Effects of Variations in Air volume on Air Pressure – Boyle`s law

Introduction

Gases are distinguished from liquids and solids by their ability to be compressed into much smaller volumes. According to Boyle's law, the volume of a sample of gas at a given temperature varies inversely with the applied pressure:

$$V \propto 1/P \quad \text{or} \quad PV = \text{constant}$$

In this experiment we investigate the relationships existing between pressure and volume in their effect on gas behavior, by measuring the effects of changes in air volume on the pressure of air sealed in a flask.

Equipment

- A 50 ml glass flask.
- A rubber cork.
- A 50 ml plastic syringe.
- Two 23 gauge syringe needles.
- 3 short latex tubes.
- A three way valve.
- A pressure sensor.
- A stand.
- A MultiLog.

Equipment Setup Procedure

1. Connect the MultiLog to the serial port of the computer and to the power supply.
2. Connect the pressure sensor to the I/O 1 port of the MultiLog
3. Assemble the equipment as illustrated in figure 1 below.
4. Turn the MultiLog on. Set the MultiLog up according to the setup specified below. You can set up the MultiLog in two ways: Use the keyboard of the MultiLog or select the **Control Panel** from the **Logger** menu.

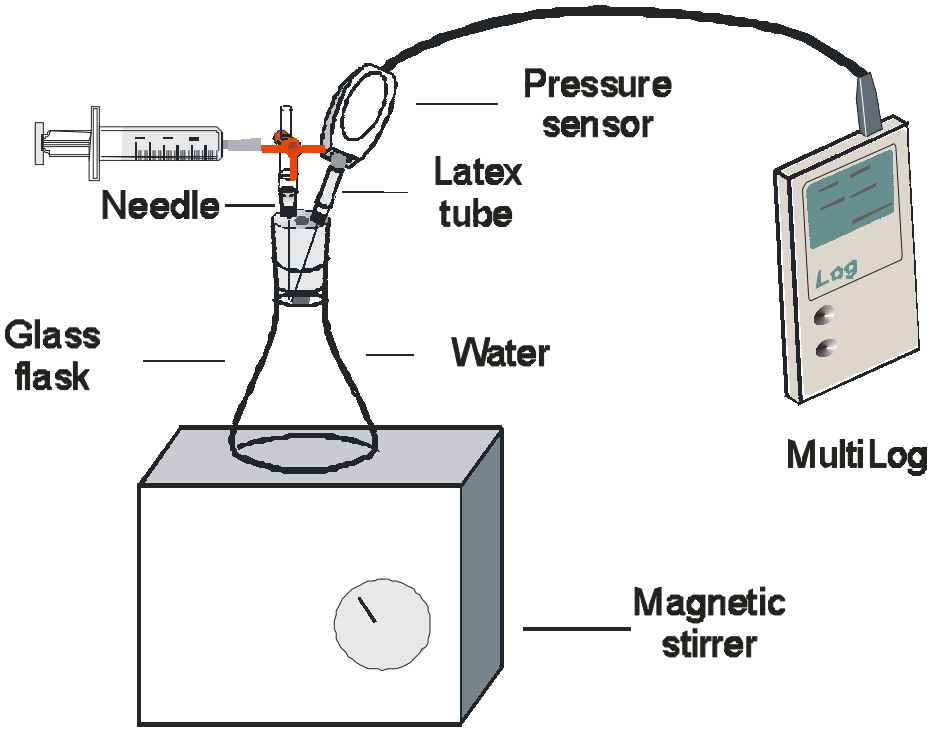


figure 1

Two syringe needles (no 23) are inserted through the cork, till their tips project somewhat out of the cork (figure 2)

To the other end of one of the needles, projecting out of the upper side of the cork, a three way valve (the one used in infusions) is attached via a very short latex tube. A 50 ml syringe is attached to the latex tube on the other end. A pressure sensor is connected to the second needle, through another short latex tube.

Turn the valve till its opening is directed vertically. In this position, air can flow through the valve from the flask to the surroundings. In order to stop air flow, turn the valve till its opening reaches an horizontal position. In this position air can flow from flask to the syringe.

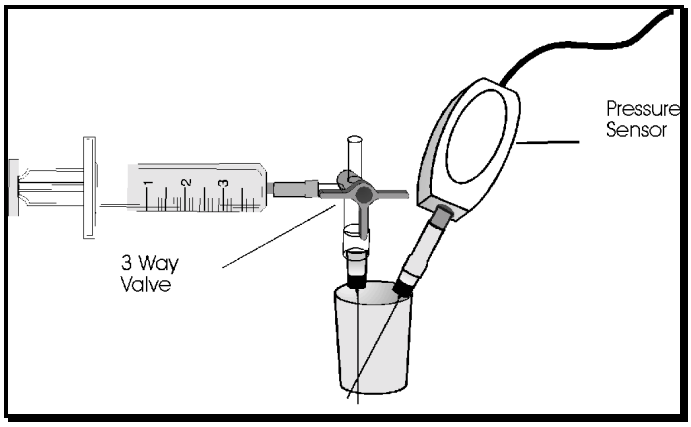


Fig. - 2

MultiLog Set Up

- Input 1: Pressure
- Rate: Manual.
- Samples: 50.

Experimental Procedure

1. Fill the glass flask with water. Leave a small volume of air in the flask, to prevent water penetration into the needles.
2. Close tightly the flask with the cork. Make sure that the system is completely sealed from air penetration!
3. Follow the pressure level in the flask. Collect the data manually: Push the **Run** button in the MultiLog any time you wish to collect data.
4. Turn the valve attached to the cork of the flask, till an atmospheric pressure (about 0 mBar) is obtained in the flask. Turn the valve again to enable air flow from the flask to the syringe.

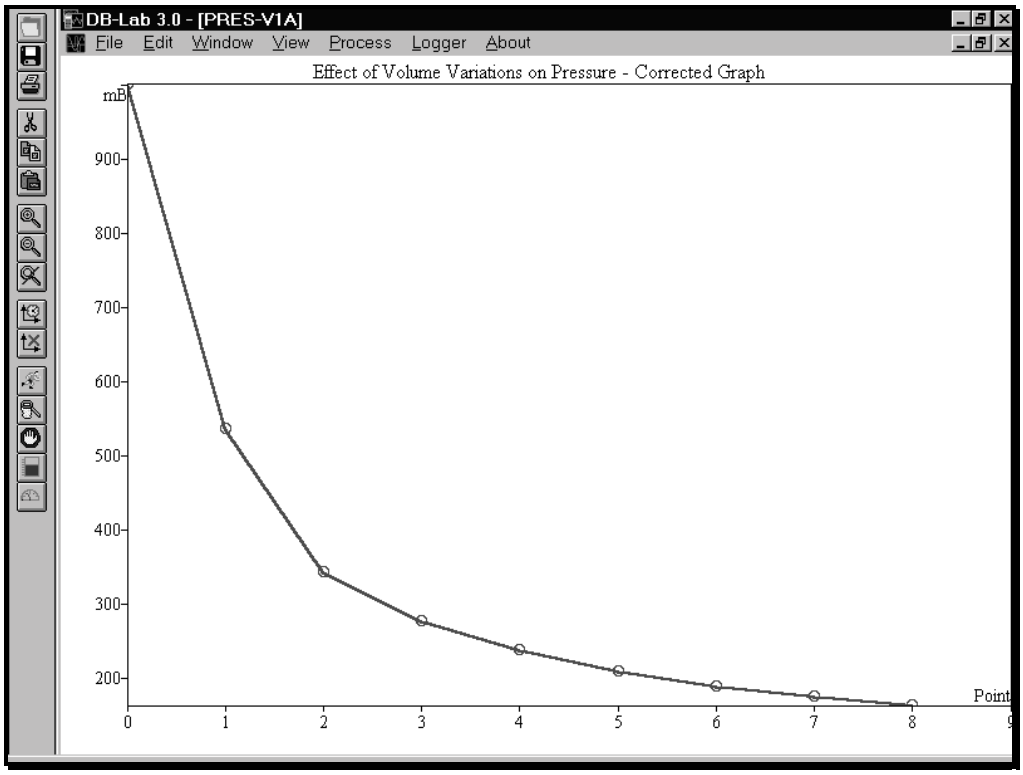
5. Draw the syringe's piston to about 5 ml volume. Push the **Samples** button in the MultiLog to receive the measured new value of pressure obtained after the increase in the volume of air in the system (syringe air volume added to air volume in the flask).
6. Repeat this step for at least 9 more samplings: draw the piston for an additional volume of 5ml each time.
7. Follow changes in pressure registered on the computer's monitor, during the experiment.

Data Analysis

1. The values of the pressure sensor, are in the range of -900 to 200 mBar. To receive appropriate relations between pressure and volume, positive values are needed. The values can be corrected by adding a constant value. Correct the values by performing the following steps:

- Choose **Process \ More \ linear** from the menu. The **Processing** dialog box will open
- Enter the value 1000 at C2. Make sure that the pressure appears in **Select G1**.

2. The graph obtained in the experiment is shown below:



3. Calculate the rate of changes in the pressure: Since increase in volume is inversely related to pressure, to receive a linear line, prepare 1/x curve:

*Choose **Process / Function / 1/x** from the menu. A linear line is obtained. Prepare a linear regression of this line, by selecting **Linear Regression** from the **Process** menu. The graph and the formula of the linear regression will appear in the same window*

4. The slope of the regression line is the reaction rate measured in this experiment.

Questions

1. By what means was the volume of air in the system was changed?
2. Air volume was changed in a stepwise manner and data collected manually: What is the meaning of each point collected in this way?
3. How is the pressure developed in the experiment related to the changes in air volume? Support your conclusions with the results you obtained in the experiment.

4. The changes in volume were performed by adding a constant value at each step. The shape of the graph obtained exhibits a 1/x pattern. What is the explanation for that?

Further Suggestions

1. Start the experiment with a 1ml syringe attached to the cork, and the syringe‘s piston extended. Compress the air by pushing the piston. Follow the changes in pressure resulting from the compression.

Advantages of Using the MultiLog in Studying Boyle`s law

- Use of an easy to operate system, enabling the teacher and student to investigate the fundamental laws of gases.