Exploring the Properties of Gases

The purpose of this investigation is to conduct a series of experiments, each of which illustrates a different gas law. You will be given a list of equipment and materials and some general guidelines to help you get started with each experiment. Three properties of gases will be investigated: pressure, volume, and temperature. By assembling the equipment, conducting the appropriate tests, and analyzing your data and observations, you will be able to describe the gas laws, both qualitatively and mathematically.

OBJECTIVES

In this experiment, you will

Conduct a set of experiments, each of which illustrates a gas law.
Gather data to identify the gas law described by each activity.

MATERIALS

Vernier computer interface
computer
Vernier Gas Pressure Sensor
Temperature Probe
20 mL gas syringe
plastic tubing with two Luer-lock connectors
rubber stopper assembly with two-way valve
large-volume container for water bath (at least 10 cm in diameter and 25 cm high)
125 mL Erlenmeyer flask
hot-water supply (up to 50°C) or hot plate
ice
100 mL graduated cylinder

PROCEDURE

Part I Pressure and Volume

1. Obtain and wear goggles.

2. Position the piston of a plastic 20 mL syringe so that there will be a measured volume of air trapped in the barrel of the syringe. I suggest a volume of 10 mL in a 20 mL syringe. Attach the syringe to the valve of the Gas Pressure Sensor, as shown in Figure 1. A gentle half turn should connect the syringe to the sensor securely. **Note:** Read the volume at the front edge of the inside black ring on the piston of the syringe, as indicated by the arrow in Figure 1.

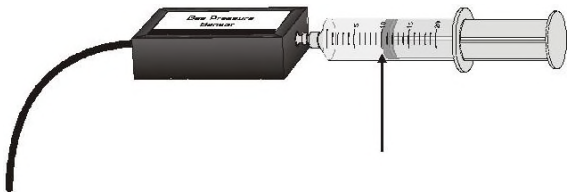

Figure 1

3. Connect the Gas Pressure Sensor to Channel 1 of the Vernier computer interface. Connect the interface to the computer using the proper cable.

Computer 30

4. Start the Logger *Pro* program on your computer. Open the file "30a Gases" from the *Advanced Chemistry with Vernier* folder. **Before collecting any data you must click on the green** Collect **button on the toolbar.** The button will change to a red **Stop** button. **Do not click on the** Stop **button until all data for this part have been collected**.

5. Click the Keep button. In the data box that opens, enter the volume reading of the air in the syringe as accurately as you can.

6. Measure the pressure of the air in the syringe at various volumes by moving the plunger of the syringe in or out. **NOTE:** Make sure you do not accidently pull the plunger completely out of the syringe. If you do, you will have to start over from step 2. The best results are achieved by collecting at least six data points. Click on the Stop button.
   Print a copy of the graph and data, using File than Print command.

Part II Volume and Absolute Temperature

In this experiment, you will study the relationship between the volume of a gas sample and its absolute temperature. Using the apparatus shown in Figure 3, you will place an Erlenmeyer flask containing an air sample in a water bath and you will vary the temperature of the water bath. Keep some of these factors in mind as you plan your procedure.

If you are starting with a cold-water bath, set the piston at the 0 mL mark on the syringe. This will allow the gas volume to be increased in warmer water baths.
The temperature of the water bath cannot be increased by more than 30-40 degrees from your starting temperature.
It is important to know the *total* volume of air in the flask *and* the syringe. The volume of the flask, up to the bottom of rubber stopper, can be estimated using the values on the side of the Erlenmeyer Flask. For the estimated volume of the tubing (from the rubber stopper to the Gas Pressure Sensor box), as well as in the valve below the bottom of the syringe, use a value of about 4 mL. Add these 2 values together and always add them to the syringe readings when entering the volume data.

10. Ensure that the Gas Pressure Sensor is plugged into to Channel 1 and the Temperature Probe is plugged into Channel 2 of the interface.

11. Assemble the apparatus shown in Figure 3. Be sure all fittings are air-tight. Make sure the rubber stopper and flask neck are dry, then twist and push hard on the rubber stopper to ensure a tight fit. Be sure the water level is at least as high as the confined air in the syringe.

Figure 3

12. Open the file "30c Gases" from the *Advanced Chemistry with Vernier* folder. This file is set up to collect pressure and temperature data from the attached sensors, using Events with

Entry mode. This mode allows you to collect a data pair simultaneously from the Gas Pressure Sensor and Temperature Probe by clicking on the Keep button and entering a value for the volume.

Before beginning data collection you must click on the green Collect button on the toolbar, which will change to a red **Stop** button. . **Do not click on the Stop button until all data for this part have been collected**.

12. Set-up a second beaker filled 2/3 full with tap water, on a hot plate, and heat at a low to middle setting.

13. Collect volume data at 4 different temperatures. Set up water baths in the large-volume container as you need them, ranging from ice water to hot water.

    a. Start with a mixture of ice and water in the beaker. **Make sure the plunger on the syringe is pushed all the way down**. The temperature reading should be close to 0 degrees Celsius or 273 K. Click on the Keep button and then enter the volume of the flask (125 mL) + the volume of the tubing (4mL)).

    b. For the 2nd reading, pour the ice-water mixture down the drain and fill the beaker with tap water. Place the syringe-flask assembly with all probes in this beaker. Move the plunger on the syringe until **the pressure reading is the same as the value in the previous step**. Click on the Keep button and **add the syringe** volume reading to the volume reading from the previous step.

    c.. For the 3rd reading, add some the ice to the beaker by hand. Try to get a temperature of about 10 degrees Celsius or 283 K. Again move the plunger on the syringe in or out **until the pressure reading is the same as the value in the previous steps**. Click on the Keep button and **add the syringe** volume reading to the volume reading from the first step.

    d. For the 4th reading, take the hot water beaker off the hot plate and place on the desk. Move the temperature probe to the hot beaker and make sure that the temperature is no higher than 40 degrees Celsius or 313 K. If it is **not** , cool it down by adding some ice. Move the rest of the syringe-flask plus probes assembly to this beaker. **Again move the plunger on the syringe in or out until the pressure reading is the same as the value in the previous steps**. If you cannot keep the syringe on the graduated part of the barrel, add more ice, until you can do so, but do go below the temp. reading of the reading #2 (room temp). If you need help, call your instructor over.
    Click on the Keep button and **add the syringe** volume reading to the volume reading from the first step. Click on the **Stop** button.

14. Print a copy of the graph and data using File than Print

    command.

15. DATA ANALYSIS

1. Does the graph for Part I illustrate Boyle's Law? How do you know?

2. Does the graph for Part II illustrate Charles' Law? How do you know?