BOYLE'S LAW

A SMALL-SCALE EXPERIMENT

Acknowledgment

This experiment is a very slightly modified version of an experiment developed by Dr. Sylvia Cooper, Ms. Kathy Conway, and Mr. Phil Guseman, teachers at Morgantown High School in West Virginia. We are grateful to these teachers for making the details of this experiment available to us, and pleased that we can make other teachers aware of the excellent experiment the Morgantown group developed.

These Morgantown teachers are nationally known for their well-written, innovative microscale chemistry experiments. For further information about their work and how you can acquire a copy of their set of experiments, contact Dr. Sylvia Cooper, Morgantown High School, 109 Wilson Avenue, Morgantown, WV 26505.

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Boyle's Law states that the volume of a gas varies inversely with the pressure. In other words, as the pressure on a confined gas increases, the volume of the gas decreases; conversely if the pressure decreases, the volume increases.

This relationship can be expressed by the proportionalities below:

$$V \propto \frac{1}{P} \quad \text{or} \quad P \propto \frac{1}{V}$$

Where V represents the volume of the gas and P represents the pressure.

Another way to express the relationship is:

$$V = k\left(\frac{1}{P}\right) \quad \text{or} \quad P = k\left(\frac{1}{V}\right)$$

Where k is a proportionality constant.

Rules of algebra tell us that an equality of this type, when plotted, gives a straight line. Thus, if we plot P versus $\frac{1}{V}$, we should get a straight line with a slope of k.

Discussion

For this experiment you will be given a sealed Beral pipet containing a colored liquid in the bulb of the pipet and air trapped in the stem between the liquid and the tip of the pipet. By putting pressure on the bulb of the pipet, some of the liquid in the bulb is forced into the stem of the pipet. This causes the air in the stem to be compressed (since it cannot escape) and its volume decreased.

We shall place books on the bulb of the pipet as a means of increasing the pressure on the system. The pressure on the gas confined in the pipet is a function of the number of books placed on the pipet bulb. The volume of the trapped air is proportional to the length of the trapped air column. For this experiment it is not necessary to use the "official" units for pressure and volume. We shall simply use number of books as our unit of pressure and length in millimeters of the air column as our unit of volume. This experiment will be done at room temperature, so you can assume the temperature is constant for the brief time needed to complete the measurements.

Supplies

1 sealed, colored liquid-filled Beral pipet with a transparent plastic metric ruler attached
1 magnifying glass
6 identical textbooks

Procedure

1. Obtain a colored liquid-filled pipet. The liquid in the pipet should all be in the bulb. If it is not, shake it down as directed.

2. Read the length of the air column in millimeters. Record this value to two decimal places under "stem reading" on the data sheet. This is your zero book reading.

3. Gently place one book on the pipet bulb. Re-read the length of the air column. Record this value to two decimal places on the data sheet.

4. Repeat step 3 until a total of five or six books are on the bulb. As subsequent books are added to the first book, make sure the front edge of each book is vertically aligned with the edge of the book below it.

5. Remove the books and return all equipment.

6. Calculate 1/V and record to three significant figures.

7. Plot pressure, P, on the y axis (in number of books) versus volume, V (in mL), on the x axis. Connect the data points in a smooth curve to give Graph 1.

8. Next, plot P on the y axis(in number of books) versus 1/V on the x axis (in mL^{-1}). Draw the best straight line.

Questions

1. What unit of pressure is used in this experiment?

2. What is the dependent variable in this experiment?

3. What is the independent variable in this experiment?