

## Experiment 3

### Boyle's Law

$$\text{pressure} \propto 1/\text{volume}$$

or

$$\text{pressure} \times \text{volume} = \text{constant}$$

For a system composed of a fixed quantity of gas at constant temperature, it is observed that the measured system pressure is inversely proportional to the volume occupied by the gas. This relationship is known as Boyle's Law named after the physicist Robert Boyle (1627-1691) who first stated it. It may also be written as follows: if the temperature of a confined gas does not change, the product of the pressure and the volume is constant.

Boyle's Law can be derived from any closed isothermal system in which the pressure or volume can be varied providing these quantities can be measured. A good example of this might be a closed vessel of known initial volume with a plunger at one end and a pressure gauge at the other. The pressure is read directly whereas the volume is proportional to the height of the plunger. Another useful but somewhat cruder system is a familiar one - the expanding balloon. The balloon represents a closed system whose volume and pressure is changed by varying the force of the surrounding air on its exterior surface (see The Expanding Balloon in the demonstration section of this manual).

There are two primary goals of this exercise: to use a vacuum system and a balloon to test Boyle's Law, and to discuss the difference between model and experimental observations.

#### ***Experiment #3: Gas Invariance to PV Product***

- Measure the initial volume of the balloon.

Construct a theoretical P vs. V curve (model) by determining the value of the constant at atmospheric pressure using the measured volume of the balloon and then calculate a set of P, V points for a number of pressure values.

Place the balloon in the vacuum chamber and begin the pumpdown. Since the balloon is expanding to equalize its internal pressure with the reduced external pressure of the vacuum jar the pressure can be read directly from the gauge. Note that you can stop the pump for brief periods of time to take data points or you can pump until the balloon reaches maximum expansion, shut off the pump, and vent the system in controlled increments of pressure.

The only other measurement that is needed is that of the volume of the now nearly spherical expanding balloon which is in the vacuum jar. There are a number of ways to obtain values for the volume and we will leave the approach to making this measurement up to you. Be creative but remember to be as accurate as you can!

- Plot the pressure vs. volume data on the graph paper provided. Using the initial (atmospheric) PV product where the volume of the balloon is accurately known, calculate a theoretical volume for each recorded pressure and plot this PV data on the same graph.

Compare the experimental results with the theoretical values. Discuss the likely sources of error. Aside from measurement errors how does the choice of the experimental setup play a role in the inaccuracies present in the data? (Hint: How does the balloon itself affect the volume measurements?).

