

Experiment 8

Gas Laws

OUTCOMES

After completing this experiment, the student should be able to:

- use the pressure probe to carry out experiments with gases.
- determine the relationship between the pressure and volume of a gas.

DISCUSSION

Pressure, volume, temperature, and amount (or moles) of gas are properties of gases that reveal their relationships when any one of them is varied. For example, if we wanted to look at the relationship between volume and moles, holding pressure and temperature constant, we can think about blowing up a balloon. What happens to the volume of the balloon as you blow more moles of gas into it? The volume increases – at least until the balloon pops. Because the volume increases as the moles are increased, we would say that volume and moles are directly proportional to each other and could develop the following relationship between the two:

$$V = n \times \text{constant} \text{ or } \frac{V}{n} = \text{constant}$$

A graph of V vs. n should then give a straight line whose slope is equal to V/n . Any other pair of properties may also be studied to determine the effects that changes in one have on the other. Studying these relationships between the properties enables one to predict their values under given conditions.

In this experiment, you will determine the relationship between the pressure and volume of a gas at constant temperature. You will draw upon your experience with computer-based laboratory methods from previous lab activities utilizing the computer. You will use the Logger Pro program and a pressure-sensing probe. The data you collect will be non-time based, meaning you will be entering values manually. As with all computer-based experiments, your analysis of the data is the most important part of the experiment.

PROCEDURE

⚠ Save your data early and often in order to avoid the accidental loss of your work.

Preparing Logger Pro for Measurements

1. Connect the pressure sensor to Channel 1 of the LabPro[®] interface. You may need to use an adapter to connect the probe to the interface.
2. Open the Logger Pro application from the Start menu or the desktop. Check your probe to see whether it is labeled “Pressure Sensor” or “Gas Pressure Sensor.” Open the appropriate **Boyle’s Law** file for your specific pressure sensor probe from the **Probes & Sensors** folder of the **Experiments** folder.
3. Click on the LabPro icon on the toolbar, then on **Channel 1**. Select “mmHg” from the list of units possible for making measurements.

Collection of Data

1. Set the plunger of the syringe to 1/10 of the capacity of the syringe (the 2.0 mL mark if using a 20 mL syringe). The volume is read from the edge of the bottom rib of the plunger.
2. Attach the syringe to the connector at the end of the sensor. If you have a blue stopcock attached to the syringe, make sure that the blue valve is turned in such a way that the syringe is open to the sensor and closed to the atmosphere.
3. Decide which of you will control the syringe (you or your lab partner) and which will enter the volumes into the computer. Click **Collect** on the toolbar to begin collecting data.
4. Read the volume on the syringe and click **Keep**. Enter the volume to the nearest ± 0.1 mL into the data box that opens and click “OK.” The pressure will be automatically recorded.
5. Pull the plunger back in increments of 1/10 of the capacity of the syringe (2.0 mL increments if using a 20 mL syringe) and manually enter the volume each time as in step 4. If you did this correctly, you should have 10 readings when finished. *NOTE: Hold the plunger firmly and steadily. It will become increasingly difficult to pull back with each reading. Do not click on **Keep** until each volume reading is ready to be made.*
6. Click **Stop** once you have taken all of the readings. Remove the syringe from the sensor.
7. Repeat steps 1 to 6, except set the initial reading of the plunger to 1/5 of the capacity of the syringe in step 1 (the 4.0 mL mark if using a 20 mL syringe). This should give you 9 readings for the trial.
8. Repeat steps 1 to 6, except set the initial reading of the plunger to 2/5 of the capacity of the syringe in step 1 (the 8.0 mL mark if using a 20 mL syringe). This should give you 7 readings for the trial.



DATA ANALYSIS

1. Copy and paste the data from each trial into a separate sheet of an Excel spreadsheet. *Make sure to save your spreadsheet early and often to either the M:drive or your own flash drive.*
2. It turns out that the volume reading on the syringe is not equal to the volume of the gas since some gas occupies the space inside the tubing and inside the pressure sensor. To correct for this, add a new column to each of your sheets between the existing volume and pressure columns called corrected volume. In this column, add 0.5 mL to each of your syringe readings if your sensor was a “Gas Pressure Sensor.” If your sensor was a “Pressure Sensor,” add 2.3 mL to each of your syringe readings. To abbreviate, use V_s for syringe readings, V for corrected volumes, and P for pressure.
3. Create columns in each sheet to calculate V^2 , $1/V$, $1/V^2$, $\log V$, and 10^V . Use the curve-fitting techniques you learned in Spreadsheet II Lab to determine a mathematical relationship between pressure (P) and corrected volume (V). Assign pressure to the y-axis. The various forms of corrected volume will be on the x-axis. Keep only the graph that is linear.
4. Does your data show that pressure and volume are directly proportional, inversely proportional, or some other relationship?
5. For your best-fit linear graph, use the trendline analysis to determine a mathematical equation for the relation. On the plot of P vs. $1/V$ and P vs. $1/V^2$, the y-intercept should be set to zero.
6. Make a new column on each sheet that calculates the product of P and V . At the bottom of this column, use a formula to calculate the average product.
7. How does the average product of PV compare to the slope of your best-fit line for each trial?
8. For each trial, calculate the pressure in the syringe if the reading on the syringe, V_s , was 15 mL. Show your calculation.



POSTLAB ACTIVITY

You will be turning in a worksheet for this experiment. It will be completed either individually or in pairs, according to your instructor's directions. If you are submitting the worksheet electronically, the tables and graphs that you generated in the data analysis will be pasted into

the worksheet. The worksheet contains embedded Excel tables into which you may paste your tables. The graphs will have to be copied and pasted into the appropriate sections.

Follow your instructor's directions for submitting the worksheet. If you are submitting electronically, please use the following convention for naming your worksheet: *Lastname1 Lastname2 Gas Laws*. If you are emailing the worksheet, use a subject line of *Chem 1061: Gas Laws Lab*.