
Experiment #2: Graphical Representation of Data and the Use of Excel[®]

Scientists answer posed questions by performing experiments which provide information about a given problem. After collecting sufficient data, scientists attempt to correlate their findings and derive fundamental relationships that may exist between the acquired data. Graphical representations of data illustrate such relationships among data more readily. A graph is a diagram that represents the variation of one factor in relation to one or more other factors. These variables can be represented on a coordinate axes. The vertical axis is the y-axis (or ordinate), and the horizontal axis is the x-axis (or abscissa). When plotting a certain variable on a particular axis, experiments are normally designed so that you vary one property (represented by the *independent variable*) and then measure the corresponding effect on the other property (represented by the *dependent variable*).

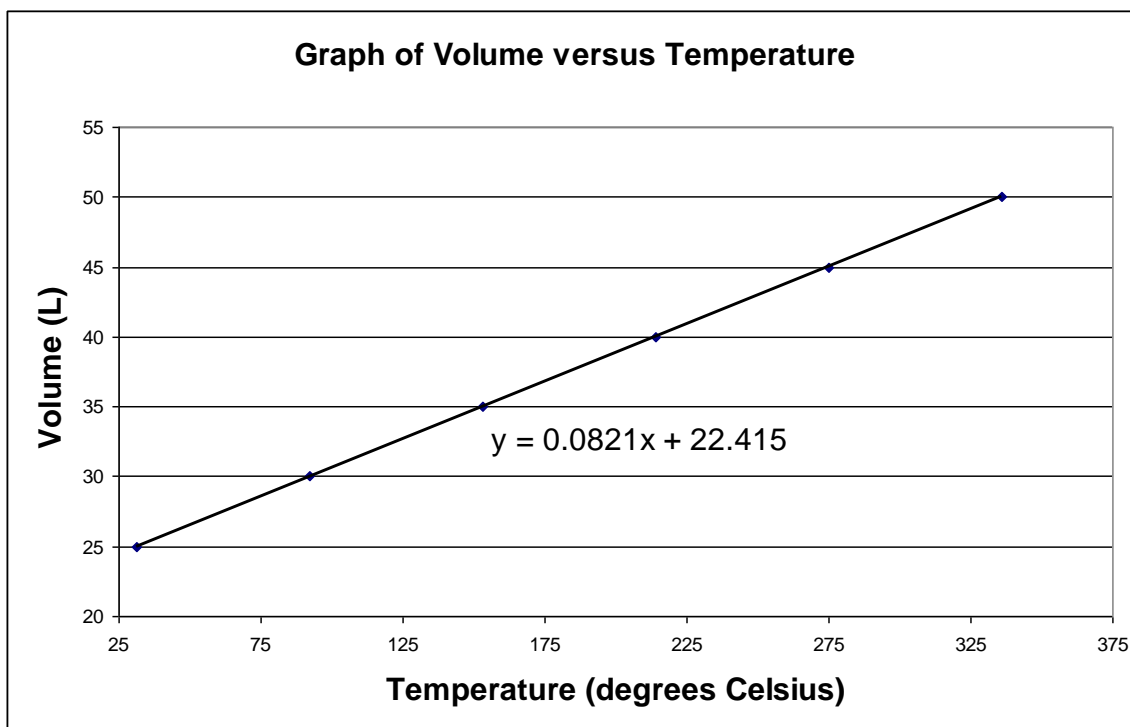
All graphs should conform to the following guidelines:

1. They should have a descriptive title.
2. The independent variable is conventionally placed on the horizontal axis; the dependent variable is plotted on the vertical axis.
3. Label both the vertical and horizontal axes with units clearly marked.
4. The scale chosen for the data should reflect the precision of the measurements. For example, if temperature is known to be ± 0.1 °C, you should be able to plot the value this closely. Moreover, the data points should be distributed so that the points extend throughout the entire page (as opposed to a small portion of the paper).
5. There should be a visible point on the graph for each experimental value.

Let us first examine a direct function involving a linear graph. Consider the following measurements made of an oxygen sample under standard pressure:

Temperature (°C)	Volume (L)
31.49	25.00
92.38	30.00
153.28	35.00
214.18	40.00
275.08	45.00
335.97	50.00

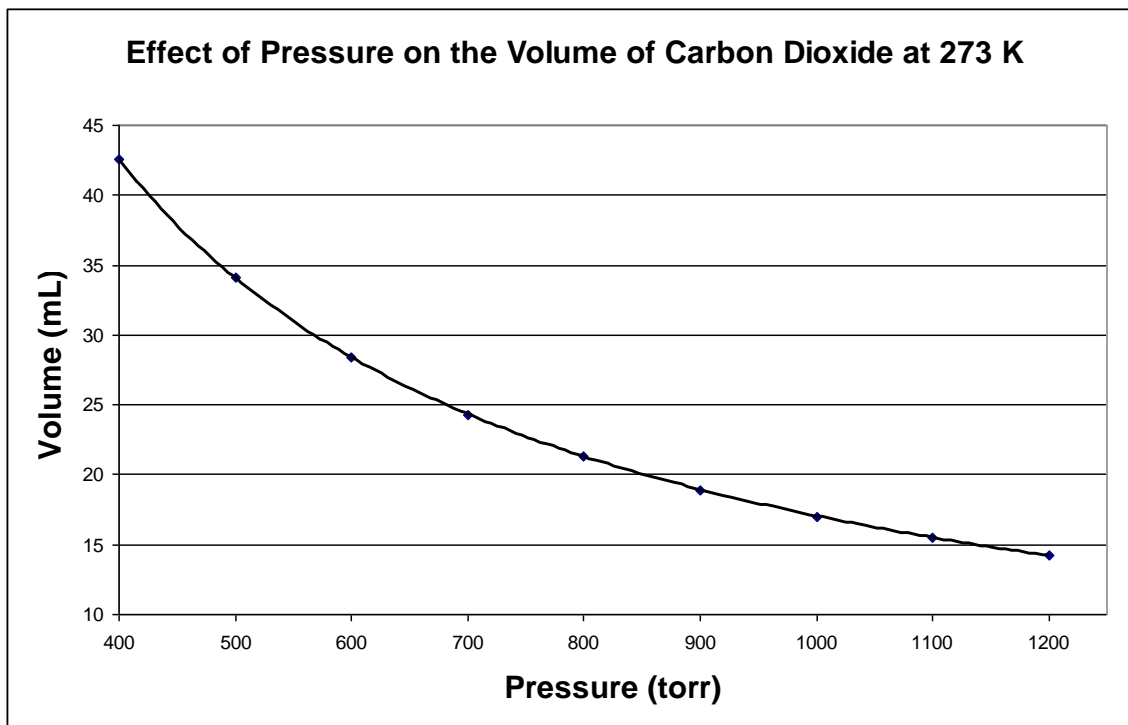
Using graph paper or any graphing program such as Microsoft Office Excel[®], one can first construct a plot of the data, where volume is determined to lie on the y-axis, and temperature is plotted on the x-axis. Once the data is plotted, a best-fitting line is constructed, and an equation of the line in slope-intercept form $y = mx + b$ is formulated, where m = slope and b = y-intercept. That is,



Now examine an indirect function involving a hyperbola. Consider the following measurements made of a carbon dioxide gas sample at 273 K:

Pressure (torr)	Volume (mL)
400	42.6
500	34.1
600	28.4
700	24.3
800	21.3
900	18.9
1000	17.0
1100	15.5
1200	14.2

Once again, using graph paper or any graphing program such as Microsoft Office Excel[®], one can construct a plot of the data, where volume is determined to lie on the y-axis, and pressure is plotted on the x-axis.



As depicted in the graph above, some chemical relationships are not linear; that is, there are no simple linear equations to represent such relationships. Instead, a plot of data for this kind of relationship gives a curved (non-linear) fit. Such a graph is useful in showing an overall chemical relationship, although the slope and the y-intercept are NOT relevant to its interpretation.

In this experiment, you will use acquired measurements and graphical analyses to determine the density of an unknown liquid, learn to use Microsoft Office Excel[®], and create computerized linear and non-linear graphs of provided experimental data. *Students without personal computers or Microsoft Office Excel[®] are invited to use the college's library computers designated for student use.*

Laboratory Procedure

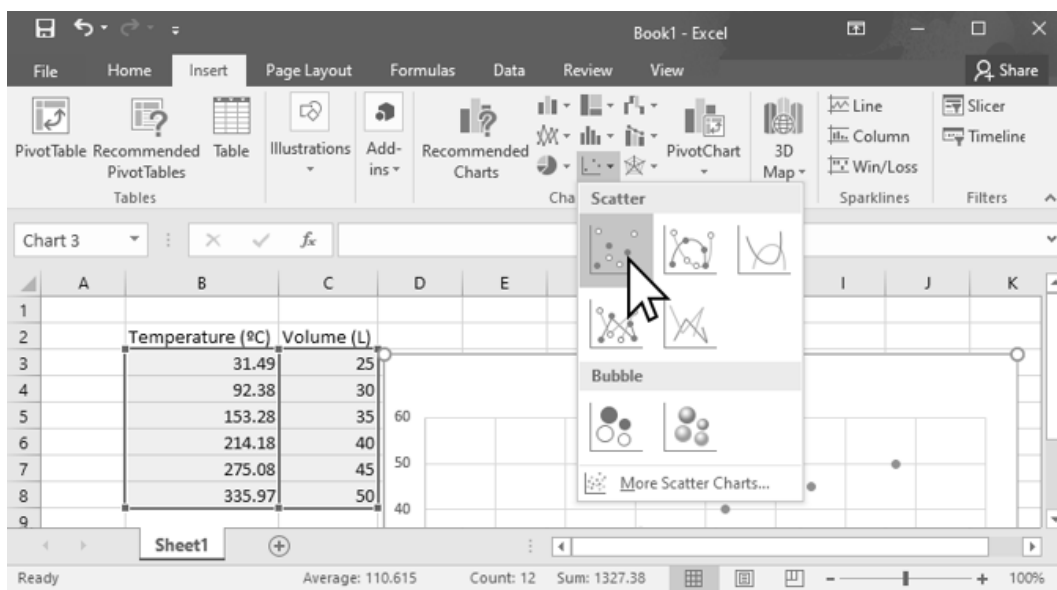
1. Fill one of the 100 mL beakers a little more than half-full of the unknown liquid assigned to you.
2. Pipette 10.00 mL of the liquid from the half-full beaker into the empty one. Pipettes are calibrated to deliver the volume of a liquid specified by the markings on the pipette. Make sure that the bottom of the concave meniscus of the liquid exactly coincides with the line marked on the upper stem of the pipette. Do NOT blow the liquid out of the pipette; let it drain naturally. If there is still a drop of liquid on the tip of the pipette, touch it gently to the side of the container to which the liquid is being transferred. Cover the beaker with the provided watch glass to avoid evaporation of the unknown liquid.

3. Weigh the beaker and cover with the 10.00 mL of liquid in it. Your measurements should be accurate to the nearest 0.001 g.
4. Transfer another 10.00 mL portion of the liquid to the beaker and reweigh the covered beaker and liquid. Repeat this process until you have SIX collective readings of volume and mass.

Excel® Procedure

Note that various versions of Excel® may function a bit differently from the directions outlined below (which work on department-owned laptop computers):

Put the title for your x-axis (include units) in one Excel® cell (box). In the cell to the right, put the title for your y-axis. Using these boxes as headings, input the numeric data (like a table) in the cells under these titles (each box should contain one number; each row represents one data point in x,y format). Click and drag your mouse to highlight just the numeric boxes. From the “Insert” tab, choose a “Scatter” plot. (See example, below.)



Your graph must include a meaningful Chart Title and Axis Titles (with units). These Chart Elements can be added to your graph by clicking on the “+” icon in the upper right corner of your graph. Your instructor may request additional Chart Elements.

To add a Trendline, right click on any data point on your graph and choose “Display Trendline” from the menu that appears. The format trendline pane will appear on the right side of your screen. Linear should be selected by default. From this pane, you should check the box next to “Display Equation on chart.” Your instructor may also ask you to check the box for “Display R-squared value on chart.”

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Data and Calculations

Liquid Unknown # _____

<u>Measurement #</u>	<u>Volume (mL)</u>	<u>Mass (g) of beaker + cover + liquid</u>
1	_____	_____
2	_____	_____
3	_____	_____
4	_____	_____
5	_____	_____
6	_____	_____

Post-lab Questions

1. Using your hand-written graph, determine the density of your unknown (recall that slope = $\Delta y / \Delta x$). When graphing, use all the data points, then draw the best fit straight line. Start at zero for the x axis, and about 10 to 20 grams less than your smallest mass for the y axis. The line may not exactly touch each point. Determine the slope using two points on the best fit line spread apart from each other. Do not use just two data points measured in the experiment as they may not be on the best fit line.
2. Using your hand-written graph, estimate:
 - A. the mass (in grams) of 27.0 mL of your liquid. _____
 - B. what volume (in mL) would 17.0 g of your liquid occupy. _____
3. Using your Excel[®] plot and constructed trendline, write the slope-intercept equation for your liquid unknown. What is the density of your unknown? Make sure to include the appropriate units. How does this density value compare to your result from question #1 above?

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4. Using your slope-intercept equation, determine:

A. the mass (in grams) of 27.0 mL of your liquid.

B. what volume (in mL) would 17.0 g of your liquid occupy.

5. The data for temperature and pressure of a certain sample of gas is found to be:

Temperature (°C)	Pressure (mmHg)
-196	215
-78.5	542
-17.8	711
0.1	761
22.7	824
99.3	1037
189	1287

The researcher seals the gas inside of a container, adjusts the temperature of the container, and then measures the pressure of the gas inside. Therefore, temperature is the independent variable and pressure is the dependent variable.

A. Construct an Excel[®] graph of this data with a linear trendline. Make sure to print out a copy of this graph with the slope-intercept equation of the trendline displayed for inclusion with this report. Rewrite the equation, below, using T and P instead of x and y to show the relationship between temperature (T) and pressure (P):

B. Use the equation of the line to calculate the expected pressure of the gas at a temperature of 42.3 °C.

C. Use the equation of the line to predict the temperature of the gas when its pressure is 437 mmHg.

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