EXPERIMENT 16:   BOYLE'S LAW

Introduction: You will examine the relationship between the volume and the pressure of an ideal gas, first recognized by the British/Irish scientist Robert Boyle in 1662. You will observe both aspects of Boyle's Law: that, under constant temperature and moles, volume and pressure are inversely proportional, and that the pressure-volume product is a constant.

PV = k   (constant T and number of moles)   or $\mathbf{P_1V_1 = P_2V_2}$

In this experiment, pressure and volume data are taken on a sample of air. You calculate the PV product for each set of P & V data, and you will graph the pressure and volume data. You will then be able to verify the validity of Boyle's Law.

Equipment/Materials:

Boyle's Law Labquest apparatus , graph paper (2), flexible drawing tool.

Procedure:

Note: your instructor will demonstrate the use of the apparatus. Also, the volume that you record is an *apparent volume*, not the real volume. Because of the additional volume within the connector tubing and the pressure gauge, a volume correction must be added to your recorded apparent volume. An additional 0.8 mL exists within the pressure apparatus which must be added to the apparent volume (syringe)

- Set up the labquest module with the pressure sensor as shown by your instructor.
- Press only the button on the upper left corner of the module to turn it on. Do not touch any of the buttons in the middle.
- With the stylus – choose the sensors menu and units to change from kPa to torr (or mmHg), the pressure reading will come up on the module close to 760 torr.
- Collecting the Data: (This may be an instructor demonstration.) With the connector tube disconnected, set the syringe plunger to a volume of 20.0 mL. Reconnect the connector tube and record the pressure on the pressure gauge. **CAREFUL** – the plastic is not strong so don't twist it hard !!! Do this only with the instructor's supervision. The pressure should be close to 760 torr. Record the P and V in the table. (apparent V – 20.0. actual V = 20.8 mL)
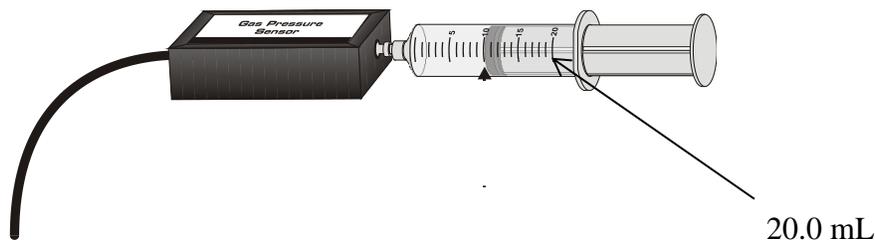
20.0 mL

- Choose six volumes that are less than 20.0 mL. You will compress the gas slowly to these volumes and record the resulting pressures. Record the volumes to the nearest 0.1 mL and the pressure to the nearest 0.1 psi. DON'T HOLD THE PRESSURE SENSOR – ONLY THE SYRINGE, WHILE CHANGING THE VOLUMES !!!! The connector can snap.
- The pressure sensor "maxes out" if the volume is less than 7 mL – so choose 6 volumes between 7 and 20. A steady hand is necessary to hold the syringe at the lower volumes. A partner might be useful to read the pressures while yhou are holding the syringe.

- RECORD ALL THE P & V READINGS IN YOUR NOTEBOOK FIRST. You may wish to do a second run, so don't clutter your report sheet with values until afterwards.

Analyzing the Data:

1) To your experimentally determined apparent volumes, add the volume correction and record the true volumes in the appropriate column on your data sheet.

2) Calculate the pressure-volume product (P x V) for each set of data and record the values in the appropriate column. Remember to use the corrected volume and the pressure in torr. Does this product vary significantly? Find the mean (average) value. Don't worry about sig figs for now – for ex if you get a PV product of 15437 just record it. When taking the average, reduce the number to three sig figs using scientific notation, for ex 1.54×10^3 mL torr

3) **Graph #1.** Plot your pressure (psi) vs. volume on graph paper.   The pressure should be on the vertical axis, and the volume should be on the horizontal axis. Be sure to label your axes. Include the units. Give the graph a title. Draw the best possible <u>smooth</u> curve. Do not merely "connect the dots!" Use the graph paper with at least 10 sq/inch

4) **Graph #2**. Plot P vs. 1/V using Excel. Use new points on the line – do not use your data points to find the slope On this graph, be sure to display the equation of the line.   Record the value of the slope .

If you wish to do a computer generated graph in addition to the P vs 1/V graph #2, go ahead and submit it for a few extra points. The trendline must be straight, and the slope calculated. A pretty "connect the dots " graph is not acceptable
In the Excel program, find the chart menu , go to *add trendline* then the *options* tab and select *display equation on graph* option.

Sir Boyle, in his book, published about 1660 "The Sceptical Chymist"
Emphasized that experiments must be quantitative and reproducible.
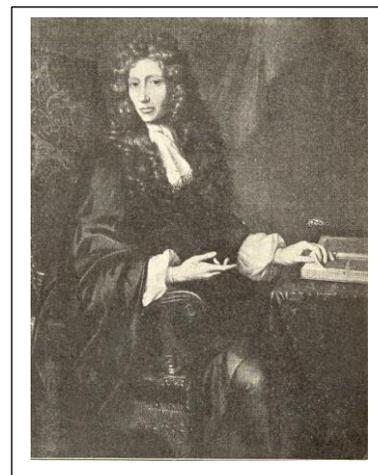
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Data table**:**

Volume correction used: 0.8 mL. Add this to the observed volume in each case to obtain the actual volume (second column). Then calculate 1/V (use the actual V)

Observed Volume (mL)	Actual Volume (mL)	$\frac{1}{V}$ (mL^{-1})	Gauge Pressure (torr)	P (torr) x V (mL) = k multiply the pressure in torr units by the actual V
20.0	**20.8**			

Average value of k _____

Graphing: 1. Graph the pressure (torr) on the y-axis and the actual volume (mL) on the x-axis, by hand. Label the graph properly.

2. Make another graph, plotting the torr units of P on the y-axis, and $1/V$ (mL^{-1}) on the x-axis. Give the equation of the line on the graph, and give the value of the slope: _____

Questions:

1. Do your data (see table above) prove Boyle's Law? How?

2. Compare the value of the slope of the second graph with the average k in the table above. Are the values consistent to 2 sig figs ?

3. Predict the pressure in torr units which you would expect to see if you could compress this system
      To a volume of 2.8 mL