**

**Teacher notes**

**Time needed to complete lab:** Approximately 1.25 hours, can be shortened or lengthened to meet your time needs

**Target grade level**: Middle-High School Chemistry

**Objectives:**

* The students will determine how pressure, temperature and volume are related using Boyle’s and Charles’ Law.
* The students will use gas laws to explain how certain real world things work.

**Major concepts**:

This lab can be done as an intro to a unit on gases, or as a review lab at the end of the unit. It can be modified to meet your specific needs/supplies as well.

**Preparation:**

**Materials:**

Part 1: Teacher Led Demos

1. Weigh boat (or some other plastic container/mold), butter, popcorn, hotplate, large beaker
2. Hard-boiled egg, matches, narrow mouthed bottle, wood splint/paper (or candle)
3. Liquid Nitrogen, Dewar flask, balloons, tongs, gloves

Part 2: Rotating Student Stations

1. Beaker, Cold Water, Mirror or Coin, Glass Soda Bottle
2. Glass Tube, Cotton balls, 2 pairs of forceps, gloves, concentrated HCl & aqueous

 NH3, 2 small beakers

1. Potato, plastic straws, sharpie
2. Film canister, Alka-Seltzer, Large Pipette, frogs (optional)
3. Mini bell jar vacuum, syringe, balloon
4. Drinking Bird, Cup of water
5. Water filled pipette, weights (books)
6. Empty Soda Can, Hot Plate, Tongs, Water, Beaker with Ice Cold Water
7. Balloon, Erlenmeyer Flask, water, Hot Plate, Cold Water Bath
8. Marshmallows, Bell Jar, Syringe

Part 3: Explanations & Conclusion

* Calculator
* Ruler
* Full can of soda
* 8 foot straw

**Safety:**

Goggles should be worn during the lab.

Gloves are required at Station B.

Do not mix the chemicals at Station B. Follow instructions carefully.

Be careful of hot glassware at Stations H & I.

**Procedure:**

Part 1: Teacher Led Demos

1. Intro to the States of Matter: In a weigh boat, place popcorn kernels into melted butter and let harden. Once hard, have students come up and look at the “solid” block. Explain that the popcorn represents the molecules and the butter is the bonds. Have students brainstorm properties of solids and list them on the board. Place the solid into a large beaker and place beaker onto a hot plate on high. Keep swirling the beaker around on the hot plate. As butter begins to melt, explain that when solids become liquids, the molecules begin sliding past each other. Again, brainstorm the properties of liquids on the board. Continue heating the beaker until the popcorn starts popping. This represents the gas phase and students can see how spontaneous the movement of gas molecules really can be. Have students brainstorm properties of gases on the board as well.
2. Egg in a Bottle Experiment: Place a hard-boiled egg on top of a narrow mouthed bottle to show the students that the egg is larger than the container opening. Remove the egg and place a piece of burning paper/wood splint into the bottom of the bottle. Sit the egg on top of the bottle and watch. Explanation: An egg is not a solid; it has air pockets like a sponge. By burning the paper in the jar, the oxygen is being used up and you decrease the pressure inside the jar which causes the egg to decrease in size, becoming a solid and allows the egg to slip through the opening of the jar.
3. Balloon in Liquid Nitrogen: Have a Dewar Flask of Liquid Nitrogen on the lab table. Ask the students if they know the temperature of the liquid (-196°C) & it is boiling! Ask what they think might happen if I place a balloon in the liquid nitrogen. Then carefully place 5-6 small balloons in to the liquid nitrogen. Using tongs, pull them out and lay them on the table. Have the students explain what happened. (The molecules were turned to liquid because they were so cold and as they heat up, the molecules start moving and get farther apart until they become a gas again.)

Part 3: Explanation of the Gas Laws Activities & Conclusion

Review the activities from the rotating student stations and review Charles’ and Boyle’s Laws.(See explanations below in data table.) Then ask for a volunteer from the class. This student will use an 8 foot straw to try to drink a can of soda. (You can tape 11-12 straws together with duct tape.) The other students will need to time the drinker to see how long it takes to get the soda to their lips. Then students should explain how straws work and as a class try to calculate the volume of displaced air in the 8 foot straw.

**Explanation:** When you suck on the straw, you are decreasing the pressure in your mouth and lowering the pressure of the air in the top of the straw. When that happens, the force of the atmosphere pushing on the water in the glass is higher than the force of gas inside the straw. The atmosphere forces the liquid up the straw into your mouth. So, in essence, you ARE NOT *sucking* the liquid into your mouth, the atmosphere is *pushing* it there.
<http://wiki.answers.com/Q/How_does_a_drinking_straw_work#ixzz1zkkAC5Vb>

**Typical results or sample data:**

**Data table:** Record observations & explanations for each of the stations. Then try to determine which gas law the activity represents.

Station A: Magic Moving Mirror (Boyle, **Charles**, Other) Can use a coin!

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| Observations:After a few minutes, the mirror should begin jumping up off the bottle’s mouth. |
| Explanation:As the heat from hands warms up air inside the bottle, it increases the pressure causing the mirror to be pushed upward. If students remove hands, the mirror should quit jumping. |

Station B: Dramatic Diffusion (Boyle, Charles, **Other) The tube must be clean and dry between groups, so it would be wise to have extra tubes.**

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| Observations: Students should see gas molecules move towards each other and then see the reaction in the tube, in the form of a white ring. |
| Explanation: HCl & NH3 are different sized molecules and will diffuse at different rates, where they meet and react, you should see a white ring and if time permits, you can talk about Graham’s Law of Diffusion in greater detail. Students can discuss why the reaction didn’t occur in the exact middle of the tube. |

Station C: Who Killed Spud? (Boyle, Charles, **Other)**

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| Observations: The first time without capping the straw, it should barely go into the potato. Once the thumb caps the end, it should easily slice through the potato. \*\*Make sure the students have their hands at the top of the straw, not in the middle! |
| Explanation:Once you cap the straw, the trapped air inside gives the straw more strength to cut much farther through the potato.  |

Station D: Bouncing Bullfrogs (Boyle, Charles, **Other**)

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| Observations: After a minute or so, the cap with frog should fly off the canister. |
| Explanation: This is an effervescent reaction, when alka seltzer hits the water, the acid/base within the tablet reacts and CO2  gas is produced. The volume that the gas can contain is limited to the film canister and as more CO2 is produced, the cap flies off due to the pressure inside. **You can also do a lab with only the film canisters by changing the amount of Alka-Seltzer, temperature of water, etc.** |

Station E: Just Keep Pulling…Just Keep Pulling…Just Keep Pulling! **(Boyle**, Charles, Other)

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| Observations:As you pull air out of the bell jar with the syringe, the balloon gets larger, filling the jar. Once you release the vacuum, the balloon shrinks back to its original size. |
| Explanation:As pressure is removed from the bell jar, the item inside can increase in volume, which is exactly what Boyle’s Law states. Once the pressure is back in the jar, the item returns to normal size. |

Station F: Thirsty Tweety (Boyle, **Charles**, Other) indirectly

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| Observations:Once bird’s head is wet, he will continue to dip his head into the cup of water. |
| Explanation: When the water evaporates from bird’s head, the methylene chloride vapor condenses, decreasing the pressure in the head compared to the abdomen. The greater abdomen pressure forces liquid up through neck & into head. As the fluid enters head, bird becomes top heavy and dips forward into water which restarts the cycle. |

Station G: Piping Pressure (**Boyle**, Charles, Other)

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| Observations: When placing more books onto the bulb of the pipette, the liquid in the stem moves farther from the bulb. |
| Explanation: As more mass (pressure) is applied to sealed pipette, the air bubble’s volume decreases and is displaced by the water in the pipette. |

Station H: Shy Soda (Boyle, **Charles**, Other)

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| Observations: Soda can should implode when it hits the ice water. |
| Explanation: When water in the can is heated to its boiling point, it rapidly vaporizes. The generated steam quickly displaces all the molecules of air in the can, exerting as much pressure on the inside walls of the can as the air exerts from the outside. When the can is inverted into a bucket of cold water, the steam inside the can is rapidly cooled. This causes the steam to condense back into the liquid phase, leaving the inside of the can nearly empty. Liquid water molecules do not exert the same pressure on the inside of the can the way steam did, causing the air pressure from the outside to crush the can from the outside in, about the same way as you could crush it by tightening a fist around the empty can. http://answers.yahoo.com/question/index?qid=20100209210548AAKwyeo |

Station I: Innie or Outie? (Boyle, **Charles,** Other) Have students hold onto limp balloon so it doesn’t get melted to side of flask & pop.

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| Observations: As water boils, balloon fills up. When put into a cold water bath, balloon inverts into the flask. (You can keep going back & forth too) |
| Explanation: The boiling water turns to steam and inflates the balloon. As the flask is put into the cold water, the gas molecules are rapidly cooled and condensed back into liquid and the balloon is pushed into the flask. |

Station J: Mini & Mega Marshmallows (**Boyle,** Charles, Other)

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| Observations: As you pull air out of the bell jar with the syringe, the marshmallow gets larger, filling the jar. Once you release the vacuum, the marshmallow shrinks back to its original size. |
| Explanation: As pressure is removed from the bell jar, the item inside can increase in volume, which is exactly what Boyle’s Law states. Once the pressure is back in the jar, the item returns to normal size. |

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**Sample calculations**

Calculate the volume of air displaced in the 8 foot straw:

**h**

 V = πr2h

 V= (3.14) ( .06cm)2(256.8cm) = 2.90 cm3

**Answers to questions:**

**Guiding questions:**

1. What are the properties of gases?

Easily compressible, indefinite shape & volume, molecules move quickly, lots of collisions

1. What real-world applications/everyday things deal with gases?

Popcorn popping, carbonated soda, cooking, internal combustion engines, aerosol cans, airbags

**Questions:**

1. How does changing the temperature of a gas impact its pressure? When temperature is increased and volume is constant, the pressure also increases. When temperature is decreased and volume is constant, the pressure decreases.
2. What is the relationship between volume and pressure? Explain how you know. Indirect relationship, as pressure increases, volume decreases. As pressure decreases, volume increases.
3. Refer to your answer from the previous question, what will happen to the number of collisions of the gas molecules as pressure is changed? As pressure decreases and volume increases, the number of collisions will decrease. As pressure increases and the gas is fitting into a small volume, the molecules will be colliding more frequently.
4. What would happened to the size of the air bubble in the sealed pipette if 8 books were added to it? It should decrease twofold from their data when 4 books were added.

**Additional References:** [**http://www.kids-science-experiments.com**](http://www.kids-science-experiments.com)