Experiment # 7. Gas Laws.

Goal
To observe gas laws in the laboratory.

Introduction
All ideal gasses, regardless of molar mass or chemical properties, follow the same gas laws under most conditions. Gas Laws are derived from the Kinetic Theory which makes the assumptions:

- Gasses are composed of small particles that are in constant random motion
- The volume of particles is negligible compared to the space they occupy.
- The attraction between particles is negligible.
- The average speed of the gas is directly proportional to its Kelvin temperature.

If a gas follows these assumptions, the gas is said to be ideal.

The pressure of a gas results from the collision of gas particles with the sides of the container – the more collisions, the higher the pressure of the gas. The volume of a gas is equal to the volume of its container. Unless a gas container is rigid, the container will change volume to maintain the same pressure inside and outside the container. Balloons can change volume very easily to maintain the same pressure outside and inside – in all balloon experiments the pressure remains constant.

Boyle's Law Pressure and volume are indirectly related at constant temperature – as one increases the other decreases. As the volume of a sample of gas increases, the particles collide with the sides of the container less often, leading to lower pressure.

$$P_1V_1 = P_2V_2$$

Charles' Law Volume is directly related to the temperature of a gas at constant pressure. As the temperature increases, so does the average speed of the gas which leads to more collisions with the sides of the container. In order to keep the pressure constant as the temperature rises, the volume must expand, keeping the number of collisions the same.

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Gay-Lussac's Law Pressure and Temperature are directly related at constant volume. As the temperature increases in a system with fixed volume, the molecules move faster and have more collisions with the container leading to increased pressure.

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Avogadro's Law Volume and moles are directly related at constant temperature and pressure. As the number of moles increases, the volume of the container must expand to keep the number of collisions and thus the pressure constant.

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

Combined Gas Law: The above laws joined together become the combined gas law. If more than two properties are changing, this law is used. Any properties that remain constant will drop out of the equation (for example, if temperature and number of moles are constant, they are removed from the equation and it becomes Boyle's Law).

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Ideal Gas Law: PV = nRT or, no properties are changing and PV = nRT. Where R = $0.08205\frac{atm\ L}{mole\ K}$ = $62.36\frac{torr\ L}{mole\ K}$

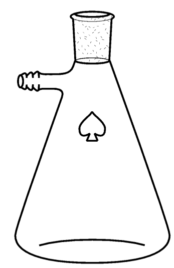
Laboratory Activity

Equipment	2 x 1000 mL beaker	aluminum can	hot plate	ice
	hot gloves	2 x balloons	beaker tongs	
	250 mL Erlenmeyer flask	vacuum flask	rubber stopper	vacuum hose
	small marshmallow			

Procedure

Part A:
1. Fill a 1000mL beaker half way with tap water. Begin heating on a hot plate
2. Fill a second 1000mL beaker halfway with water and ice.
3. Obtain a small balloon filled with air. Submerge the balloon in the ice water bath for three minutes using beaker tongs. Observe any changes.
4. Transfer the balloon to the hot water bath. Submerge with beaker tongs. Observe any changes.
5. Save the ice-water bath for Parts C & D.

Part B:
1. Obtain a vacuum flask. One person in the group should <u>hold the flask at all times</u> during the experiment – the side-arm breaks easily when the flask tips over.
2. Place a marshmallow inside and plug the top with a rubber stopper. Attach one end of the vacuum hose to the side arm of the flask and the other end to the vacuum line.
3. ***Slowly*** turn on the vacuum and observe what happens.
4. <u>Turn off the vacuum before disassembling</u>**.**
5. *Do not eat the marshmallow.*



vacuum flask

Part C:
1. Obtain a 125 mL Erlenmeyer flask and place approximately 20 mL of water in the flask.
2. Place the flask on a hotplate and heat to a boil.
3. Hold the neck of the flask using hot gloves and stretch the mouth of a balloon over the opening, centering it on the mouth of the flask. Wait up to 3 minutes and observe the results.
4. Using hot gloves transfer the flask to an ice bath for 3 minutes and observe the results.

Part D:
1. Obtain an empty aluminum can and add approximately 10 mL of water to it.
2. Place the can on a hotplate and heat until the can has been at a rolling boil for one minute.
3. Using hot gloves, quickly turn the can over into an ice-water bath so that the opening of the can is below the surface of the water for a few seconds. If nothing happens to the can after a few seconds, repeat from step 1.

Name___________________________

Team Name ________________________

CHM101 Lab – Gas Laws – Grading Rubric

To participate in this lab you must have splash-proof goggles, proper shoes and attire.

Criteria	Points possible	Points earned
Printed lab manual and goggles brought to lab	2	
• Safety and proper waste disposal procedures observed • Followed procedure correctly without depending too much on instructor or lab partner • Work space and glassware was cleaned up	4	
Observation and explanation table	10	
Post Lab Q1	1	
Post Lab Q2	1	
Post Lab Q3	1	
Post Lab Q4	1	
Total	20	

Subject to additional penalties at the discretion of the instructor.

Gas Laws – Report Sheet **Name** ________________________

Part	**Observations**(what happened)	**Why did it happen?** (Think about gas laws and collisions)
A		Balloons change volume to maintain the same pressure inside and outside. Why was expansion needed to maintain the pressure?
B		Marshmallows have tiny bubbles of gas. What happens to the number of collisions in the bubbles when the marshmallow changes in the experiment? Why does the marshmallow undergo this change in a vacuum(low pressure)?
C	heating: cooling:	The temperature of the steam is maintained at 100°C for the duration of heating. If the temperature of particles is not changing, why does the balloon expand? What happens to the number of gas particles in the balloon when the flask is cooled below 100°C?
D		Steam fills the can before it is flipped. What happens to the number of gas particles once the can is in the ice bath? Before the can is flipped, the pressure inside and outside is the same. Right after it is flipped, what happens to the pressure inside the can? How does this explain the experiment?

Show all work including units!

Q1. A balloon is filled with 15.0 L of helium at 1.50 atm. What would be the new volume of the balloon if the pressure was changed to 235 atm?

Q2. If a 9.5 L balloon contains 1.2 moles of gas, how many moles should be **added** to inflate the balloon to 12.0 L? (hint - n_2 is the is total final moles, not the amount added.)

Q3. How many moles of gas are in a 285. mL container with a pressure of 0.650 atm at 95 °C?

Q4. A 0.650 L balloon at 785 torr and 21°C floats to a point in the atmosphere where the pressure is 0.400 atm and the volume has expanded to 0.950 L. What is the temperature of the balloon?