Relationships in Gases Laboratory
Part 1 –Pressure vs. Volume

Introduction - The primary objective of this experiment is to determine the relationship between the pressure and volume of a confined gas. The gas we use will be air, and it will be confined in a syringe connected to a pressure sensor. When the volume of the syringe is changed by moving the piston, a change occurs in the pressure exerted by the confined gas. This pressure change will monitored using a pressure sensor. It is assumed that temperature will be constant throughout the experiment. Pressure and volume data pairs will be collected during the experiment and then analyzed. From the data and graph, you should be able to determine what kind of mathematical relationship exists between the pressure and the volume of the confined gas.

Purpose – The purpose of this lab is to…. (complete this sentence by reading the introduction)

Procedure – The procedure for this lab will be posted at the lab station. Please follow the directions carefully.

Data – Create a data table to record values for Volume (ml) vs. Pressure (kPa). You will need to record a pressure value for volume measurements of 5.0, 7.5, 10.0, 12.5, 15.0, 17.5 & 20.0 ml.

Calculations and Data Analysis

1. Graph the data. The vertical axis (y-axis) should be Pressure (kPa). The horizontal axis (x-axis) should be Volume scaled evenly from 0 to 20 ml.
2. Based on the shape of your curve, determine the relationship between the pressure and volume of a confined gas as inverse or direct? Explain your answer using examples from your data.
3. One way to determine if a relationship is inverse **or** direct is to find a proportionality constant, k, from the data. If this relationship is direct, k=P/V. If this relationship is inverse, k = PV. Based on your answer to the above question, chose the correct formula and calculate k for the seven ordered pairs in your data table (divide **or** multiply the P and V values). Show the answers in table format. Then calculate the average value of the constant, k.
4. Write an equation for pressure as a function of volume using the symbols P, V and k.

Post Lab Questions

1. Based on your data, what would you expect the pressure to be if the volume of the syringe was increased to 40.0 ml? Explain or show work to support your answer.

2. Based on your data, what would you expect the pressure to be if the volume of the syringe was decreased to 2.5 ml.? Explain or show work to support your answer.

3. What two experimental factors are assumed to be held constant during this experiment?

4. Good data may show some minor variation, but the values for k should be relatively constant. Explain 3 sources of error for this lab.

5. Based on the data and graph that you obtained for this experiment, express in words the relationship that exists between gas pressure and the volume of a gas when the temperature remains constant.

Conclusion

Write a one sentence conclusion that refers back to your stated purpose. Be sure to use your lab data to support your conclusion.

Relationships in Gases Laboratory
Part II –Pressure vs. Temperature

Introduction - Gases are made up of molecules that are in constant motion and exert pressure when they collide with the walls of the container. The velocity and the number of collisions of these molecules are affected when the temperature of the gas increases or decreases; in turn, pressure is affected. In this experiment, you will study the relationship between the temperature of a gas sample and the pressure it exerts. You will place an Erlenmeyer flask containing an air sample in water baths of varying temperature. Pressure will be monitored using a temperature probe. The volume of the as sample and the number of molecules it contains will be kept constant. Pressure and temperature data pairs will be collected during the experiment and then analyzed. From the data and graph, you will determine what kind of mathematical relationship exists between the pressure and absolute temperature of a confined gas. You will also find a value for absolute zero on the Celsius temperature scale.

Purpose – The purpose of this lab is to…. (complete this sentence by reading the introduction)

Procedure – The procedure for this lab will be posted at the lab station. Please follow the directions carefully.

Data – Create a data table to record values for Pressure (kPa) vs. temperature (˚C) for the four different temperature water baths. The temperatures will be recorded in Celsius, but you will need to create an additional temperature column for Kelvin temperature. [˚C + 273 = K]

Calculations and Data Analysis

1. Graph the data of Pressure vs. Temperature using Kelvin temperature.
2. Based on the shape of your curve, determine the relationship between the pressure and volume of a confined gas is inverse or direct? Explain your answer using examples from your data.
3. One way to determine if a relationship is inverse **or** direct is to find a proportionality constant, k, from the data. If this relationship is direct, k=P/T. If this relationship is inverse, k = PT. Based on your answer to the above question, chose the correct formula and calculate k for the four ordered pairs in your data table (divide **or** multiply the P and T values). Show the answers in table format. Calculate the average value of the constant, k.
4. Write an equation for pressure as a function of volume using the symbols P, T and k.

Post Lab Questions

1. In order to perform this experiment, what two experimental factors were kept constant?
2. Based on the data and graph that you obtained for this experiment, express in words the relationship between gas pressure and temperature.
3. According to this experiment, what should happen to the pressure of a gas if the Kelvin temperature is doubled? Check this assumption by finding the pressure at –73°C (200K) and at 127°C (400K) on your graph of pressure versus temperature. How do these two pressure values compare? Show your calculations
4. Plot a graph of Celsius temperature on the y axis (vertical) and pressure on the x axis (horizontal). Absolute zero is the temperature at which the pressure theoretically becomes zero. Extrapolate your best fit line back to zero pressure and determine a volume for absolute zero. How close are you to the actual value?

Conclusion - A one sentence conclusion that refers back to your stated purpose. Be sure to use your lab data to support your conclusion.

Relationships in Gases Laboratory
Part III –The mass of air

Introduction - Because we live in an ocean of air, people often assume that air has little or no mass. In this experiment you will use a syringe apparatus and an electronic scale to measure the mass of a quantity of air. Using the Ideal Gas law, the moles of air in your sample will be determined. With this information and Dalton's law of Partial Pressure you will obtain an experimental value for the molar mass of air.

Purpose – The purpose of this lab is to…. (complete this sentence by reading the introduction)

Procedure

1. Secure the syringe lock firmly on the tip of the syringe. Do not force it.
2. With the syringe lock open, fully close the syringe.
3. Close the syringe lock. When closed it will be perpendicular to the direction of air flow, like any valve. In this position no air will be able to enter the syringe.
4. While one student firmly holds the syringe barrel, the other student pulls out the plunger to 140ml (just far enough to expose the hole in the plunger) and inserts the nail through the hole. It is important that the nail be positioned properly so that it does not enter the barrel of the syringe and destroy it.
5. Place the syringe and nail on the balance and determine the mass of the evacuated syringe, record your data.
6. Remove the syringe and open the lock, which will allow air to enter the syringe.
7. Place the syringe and nail on the balance and determine the mass of the air filled syringe, record your data.
8. Record the room temperature and pressure in the room.

Data – Create a data table to record the mass of the evacuated syringe (g), mass air filled syringe (g), volume of air (mL), the room temperature (˚C) and the room pressure (atm).

Calculations and Data Analysis

1. Calculate the mass of the 140 ml of air in your syringe. (Show your work)
2. Write the ideal gas law and define all the variables
3. Use the ideal gas law to calculate the number of moles of air present in your sample.
4. Use the moles of air and the mass of air in your sample to calculate the molar mass of air (g/mol)
5. Using an approximate percent composition of air given, calculate the theoretical molar mass of air. (78.0% N, 21.0% O, 0.04% CO_2, 0.96% Ar.) Multiply the molar mass of each gas by the percent composition of that element to determine the molar mass of air.
6. Compare your experimental value of molar mass (#4) vs. theoretical value of molar mass (#5) and determine your % error.

$$\% \text{ error} = \left| \frac{\text{Theoretical value - Experimental value}}{\text{Theoretical value}} \right| \times 100\%$$

Post Lab Questions

1. Calculate the mass of air at STP in an empty refrigerator which has a volume of 1.2 m^3. Use dimensional analysis and show all work!!
2. Using Dalton's Law of Partial pressure and the percent composition of air, calculate the partial pressure of each component of your air sample.
3. Why don't we feel the weight of air pressing down on us?

Conclusion - A one sentence conclusion that refers back to your stated purpose. Be sure to use your lab data to support your conclusion.