A BEGINNER'S GUIDE TO SPREADSHEETS: *EXCEL*

A. Introduction

[note: These instructions, except where noted, are for the use of Excel on PCs. There *are* differences in behavior and use on Macs, but most of these are minor and will probably be obvious to regular Mac users. <u>However</u>, file structures for various versions of Excel are sometimes NOT compatible. The message? Be careful or you might lose your work.]

<u>GETTING STARTED</u>

Double-click on the *Microsoft Excel* icon and Excel will start initializing. Wait for the word **Ready** in the lower left-hand corner before beginning to work.

<u>THE SPREADSHEET</u>

As you will see on the screen a spreadsheet consists mainly of a grid of **cells** arranged in numbered rows starting with **1** at the top and also in columns, beginning with **A** at the left:
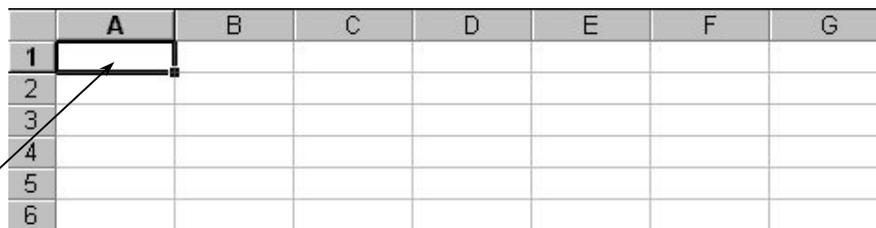
A cell is a slot for information which may be either text (words), numbers, or mathematical formulas. A spreadsheet is perhaps best thought of as a phenomenal scratch pad on which each little cell is a sophisticated calculator which is able to display both calculations as well as notes describing them. As such, it is a powerful tool which to some extent eliminates the need for programming skills in attempting mathematical modeling. It is also able to relieve the tedious task of repetitive calculation--something for which any student should be grateful!

<u>WINDOWS CONVENTIONS AND EXCEL</u>

You can easily move around the cell grid by using the arrow keys on the keyboard. **PageUp** and **PageDown** will move you vertically through screens of cells quickly. To move horizontally by screen widths, hold down the **Alt** key while pressing **PageUp** or **PageDown**. You can scroll through the cell grid by moving the mouse pointer [while on the cell grid the mouse pointer usually looks like a cross as opposed to an arrow] to the scroll bars on the right hand side of the screen and the bottom right corner. Positioning the pointer on the arrow head and pressing the left mouse button will make the grid scroll (try it!). You can also position the pointer on the square marker box within the scroll bar and drag it to another position by holding down on the left mouse button as you move it.

To move to the beginning of the sheet (i.e., **A1**), you can press **Ctrl-Home** on the keyboard (hold down the first key while pressing the second).

In the course of developing a spreadsheet you will frequently need to *select* certain cells or a region of cells. The currently selected cell has a **bold** border and you can select any cell by moving the mouse pointer to that location and pressing the left button. To select a series of cells (row or column), position the mouse pointer on the first cell you want, press the left button and hold it as you drag through the cells you want to select. They will be blackened. Release the mouse button when you reach your destination.

To select a block of cells, follow the procedure for selecting a column but move diagonally across the cells to the opposite corner of the block you want selected.

To select non-contiguous areas, hold down the **Ctrl** key as you make the selections.

To select an entire row or column click on the number or letter marker. To select the entire sheet, click on the "all" button (upper left hand corner where A and 1 meet.).

Selection can also be done from the keyboard, moving to the first cell you want using the arrow keys and then holding the **Shift** key down as you use the arrows keys to highlight the area you want.

To *cancel a selection*, simply click the mouse pointer on a non-selected area.

Throughout this tutorial reference will be made to the bar of *icons* near the top of the screen:

These icons are like buttons which perform special tasks. Most of them duplicate functions found on the pull-down menus above them but allow quicker access to the command sequences. Although many of the icons will be discussed in these pages, it is easy to forget which little picture stands for what function. If you can't remember, all you have to do is pause over the icon with the mouse pointer and a little box will appear that tells you the function of that particular icon.

Some commands are best accessed through the extensive pull-down menus that begin with **File** across the top of the screen:
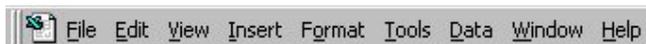
If you place the mouse pointer over one of these words and press the left button, a list of commands will appear below. These can be accessed in a similar fashion and some lead into an amazing array of options. All of which brings to mind perhaps the most important menu option: **Help**. There is extensive on-line help available from the computer along with examples of how to do specific things. When in doubt, by all means ask an instructor. But when on your own, try **Help**.

MAKING CELL ENTRIES

To make an entry all you have to do is move into a cell and start typing (well, almost). Try typing your name in cell **A1** (always press **Enter** after typing an entry--or use the arrow keys to move to another cell--so the computer knows you are finished). Although your name is probably longer than the current width of the cell all of it will appear (covering over cells to the right). Now move the active cell to **B1**. When you type anything in this cell, you will no longer be able to see all of the entry in **A1**, but it <u>is</u> still there. To see that is so all you have to do is move the active cell back to **A1** and look in the formula bar which is just above the column headings.

If you want to display your full name in column 1 you will have to make it wider. The easiest way to do this is to move the mouse pointer to the line segment between **A** and **B** in the column headings. A double arrow will appear. If you double-click the left mouse button the column is automatically sized for the widest entry it contains. You can also size the column manually by holding the mouse button down and dragging the column border. You can also format the width of a selected series of columns by choosing from the **Format** pull-down menu the option for **Column**. More general formatting hints follow this section on entering data in cells.

Entering a number is done in exactly the same way. Trailing zeros after a decimal point may not be displayed but you can adjust the number of decimal places displayed by using the decimal icons represented by these symbols:

<div align="center">

increase places   decrease places

</div>

To use these icons, select the cell or cells you want to format. Then click on either button to adjust the number of decimals *displayed.*

Very small or large numbers that require scientific notation can be entered in a format like this:

<div align="center">

to enter 1.08×10^{-4} type 1.08e-4

</div>

If a number you type is too long to fit in a cell, you will see ###. You can change the width of the column to solve this problem. Special number formatting needs not covered by this brief description can usually be accomplished with the **Format** pull-down menu, selecting **Cells**.

So far the spreadsheet is just a memo pad. But its real power lies in its ability to calculate. For that you need to enter a *formula*. Formulas are typed in much the same way as you would write them on paper except that you must first type an equal sign (=) so that the computer knows you are typing a formula and not just a line of text. Try typing this simple formula into cell **A4**:

<div align="center">

=2+5

</div>

The number 7 will be displayed in the cell after you press **Enter** but when the cell is active the formula you typed will appear in the formula bar below the icons. Other math symbols can be used of course, but you should know that three common ones are a little different for the computer. To multiply use an asterisk (*), to divide use the slash bar (/) and to raise to a power use the caret (^). Techniques for deleting, editing and special effects can be illustrated now with the information on your spreadsheet.

CHANGING CELL ENTRIES

Suppose you misspelled (or mistyped) your name in **A1**. You have several options. You can delete the entry and type it in again. A quick way to do this is to make the cell active and press the **Delete** key on the keyboard. If you double-click on the cell then you can edit right in the cell by positioning the insertion point marker and using the backspace, insert, delete, etc. on the keyboard. Or you can simply move up to the formula bar and do the work there (this is useful if you are editing a long formula which is only partly visible in the cell itself). When you are finished in the formula bar you move the mouse pointer to the green check mark and click on the left mouse button to enter your changes (or just press **Enter**).

For the purpose of emphasis you may want to make an entry bold or perhaps italicize or underline it. You can do this by selecting the cell and then using one of the icon buttons shown below:

B   *I*   U̲

Bold   *Italics*   Underline
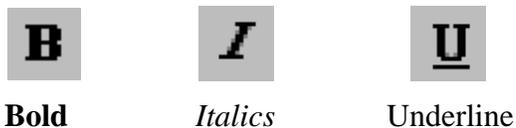
Since you are in A.P. Chemistry and may want to use sub- or superscripts occasionally in your text, you should know how to do that. In cell **C3** type H2O. Press **Enter** and then position the mouse pointer on the cell and double-click as if preparing to edit your entry. Use the arrow keys to position the cursor bar between the H and the 2.

You can select just the 2 in one of two ways: hold down the **Shift** key and use the right arrow key to move over the 2 (it is highlighted) or use the mouse pointer while holding down the left mouse button. Once the 2 is highlighted, pull down the **Format** menu.

Select **Cells**, click on the **Font** tab and mark the box for subscripting. Then click on **OK** or press **Enter**. This is somewhat tedious, so if you have a lot of sub- or superscripting to do you might want to use the keyboard equivalents. After marking (highlighting) the characters you want to change, hold down the **Alt** key while typing the following:

> *Superscript:* oee **Enter**
> *Subscript:* oeb **Enter**

Finally, alignment of text or numbers in cells or columns or rows is easily accomplished. First select the region or cell you want to format. Then choose from among these icons:

left align   center   right align
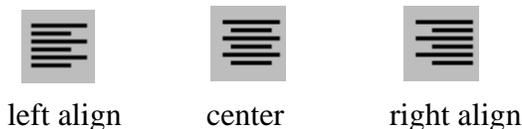
USING FONTS IN FORMATTING

The default font for the spreadsheet is Arial which you will see indicated up near the top left in a little box that has a pull-down menu. You may occasionally have use for some Greek letters or other special symbols. Most of these are contained in the Symbol font which you can select from the menu. Below is a table of some more commonly needed symbols and their keyboard equivalents. You can either change to the Symbol font and then type the symbol OR type the keyboard equivalent in the default font, select (highlight) the resulting letter and then select Symbol for just that character.

character	D	a	b	f	g	l	m	n	p	q	y	Alt 0174	Alt 0176	Alt 0214
symbol font	Δ	α	β	φ	γ	λ	μ	ν	π	θ	ψ	→	°	√
wingdings 3	⇆													

[note: Mac users access the Symbol font differently and have no equivalent for Wingdings 3]

B. Starting to use Excel

A CALCULATION USING REPLICATION

Start with a blank spreadsheet by either cleaning up what you have done or select **New** from the **File** pull-down menu or click on the icon:

New Workbook

Excel files are known as *Workbooks* and each workbook contains a number of *Sheets*. These sheets can be related to one another or completely different--it's up to you. The "active sheet" is shown by the highlighted tab near the bottom of the screen and you can change sheets by clicking on the tabs with the mouse pointer. You can *name* a sheet by double-clicking and supplying a name. You can also insert and delete sheets using, respectively, the **Insert** and **Edit** pull-down menus. A sheet can either contain a spreadsheet, a chart (graph) or a combination of the two.

For this first example we'll choose something simple like calculating the molar masses of a table of organic compounds. Rename the first sheet something appropriate and then meet me in cell **A1**.

Reproduce the spreadsheet below. Note the formatting and try to duplicate it.

	A	B	C	D	E
1	Atomic mass of H = 1				
2	Atomic mass of C = 12				
3	Atomic mass of O = 16				
4	MM = molar mass				
5					
6		# of C	# of H	# of O	MM
7	ethanol	2	6	1	
8	propanone	3	6	1	
9	methanol	1	4	1	
10	methane	1	4	0	
11	ethane	2	6	0	
12	propane	3	8	0	
13	ethyne	2	2	0	
14	benzene	6	6	0	
15	naphthalene	10	8	0	

Now that the data has been entered, you are ready to demonstrate computer power. Place the active cell under the column labeled **MM** (cell e7) and type the following formula:

$$=12*b7+1*c7+16*d7$$

then press **Enter** (note: the cell references may be in either lower or upper case).

Notice that the molar mass of the first compound, ethanol, appears in the cell and the active cell moves down one place. The formula, of course, says to multiply the contents of cell b7 by 12, add that to the contents of cell c7 multiplied by 1 and finally add on the contents of cell d7 multiplied by 16. This gives the molar mass of ethanol. You *could* now proceed to type similar formulas in the remaining cells in this column to produce a similar result for the rest of the compounds. But the power of the spreadsheet is its ability to do this for you by replicating the formula and adjusting it as it does so.

Use the mouse pointer to make the cell containing the formula active again. Now move the pointer to the lower right corner of the cell. The mouse pointer should change to a small black cross. Press down the left mouse button and drag the mouse through the column down to the row containing naphthalene. When you release the button the formula will have been copied and adjusted throughout the range!

Notice that in the spreadsheet you just made most of the information is labeling, i.e., it is not needed for the calculations. However, experience shows that good labeling produces spreadsheets that print well and make sense months later when you return to them--not to mention being appreciated by the instructor...

PRINTING A SHEET

To print your work you can either choose the Print icon shown below or the Print Preview icon on the right:

Print   Print Preview

The best choice is the second one because you have the most control over how your printout will look, including margins, headers, footers, portrait or landscape mode, pagination, etc. When you choose either, Excel will print only the active sheet. Try the Print Preview icon and experiment with a few of the options before you finally print a copy.

SAVING A WORKBOOK

To save your work you will need a disk. If you are at school you can't save your work on the network and it is dangerous to save it on the hard drive of the local machine where you are working. Insert a floppy or zip disk. Then select the Save icon from the tool bar:

Save

If you haven't saved the Workbook before you will be prompted for a name for the file and a drive. The file name should be something you will recognize later (i.e., avoid names like George, Lucy, Stud, etc.).

EXITING EXCEL

From the **File** menu choose **Exit** or simply hold down the **Alt** key and type **FX**.

<u>STARTING A NEW WORKBOOK OR LOADING A PREVIOUS ONE FROM DISK</u>

If you want to begin a new Workbook (file) on a subject unrelated to the one you are working with, save your current work and then select **New** from the **<u>File</u>** menu (or use the icon). If you are restarting Excel and want to resume work on a previous Workbook you stored on disk, select the Open File icon:

Open File

If you select the drive letter where your disk is you will be shown a file list that corresponds to the Excel Workbooks on the disk. Select the one you want to work on.

<u>PRODUCING GRAPHS FROM DATA</u>

One of the nicest things about modern spreadsheets is their ability to manipulate data in many ways. For a scientist, graphing is a powerful way to discover new relationships in data. In Excel, a graph is known as a chart. There are two ways to produce charts. An *embedded* chart becomes part of the sheet with your data on it and will print along with the numbers or text. You can position it wherever you want on the sheet and size it to suit. A *chart sheet* contains only a chart and can be sized or printed full page. It is a separate sheet in a Workbook. In both cases, the charts are automatically updated if you change the data (!). Let's use some of Robert Boyle's original data that supported his law: "The product of pressure times volume of an ideal gas is constant at constant temperature; i.e., PV = constant".

Boyle's volume measurements were given in arbitrary units of length because the gas was contained in tubing of uniform cross-section. The pressure was measured in inches of Hg. Enter the following data in your spreadsheet (either open a new Workbook, or select Sheet 2):

	A	B	C	D	E
1	Boyle's Law: PV = constant				
2	V: arbitrary units of length; P: inches of Hg				
3	volume	pressure	PV	1/V	
4	48	29.1			
5	40	35.3			
6	32	44.2			
7	24	58.8			
8	20	70.7			
9	16	87.2			

You might wonder how I formatted that! I placed the text "volume" and "pressure" in their respective columns <u>first</u> and used those words to size the column width. Then I typed in the rest. There are a lot of other ways to get a similar result.

In the column labeled **PV** a representative formula should be typed to multiply a4 by b4:

$$=a4*b4$$

Copy the formula down through the rest of the data.

Next write a formula for the column labeled **1/V**. This is a good time to point out that when you use the decimal adjust buttons to display the right amount of significant digits, the computer actually stores the *entire* number, not just the rounded version. When it does calculations it uses the *entire* number. So when you round the answers you are doing exactly what should be done when using significant digits in a series of calculations. That means you should always have your significant digits displayed correctly--no excuses!!!!

[you might wonder how to format a number like 1396 so that it only shows two significant digits; the solution is to format it as scientific notation and *then* use the decimal adjust buttons. To get scientific notation select the cell or cells then choose **Format** from the pull-down menus, select **Cells** and then click on the **Number** tab. You can select scientific notation from the list of possible formats]

You can see from the values of **PV** that Boyle was apparently right (especially if you have your significant digits correct...). Another way of demonstrating the validity of Boyle's law is to graph the data in some suitable fashion. The goal here is to produce **embedded** graphs or charts of both P vs. V and P vs. 1/V. The following steps will get you your first chart in Excel.

1. Use the mouse or keyboard to select the x values (i.e., the column containing the *volume* values). You can select the column heading as well if you like.

2. Hold down the **Ctrl** key and select the y values (in this case, the column containing *pressure*). It is important to remember when constructing a spreadsheet that the left-most series you select will always be treated by Excel as the x-values or independent variable.

3. Click on the Chart Wizard icon:

4. In the first dialog box you select the type of graph you want (usually X-Y (Scatter)) then click on **Next**.

5. If you are doing this at school in the Science Resource Center a default format for the X-Y chart will be used and you will see this in the next screen. Excel was originally designed for business use and many of the defaults are inappropriate for our work. **If you want a copy of this default file for home use, ask your instructor**. Click on **Next**.

6. In the next step you can enter a chart title as well as axes titles. You can also make adjustments to the default grid if you wish and add a legend (usually only needed if you are graphing more than one series). After you have made your entries, click on **Next**.

7. In this final step you can choose to have the chart embedded on the spreadsheet itself or placed on a sheet by itself. If you choose to place the graph on a new sheet [not this time!] it will be adjusted for some default printing characterisitics which are included in the Science Department X-Y format. If you choose to place the chart on your spreadsheet, you can adjust the ultimate size and aspect yourself as detailed in the remaining steps. For now, place the chart on your spreadsheet. Click on **Finish**.

8. You can position the resulting chart on the sheet by placing the mouse pointer somewhere inside and holding the mouse button down as you drag the chart around. You can size the chart by moving the mouse pointer to the mid-point of a side until a double arrow appears and then hold down the mouse button as you drag [I don't know why the charts always come out so lopsided, but you should try to square them off a little--**thin slivers of graphs are NOT acceptable in a lab report**.]

9. You can size the chart in its current relative dimensions by moving to the lower/upper right corner, looking for the double diagonal arrow and dragging the mouse as above.

Nitty-gritty things:

10. *If you are graphing your data only to see a general trend* you will want to draw a smooth connecting line through the points. Generally, you do this when data is not linear. To accomplish this, click TWICE on any of the data points. A dialog box will open up in which the choice of **None** has been made for the line. Change the selection to **Custom** and check the **Smoothed** box. Then click on **OK** or press **Enter**. Occasionally you can obtain a better "fit" for your data by using one of the curve fitting options found with the trendlines. Read on.

11. *If you are graphing your data in order to extrapolate or interpolate from it*, you will probably want the equation that best describes it. To do this, click ONCE on any of the data points. Then go up to **Chart** on the Tool Bar above and select **Add t̲rendline**. A dialog box will open up in which you select the type of function (often **Linear** for data in chemistry, but the curves may be useful for some experiments); after making that selection, click on the Options tab and select **Display Equation on Chart** and **Display R-squared Value on Chart** [remember, the R-squared value is an indication of how well your data fits the selected function--the closer to 1 the better]. You can also force the line to pass through 0,0 if that is appropriate as well as extend it beyond the confines of your actual data ("forecast"). Click on **OK** or press **Enter**. The trendline is often rather thick. If you don't like the look of that (I̲ don't), double-click anywhere on the line (not on a point) and a dialog box will open in which you can select the line **weight**. The next weight down is arguably the best looking. Click on **OK** or press **Enter** when done.

12. If the axis increments are weird or you want finer tick-marks (the little marks between numbered axis markings) you can double click on the chart to select it and then double-click on the axis you want to change and a dialog box will open. Choose **Scale** and then remove the **X** next to Auto and type in whatever you want.

13. You can dress up almost anything you want in this fashion. Just double-click on it and probably something will happen (!).

14. When you are finished, click anywhere outside the chart to deselect.

This basic sequence is used (pretty much) when you want to make a chart of any data. Now you want to try and repeat it using the 1/V data as the x-axis. But wait! There is a problem. Remember that the computer will treat the *left-most* series of data you select as the x-axis data. But P is to the left of 1/V. Of course, I made you do this on purpose so you could see how to move things around on the sheet. If you could exchange the **pressure** and **1/V** columns that would be swell. You can do so without spoiling your earlier work because Excel automatically updates charts when the sheet data is changed. Here's what to do:
  - select the **pressure** column (from cell b3 to b9)

  - select the **Cut** icon:

  - make cell e3 active and select the **Paste** icon:

Now repeat this sequence to move the **1/V** column so it is between **volume** and **PV**; then move **pressure** back to column d (you could just leave it in column e, but it looks neater back in d!)

If you cut and paste formulas be aware that Excel may try to change the cell references so that the new formula is calculating from cells relative to its *new* position, so you may need to edit a little.

Now try to make that chart of P vs. 1/V and <u>embed it</u> on the sheet as before (how about to the right of the first chart?). From your chart you should be able to see why we say P is *inversely* proportional to V.

Save your work now if you plan to continue (and especially if you plan to quit!!) just in case something awful happens (like a power failure or system crash). You might also want to try printing a hard copy.

<u>OTHER APPLICATIONS</u>

A First-Order Reaction

In this exercise you will use natural logs (a *function*--Excel has many), *absolute* references, create a chart *sheet* (rather than an embedded chart) and find the best-fit line for the data.

The thermal decomposition of gaseous N_2O_5 is a first-order reaction, i.e., the rate of change of the concentration is proportional to the concentration. Therefore the concentration decreases exponentially, obeying the equation:

$$\ln [N_2O_5] = -kt + \ln [N_2O_5]_0$$

where $[N_2O_5]_0$ is the concentration of N_2O_5 at time zero and k is the rate constant.

First you will need a set of experimental data:

	A	B	C
1	*Decomposition of N_2O_5 vs. time*		
2	time (s)	$[N_2O_5]$	$\ln([N_2O_5]_0/[N_2O_5])$
3	0	0.100	
4	50	0.0707	
5	100	0.0500	
6	200	0.0250	
7	300	0.0125	
8	400	0.00625	

You are probably wondering about the label in column c. If you examine the function above carefully you will see than it can be written so as to give a simple expression with slope equal to k, the rate constant:

$$\ln [N_2O_5]-\ln [N_2O_5]_0 = -kt$$

or

$$\ln \frac{[N_2O_5]_0}{[N_2O_5]} = kt$$

It *would* be possible to plot ln $[N_2O_5]$ vs. time and get a line with slope k, but for the purposes of this exercise we will use the approach given above instead.

In column c you want to write a formula that will accomplish what is described in the label shown. Functions like the natural log require that their arguments be in parentheses, so the formula might look like:

$$=\ln(b3/b3)$$

which will obviously give 0 as the answer ($\ln 1 = 0$). But as you drag this formula down through the cells of the column it will no longer be correct since the numerator is supposed to remain the value of $[N_2O_5]$ at time 0 but it will be changed by Excel as the formula is copied. One way out of this is to simply type in the value 0.100 as a constant in the formula:

$$=\ln(0.100/b3)$$

A more versatile way that you will find very useful as you use spreadsheets is to write a formula with an *absolute* reference. This is a cell reference that does NOT adjust as the formula is copied through different cells. Such a reference looks like this:

$$=\ln(\$b\$3/b3)$$

As this formula is copied into cell c4 and below, the numerator cell reference, b3, remains the same while the denominator reference is adjusted. Try it!

[recall the rule for significant digits and logs as you set your decimal places in column C: the number of significant digits in the original value determines the number of <u>decimal places</u> in the logarithm]

You might want to save your work now before you try creating a chart (in fact that's always a good idea just in case something goes very wrong).

We now want to plot a graph from which we can determine the value of the rate constant, k. But this time, so you can see how it is done, we will make a chart *sheet* rather than embed a chart as you have done before. When you choose this route Excel opens an additional sheet in your workbook (in front of your current sheet) and plots the chart in a more or less default size. You can still do all of the things to this chart that you can do to an embedded chart, but you can also get a printout of just the chart without the spreadsheet grid, etc. If you are working at school, the chart will be neatly sized for a nice printed copy.

To begin, select the data as for an embedded chart. Remember to select the x-axis data (time) first and then hold down the **Ctrl** key as you select the y-axis data. Click on the **Chart Wizard** icon and proceed as before in the creation of your embedded charts. When you finally click on **Finish** the chart will open up on a new sheet within the workbook.

You will notice that the axis titles and chart title do not show subscripts or superscripts properly. You can fix this. After selecting the chart (click on it) you click once on the text you want to change (say the chart title). Black handles appear around it. Now click once more within the black handles and the cursor will appear. You can move it using the arrow keys, use backspace, delete, etc. More to the point, you can select text or part of the text and apply formatting like super- and subscripts just as you would with regular text. The y-axis title even rotates when you do this so you can edit it! When you are finished, it returns to the vertical position.

Once you have your plot properly labeled, it is time to find the best-fit line. In Excel this is called a *trendline* and when you select this option the computer does a regression analysis of the data and tries to fit it to the type of function you have chosen. It will then draw an appropriate line or curve and can also print the function on the screen as well as give an estimate of the reliability of the function for your data.

The first step is to select the data series by clicking on a data point in the chart. The data points should be highlighted. Go to the pull-down menus and choose **Chart**. Then select **Add trendline**. On the *Type* tab that appears you can select the type of regression analysis you think will best fit the data. In this case that would be **Linear** but take a look at the other options while you are there--you may need them someday.

Click on the *Options* tab. At this point you can choose whether the y-intercept should be determined by the computer or whether it should be forced to zero, as well as whether to print the equation and the $\mathbf{R^2}$ value which is the reliability factor. The closer the absolute value of R^2 is to 1, the better "fit" the equation gives for your data. You can also choose to extend the trendline forward or backward past the limits of your data if you want a chart that shows where the trend is headed.

Once your trendline is drawn you will notice that there is not much scatter in the data. This will not always be the case and that's exactly when the ability of the computer to draw the "best" straight line (or curve) among your data points comes in handy.

To print the spreadsheet and chart from this exercise you will need to select one sheet at a time and go through the printing routine as before. You can choose to print the chart or spreadsheet either in landscape or portrait mode by using the Page setup options. If you are doing this at school the spreadsheet will print in portrait and the chart will print in landscape by default.

Graphing Multiple Series

It is sometimes useful or necessary to graph more than one series of dependent variables against one set of independent variables (i.e., two sets of y-data for one set of x-data). This is done in essentially the same way as the previous examples except that more than two series of data are selected before starting Chart Wizard. For this last example we will chart the progress of a hypothetical reaction as it approaches equilibrium.

Consider the reaction A + B ⇆ C and construct the spreadsheet shown below:

	A	B	C	D
1	**A + B ⇆ C**			
2	*An approach to equilibrium*			
3	time, s	[A]	[B]	[C]
4	0	0.080	0.100	0
5	20	0.050	0.070	0.060
6	40	0.030	0.050	0.100
7	60	0.020	0.040	0.120
8	80	0.015	0.035	0.130
9	100	0.015	0.035	0.130

There are no formulas to write in this case. All we want to do is visualize the process on a chart. To do that, select the first column as your x-data and then (holding down the **Ctrl** key) select the block from b3 to d9, moving diagonally. Next click on the **Chart Wizard** icon. Select the usual **X-Y (Scatter)** plot. Placing a legend on a chart such as this with multiple series is a good idea. You can edit legend entries (if you need super- and subscripts, for example) after the chart is made. This time you will want to connect the points by a smoothed line when the chart is finished. You will need to do this for each of the three series. To do this, double-click on a data point in a series and click on the **Patterns** tab and then on **Custom** (under **Line**) and check the **Smoothed line** box.

Miscellaneous

When you are writing formulas in the future you may want to use functions. Excel has a large library of functions that are financial, statistical, mathematical, etc. Below is a brief list of the most common ones you might want to use and the key words that go into formulas to represent them.

ABS( )	absolute value
SUM( )	totals range of cells; use colon to separate cells
AVERAGE( )	totals and averages a range of cells; use colon to separate cells
LN( )	natural log
EXP( )	raises *e* to the power of the argument
LOG( )	base 10 log
10^	number following this is used as an exponent on 10, e.g. 10^2 = 100
PI()	π [note: empty parentheses are required]
COS( )	cosine (argument must be in radians)
DEGREES( )	converts radians to degrees
RADIANS( )	converts degrees to radians
SIN( )	sine (argument must be in radians)
SQRT( )	square root

These last two allow you to reference the slope or intercept of a best fit line without typing in the value:

SLOPE(known_y's,known_x's)	where "known_y's" are a range such as A1:A5; ditto for x
INTERCEPT(known_y's,known_x's)	where "known_y's" are a range such as A1:A5; ditto for x