Boyle's Law: Pressure-Volume Relationship in Gases

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 Gas Pressure Sensor (see Figure 1). 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 be monitored using a Gas Pressure Sensor. It is assumed that temperature will be constant throughout the experiment. Pressure and volume data pairs will be collected during this 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 volume of the confined gas. Historically, this relationship was first established by Robert Boyle in 1662 and has since been known as Boyle's law.

OBJECTIVES (You will need this information to write out a purpose for the experiment.)

In this experiment, you will

- Use a Gas Pressure Sensor and a gas syringe to measure the pressure of an air sample at several different volumes.
- Determine the relationship between pressure and volume of the gas.
- Describe the relationship between gas pressure and volume in a mathematical equation.
- Use the results to predict the pressure at other volumes.

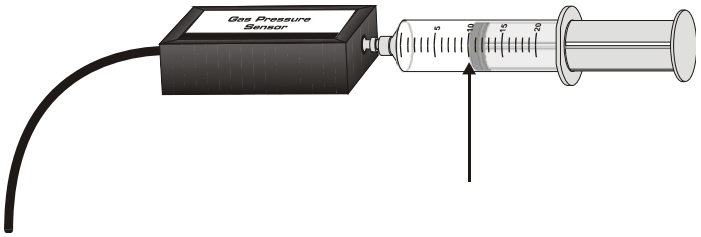

Figure 1

MATERIALS (THIS DOES NOT NEED TO BE IN THE NOTEBOOK BUT MIGHT BE IMPORTANT FOR THE PROCEDURE.)

computer
Vernier computer interface
Logger*Pro*
Vernier Gas Pressure Sensor
20 mL gas syringe

PROCEDURE (SUMMARIZE THIS INTO A PARAGRAPH FOR YOU NOTEBOOK.)

1. Prepare the Gas Pressure Sensor and an air sample for data collection.
   a. Plug the Gas Pressure Sensor into Channel 1 of the computer interface.

b. With the 20 mL syringe disconnected from the Gas Pressure Sensor, move the piston of the syringe until the front edge of the inside black ring (indicated by the arrow in Figure 2) is positioned at the 10.0 mL mark.

c. Attach the 20 mL syringe to the valve of the Gas Pressure Sensor.

2. Prepare the computer for data collection by opening the file "06 Boyle's Law" from the *Chemistry with Computers* folder of Logger*Pro*.

3. To obtain the best data possible, you will need to correct the volume readings from the syringe. Look at the syringe; its scale reports its own internal volume. However, that volume is not the total volume of trapped air in your system since there is a little bit of space inside the pressure sensor.

   To account for the extra volume in the system, you will need to add 0.8 mL to your syringe readings. For example, with a 5.0 mL syringe volume, the total volume would be 5.8 mL. *It is this total volume that you will need for the analysis.*

4. Click Collect to begin data collection.

5. Collect the pressure *vs.* volume data. It is best for one person to take care of the gas syringe and for another to operate the computer.

   a. Move the piston to position the front edge of the inside black ring (see Figure 2) at the 5.0 mL line on the syringe. Hold the piston firmly in this position until the pressure value stabilizes.

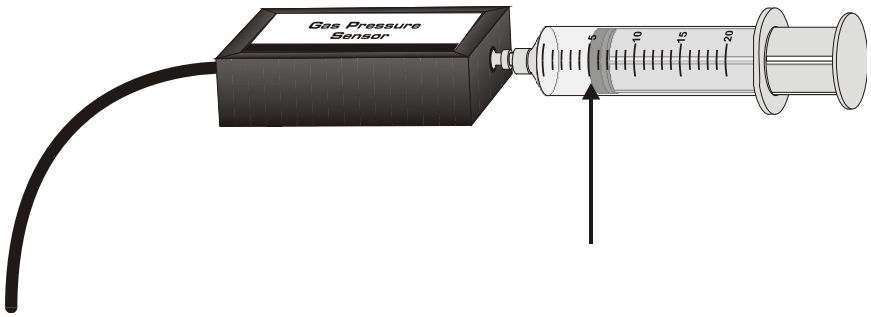

Figure 2

   b. When the pressure reading has stabilized, click Keep. (The person holding the syringe can relax after Keep is clicked.) Type in the total gas volume (in this case, 5.8 mL) in the edit box. Remember, you are adding 0.8 mL to the volume of the syringe for the total volume. Press the ENTER key to keep this data pair. Note: You can choose to redo a point by pressing the ESC key (after clicking Keep but before entering a value).

   c. Move the piston to the 7.0 mL line. When the pressure reading has stabilized, click Keep and type in the total volume, 7.8 mL.

   d. Continue this procedure for syringe volumes of 9.0, 11.0, 13.0, 15.0, 17.0, and 19.0 mL.

   e. Click Stop when you have finished collecting data.

6. In your data table, record the pressure and volume data pairs displayed in the table (or, if directed by your instructor, print a copy of the table).

7. Examine the graph of pressure *vs.* volume. Based on this graph, decide what kind of mathematical relationship you think exists between these two variables, direct or inverse. To see if you made the right choice:
   a. Click the Curve Fit button,  .
   b. Choose Variable Power ($y = Ax^n$) from the list at the lower left. Enter the power value, *n*, in the Power edit box that represents the relationship shown in the graph (e.g., type "1" if direct, "–1" if inverse). Click Try Fit.
   c. A best-fit curve will be displayed on the graph. If you made the correct choice, the curve should match up well with the points. If the curve does not match up well, try a different exponent and click Try Fit again. When the curve has a good fit with the data points, then click OK.

8. Once you have confirmed that the graph represents either a direct or inverse relationship, save a copy of the graph in your student server folder, with the graph of pressure *vs.* volume and its best-fit curve displayed. Also place a copy in your teacher's class "drop-box".

9. With the best-fit curve still displayed, proceed directly to the Processing the Data section.

DATA AND CALCULATIONS (SET THIS UP IN YOUR LAB NOTEBOOK)

Volume (mL)	Pressure (kPa)	Constant, *k* (*P*/*V* or *P*•*V*)