Experiment Handout: 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 axis. 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:

|  |  |
| --- | --- |
| **Volume (L)** | **Temperature (ºC)** |
| 25.00 | 31.49 |
| 30.00 | 92.38 |
| 35.00 | 153.28 |
| 40.00 | 214.18 |
| 45.00 | 275.08 |
| 50.00 | 335.97 |

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

**Volume (L)**

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,

**Temperature (degrees Celsius)**

375

325

275

225

175

125

75

25

30

25

20

y = 0.0821x + 22.415

55

50

45

40

35

**Graph of Volume versus Temperature**

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

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

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.

**Effect of Pressure on the Volume of Carbon Dioxide at 273 K**

45

40

35

**Volume (mL)**

30

25

20

15

10

400 500 600 700 800 900 1000 1100 1200

**Pressure (torr)**

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/Microsoft Office Excel® are invited to use the college’s library computers designated for student use.*

# Laboratory Procedure – for this week, the data is provided for you!

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 FIVE collective readings of volume and mass.

# Excel® Procedure

Note that various versions of Excel® may function a bit differently from the directions outlined below. Please adjust accordingly. One set of instructions is provided for users with Microsoft Office Excel® 2007. If you encounter difficulties, consult your instructor for assistance.

If using Microsoft Office Excel® 2007, begin by typing the data onto your Excel® spreadsheet in (x, y) form. To plot the data, highlight the x/y coordinates, select ***Insert*** from the display menu followed by ***Scatter***, choose ***X Y (Scatter)***, and click ***OK***. To label the graph and coordinate axes, use the ***Layout*** function from the toolbar and select the appropriate ***Labels***.

Once your data is plotted, you can draw a best-fitting line for the data utilizing the **trendline** function. Place the mouse cursor on one of the data points and proceed to right- click. All the data points corresponding to a particular data set should now be highlighted. Right-click again, and various menu options will pop up; select ***Add Trendline…*** utilizing the left-click. If your graph involves a linear function, select ***Linear***. If your graph involves a non-linear function, select ***Power*** for this particular lab. Under the options menu, you can display an equation on your graph by selecting ***Display Equation on chart***. Finally, click on ***OK*** (or ***Close***) and print your graph.

Plot your acquired laboratory data BOTH on graph paper (see last page of this report) and Excel®. Make sure to submit both graphs with this report.

# Data and Calculations

Liquid Unknown # sample data provided below!

|  |  |  |
| --- | --- | --- |
| Measurement # | Volume (mL) | Mass (g) of beaker + cover + liquid |
| 1 | 10.00 mL | 104.941 g |
| 2 | 20.00 mL | 112.703 g |
| 3 | 30.00 mL | 120.575 g |
| 4 | 40.00 mL | 128.436 g |
| 5 | 50.00 mL | 136.298 g |

# Post-lab Questions

1. Using your hand-written graph, determine the density of your unknown (recall that slope = ∆y/∆x).
2. Using your hand-written graph, estimate:
   1. the mass (in grams) of 27.0 mL of your liquid.
   2. 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?

1. Using your slope-intercept equation, determine:
   1. the mass (in grams) of 27.0 mL of your liquid.
   2. what volume (in mL) would 17.0 g of your liquid occupy.
2. Consider the following data, showing the effect of temperature on the vapor pressure of water at 1 atmospheric pressure:

|  |  |
| --- | --- |
| **Temperature (K)** | **Vapor Pressure (torr)** |
| 273 | 4.6 |
| 283 | 9.2 |
| 293 | 17.5 |
| 303 | 31.8 |
| 313 | 55.3 |
| 323 | 92.5 |
| 333 | 149.4 |
| 343 | 233.7 |
| 353 | 355.1 |
| 363 | 525.8 |
| 373 | 760.0 |

* 1. Graph the data on Excel®, plotting pressure on the x-axis and temperature on the y-axis.
  2. The vapor pressure of a liquid is known to be an exponential function of the temperature. Therefore, the insertion of a *power trendline* allows you to see how well this particular set of experimental data agrees with the predicted behavior. Create a *power trendline* connecting your data points. Make sure to print out a copy of this graph for inclusion with this report.
  3. Finally, prepare an Excel® graph of the log P vs. 1/T (*note: log = logarithm, the exponent to which a base must be raised to produce a given number; this function is found on most scientific calculators*). How does this graph compare to your previously constructed Excel® graph? Is this data linear? Briefly explain any similarities/differences in your two graphs. Make sure to print out a copy of this graph for inclusion with this report.

1. The data for concentration and density of glucose solutions at 20 ºC is found to be:

|  |  |
| --- | --- |
| **Concentration (% by mass)** | **Density (kg/L)** |
| 1.00 | 1.0038 |
| 2.50 | 1.0095 |
| 3.00 | 1.0115 |
| 4.00 | 1.0154 |
| 5.50 | 1.0212 |
| 7.00 | 1.0272 |
| 9.00 | 1.0352 |

The researcher can adjust the concentration. Therefore, the % by mass is the independent variable, and the density is the dependent variable.

* 1. Construct an Excel® graph of this data. Use the trendline function to formulate the slope-intercept equation. Write this equation in terms of D and %. Make sure to print out a copy of this graph for inclusion with this report.
  2. Use the equation of the line to determine the density of a 4.80% glucose solution.
  3. Use the equation of the line to calculate the % by mass of a glucose solution whose density is 1.0652 kg/L.