

GRAPHING IN EXCEL 2007

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The relationship between the pressure of a gas and its volume was investigated with the following results:

P, mmHg	V, mL	P, mmHg	V, mL
100.0	1858.74	600.0	303.03
200.0	862.07	700.0	259.74
300.0	657.89	800.0	238.10
400.0	480.77	900.0	210.53
500.0	362.32	1000.0	182.48

It is desired to plot a graph of volume versus pressure. In order to graph this data we must enter them into columns in Excel. When plotting data Excel treats the first column as the x-axis data and the second column as the y-axis data. Thus when we enter the data, the pressure should be entered in the first column and volume in the second. The column labels should also be entered (Figure 1a). At this point the data does not display the correct number of significant figures. Highlight cells B3 to B12 by holding down the left mouse button and drag to highlight cells (Figure 1b). In the number Toolbar at the top of the spreadsheet click the left arrow once (Figure 1c). The pressure now has the correct number of digits (Figure 1d).

	A	B	C
1			
2		P, mmHg	V, mL
3		100	1858.74
4		200	862.07
5		300	657.89
6		400	480.77
7		500	362.32
8		600	303.03
9		700	259.74
10		800	238.1
11		900	210.53
12		1000	182.48

P, mmHg
100
200
300
400
500
600
700
800
900
1000

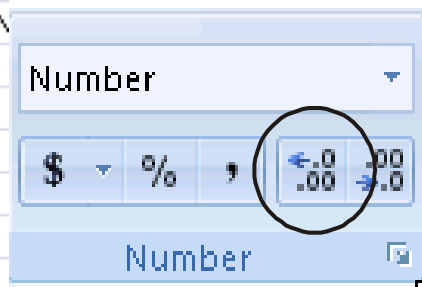


Figure 1c

P, mmHg
100.0
200.0
300.0
400.0
500.0
600.0
700.0
800.0
900.0
1000.0

Figure 1d

Figure 1a

Figure 2b

Highlight cells C2 to C12 and right click the highlighted area and click on Format Cells (Figure 1e). Click on the Number tab; select Number and select 2 in the Decimal places box (Figure 1f). The data now shows the correct number of digits (Figure 1g).

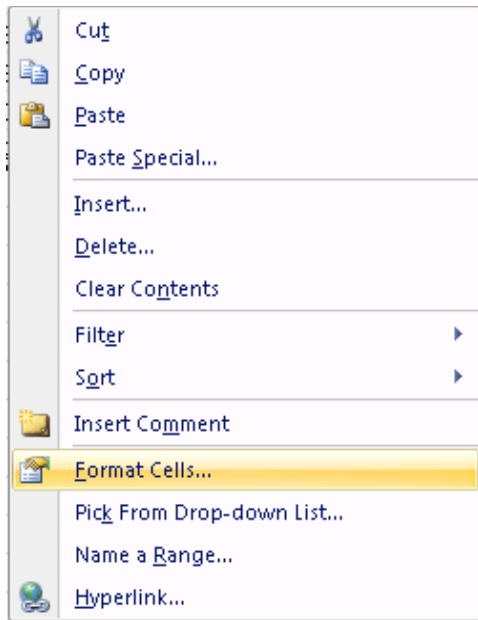


Figure 1e

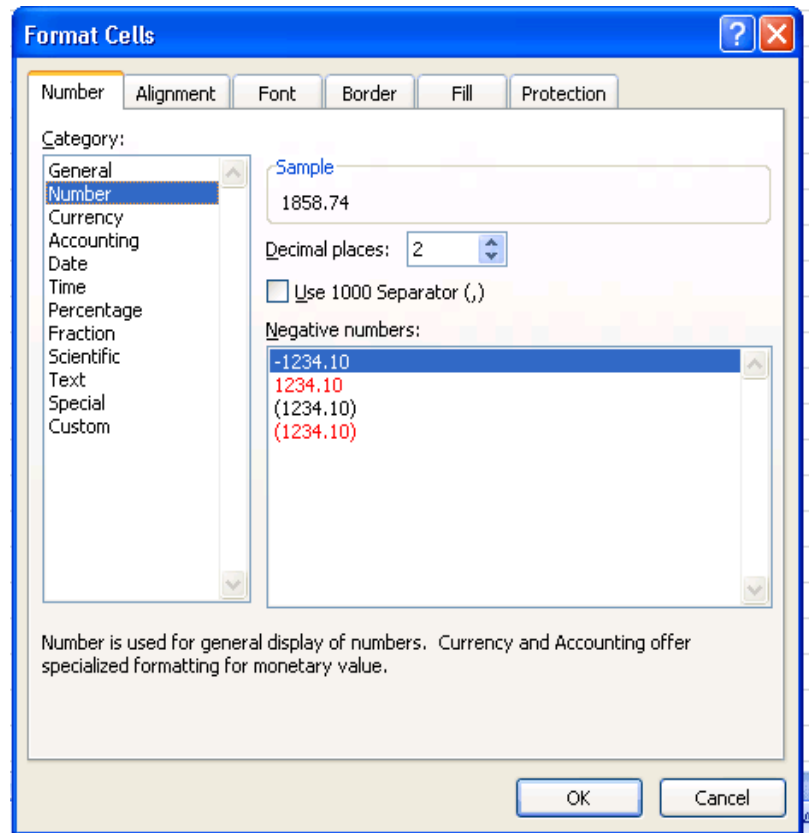


Figure 1f

P, mmHg	V, mL
100.0	1858.74
200.0	862.07
300.0	657.89
400.0	480.77
500.0	362.32
600.0	303.03
700.0	259.74
800.0	238.10
900.0	210.53
1000.0	182.48

Figure 1g

To highlight the data to be graphed, left click in cell B3, hold down the left mouse button and drag the mouse so that cells B3 to C12 are highlighted (Figure 2).

P, mmHg	V, mL
100.0	1858.74
200.0	862.07
300.0	657.89
400.0	480.77
500.0	362.32
600.0	303.03
700.0	259.74
800.0	238.10
900.0	210.53
1000.0	182.48

Figure 2

Click on the Insert tab at the top of the spreadsheet (Figure 3).

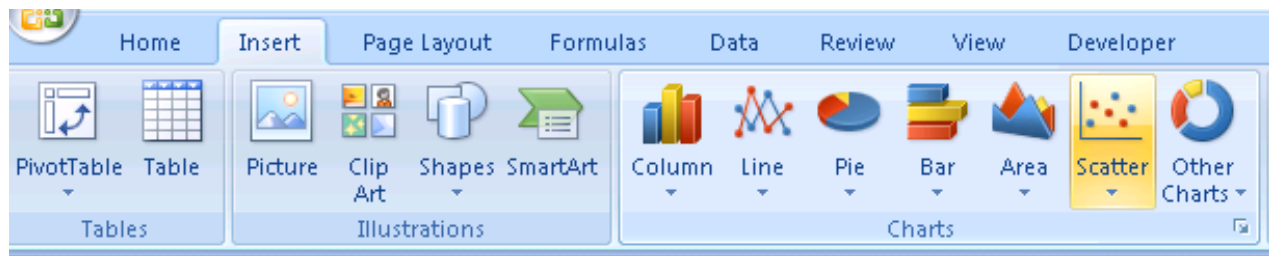


Figure 3

Click on Scatter and click on the first graph icon (Figure 4). Excel will insert a graph of the data (Figure 5).

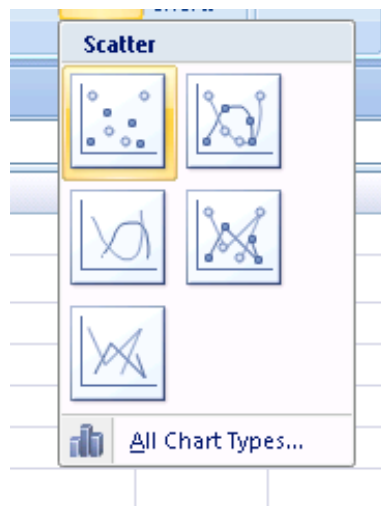


Figure 4

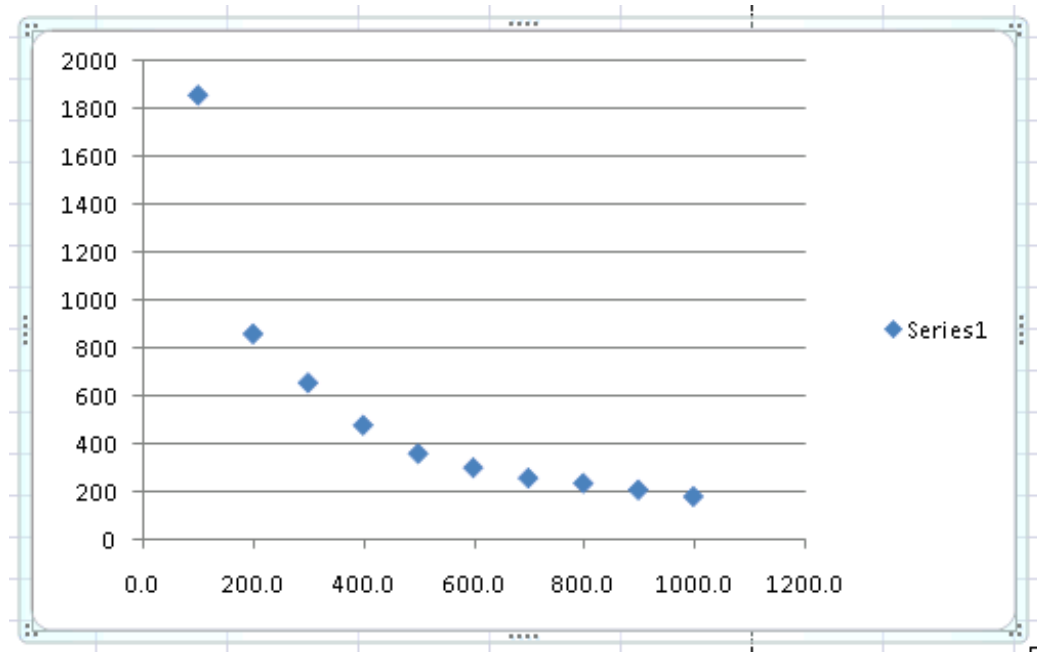


Figure 5

To format the graph to allow for a title and axis labels, click on the first graph icon in Chart Layouts (Figure 6). The graph will now have Chart Title and Axis Title labels. It will also have a series label (Figure 7).

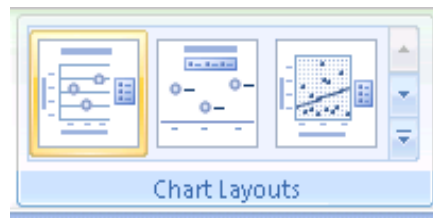


Figure 6

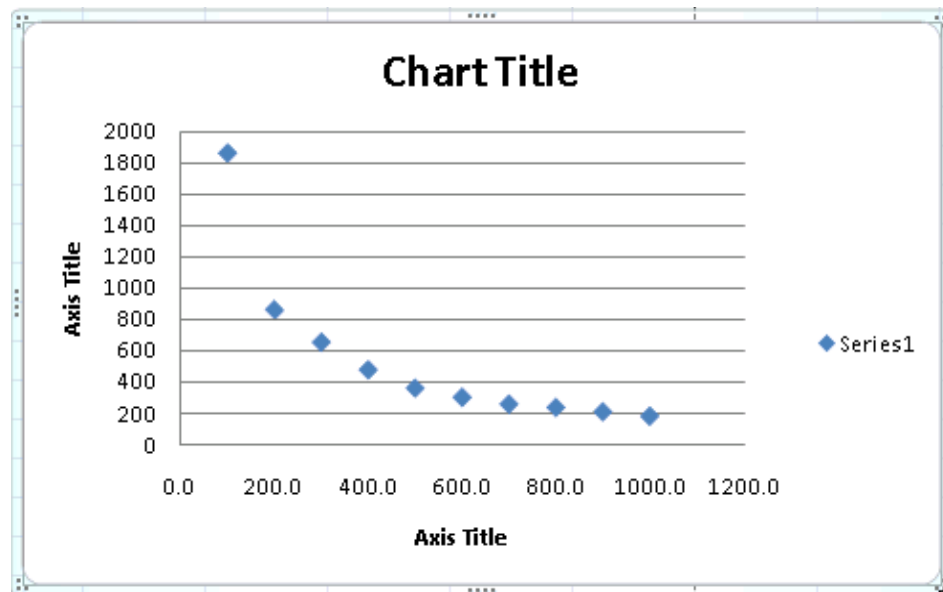


Figure 7

Since there is only one data series we will delete this label from the graph. Right click on Series 1 and click on Ddelete (Figure 8).

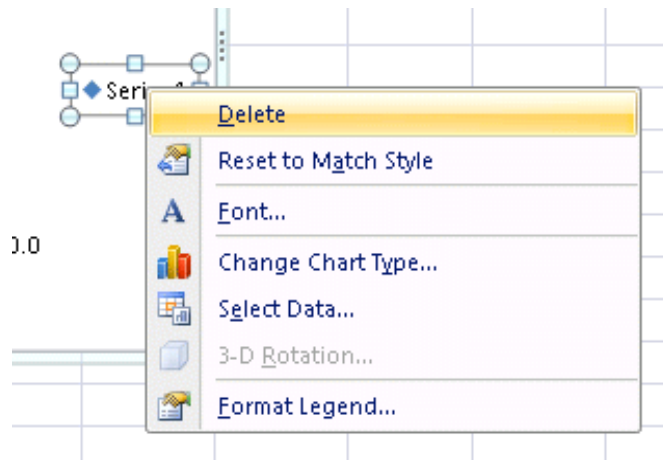


Figure 8

Left click on the Chart Title, highlight Chart Title (hold down the left mouse button and drag it across the Chart Title), type in new graph title (Figure 9).



Figure 9

Repeat this procedure for the both axis titles (Figure 10).

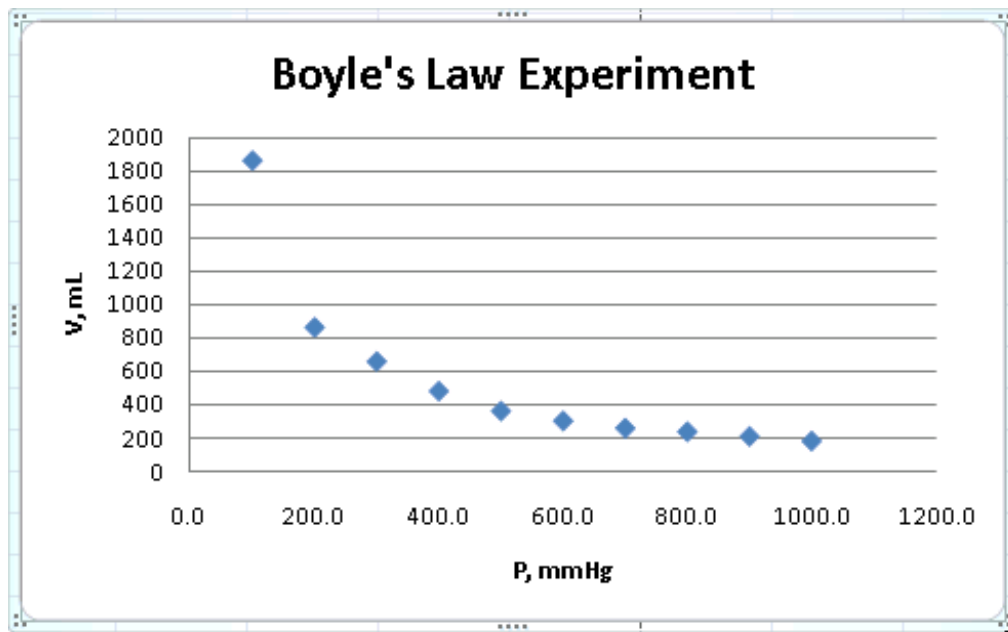


Figure 10

Next we need to draw a curve through the data. Right click one of the data points (Figure 11).

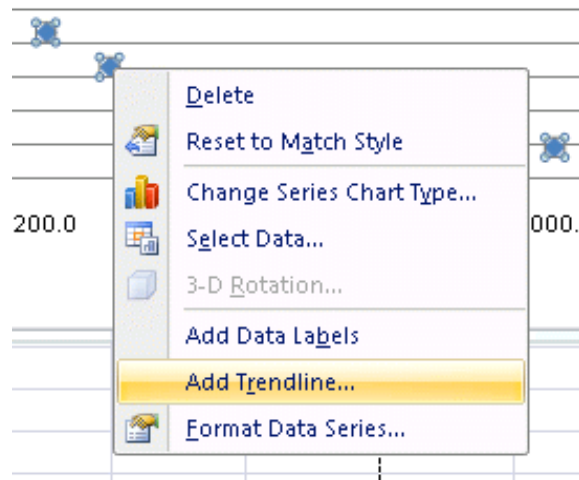


Figure 11

Click on Add Trendline... (Figure 11). For this data set the best fit curve is Power (Figure 12). To determine the correct fit for a data set just click each of the Trendline Options until the line fits the data.

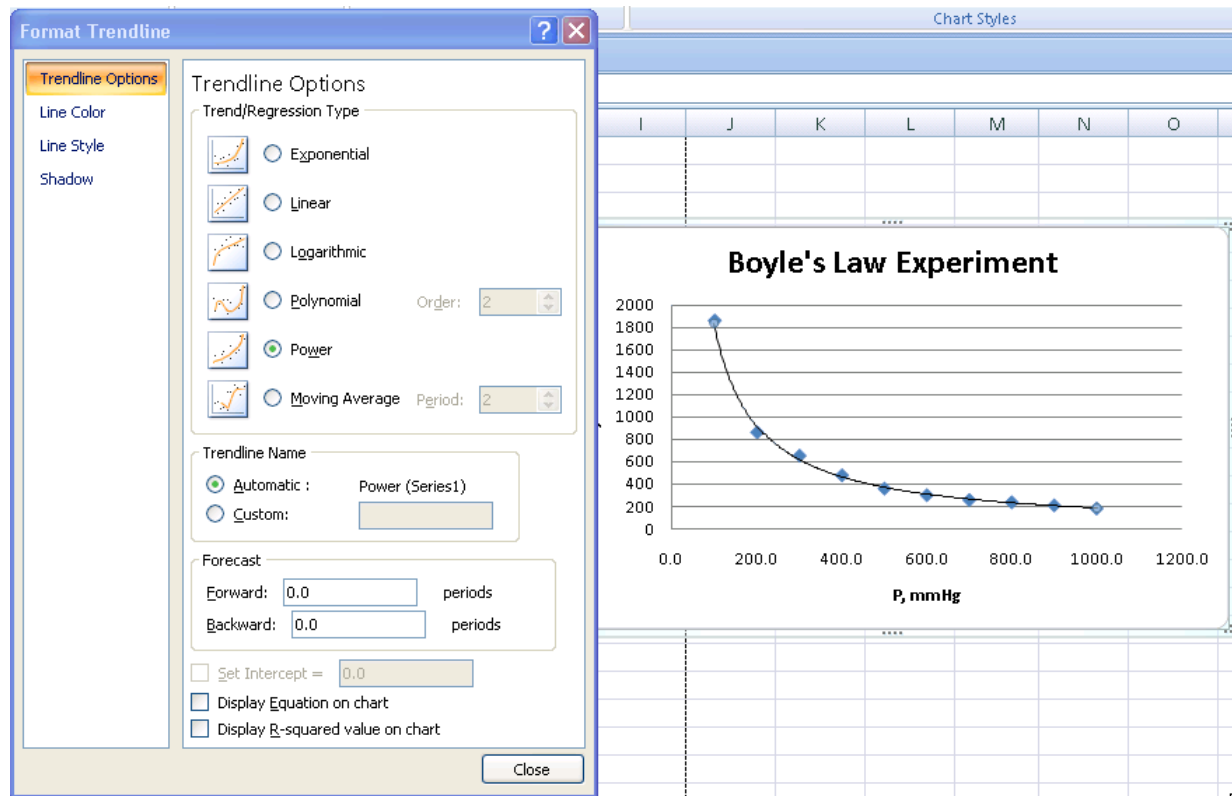


Figure 12

The relation between the Volume and the Pressure of a gas is an inverse relation. That is

$$V = \frac{1}{P}$$

Label cell D2 that contains mmHg-1; double click on cell D2 and with the left mouse button highlight the -1; right click on the cell (Figure 13).

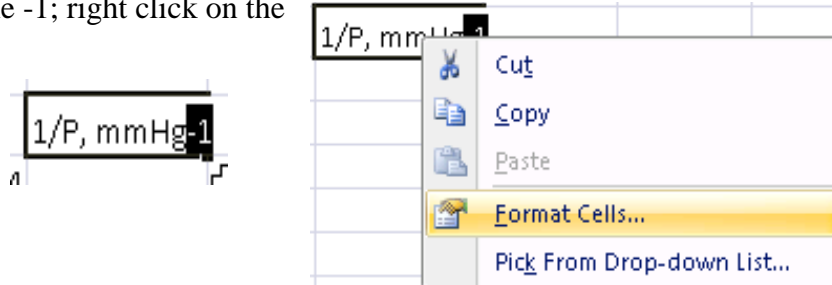


Figure 13

Click the box next to Superscript and click OK (Figure 14). The -1 will now appear as a superscript.

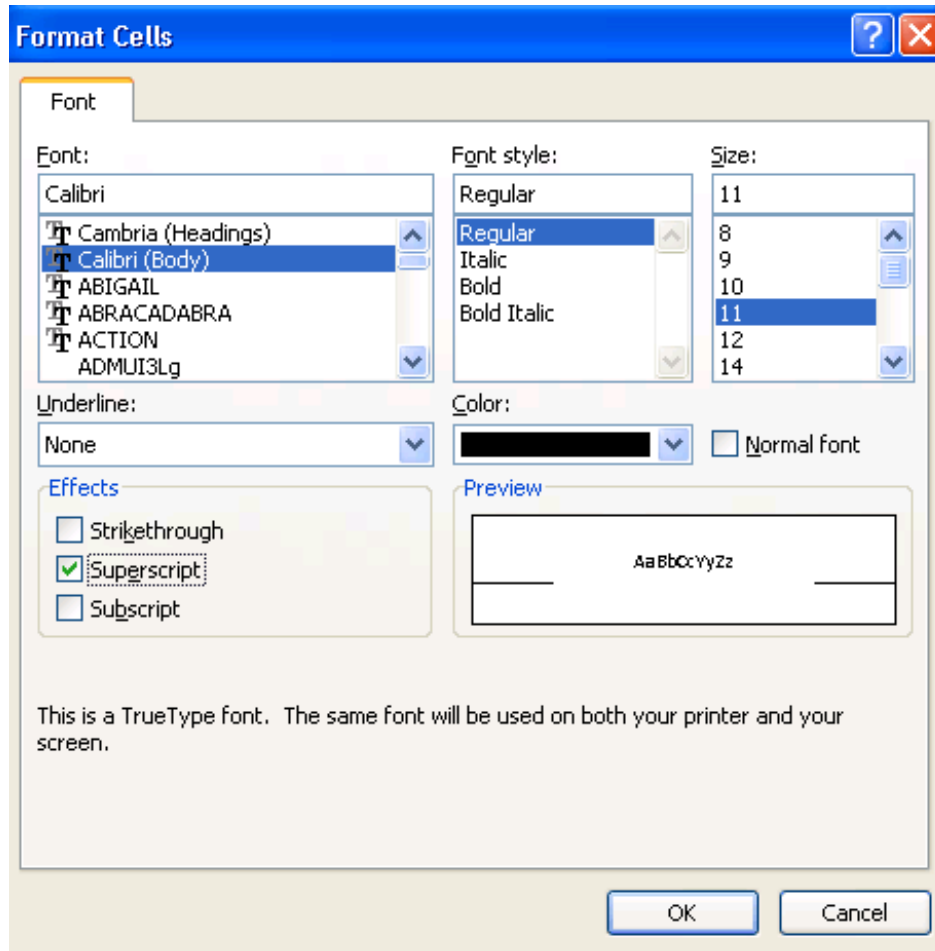
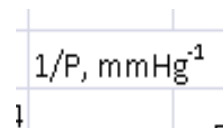


Figure 14



The label now extends beyond the cell boundaries. To resize the cell so that the label will fit, move the cursor on the boarder between the D and E columns so that it forms a double arrow (Figure 15). Double click - the column will resize to fit the label.

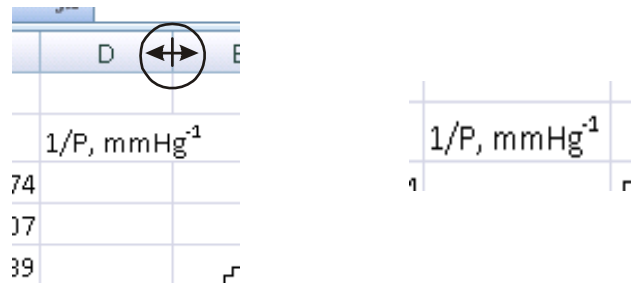


Figure 15

Excel can calculate the 1/P value when we enter the correct formulas in cells D3 to D12. In cell D3 key in the following formula =1/B3 and hit Enter (Figure 16). The value 0.01 will appear in cell D3 - 1/100.0. We will format the cell, to show the correct number of digits, later.

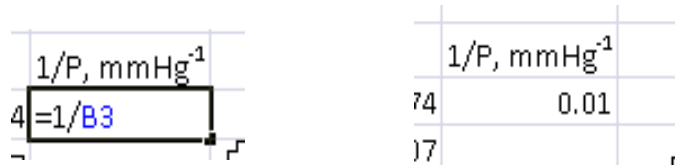


Figure 16

We now want to copy the formula in cell D3 into cells D4 to D12. Click on cell D2 and move the cursor to the right bottom corner so that it becomes a large plus sign (Figure 17). Hold down the left mouse button and drag down to cell D12 (Figure 18).

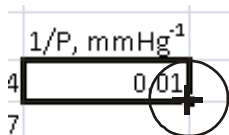


Figure 17

P, mmHg	V, mL	1/P, mmHg ⁻¹
100.0	1858.74	0.01
200.0	862.07	0.005
300.0	657.89	0.00333333
400.0	480.77	0.0025
500.0	362.32	0.002
600.0	303.03	0.00166667
700.0	259.74	0.00142857
800.0	238.1	0.00125
900.0	210.53	0.00111111
1000.0	182.48	0.001

Figure 18

Once again we need to format the cells to reflect the correct number of digits. Cells D3 to D11 should display 4 digits while cell D12 should display 5 digits. Since the cells display different levels of precision, we can not format them together. We will need to format cells D3 and D12 separately. Cells D4 to D11 exhibit the same precision and can be formatted together. For each formatting we will once again use the left arrow icon in the Number toolbar (Figure 19).

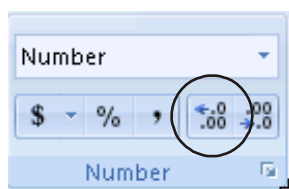


Figure 19

Click on cell D3 and then click the arrow icon three times. Highlight cells D4 to D11 and click the left arrow icon three times. Finally click on cell D12 and click the arrow icon four times (Figure 20).

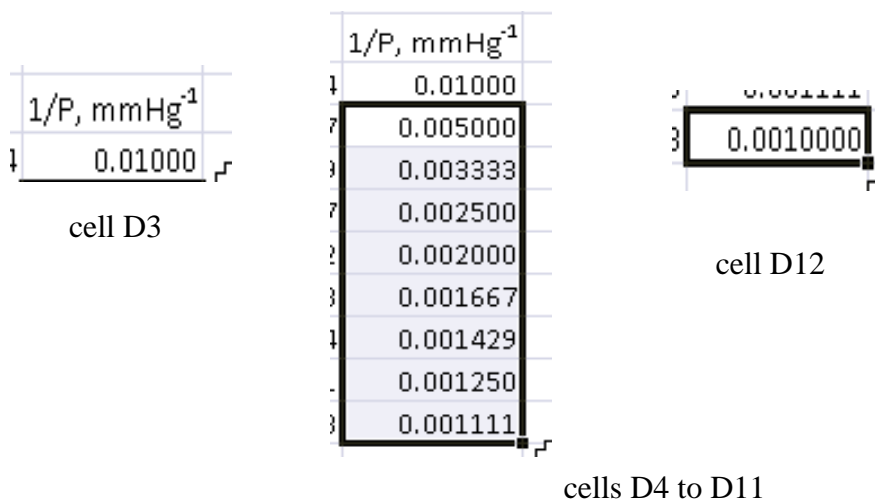


Figure 20

We now want to plot columns C and D to get our linear graph. Remember that we want to plot V vs. 1/P to get our linear graph. Column C contains the V data and column D contains the 1/P data. If we highlight these two columns and click to graph them, Excel will plot the V data (first column) on the x-axis and the 1/P data (second column) on the y-axis. We can copy and paste each column to a different part of the spreadsheet or we can plot the data incorrectly and then change how it is plotted in the graph. To move the data highlight the column to be moved, here cells D3 to D12, and holding down the control key (Ctrl) hit the C key. The solid outline will turn into a moving dashed outline. This indicates the data has been copied. Move to a place in the spreadsheet where there are enough empty cells and click on the first cell in this region. In the Home tab click on the down arrow in the paste toolbar and then click on Paste Values (Figure 21a & 21b). To display the correct number of significant digits click on the icon of the clipboard and click on Values and Number Formatting (Figure 21c). Click on the 1/P, mmHg⁻¹ title, hit Ctrl-C and past it in the first cell above the new data column (Figure 21d). Repeat this procedure for the volume dat - be sure to paste it in the column to the right of the 1/P data (Figure 21e).

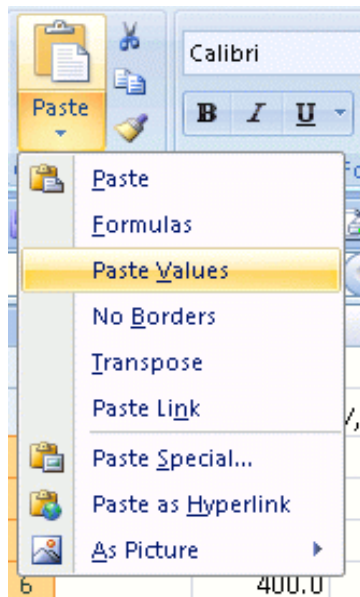


Figure 21a

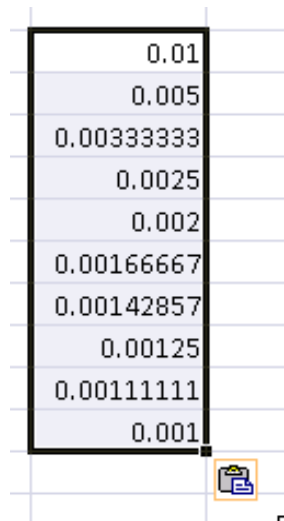


Figure 21b

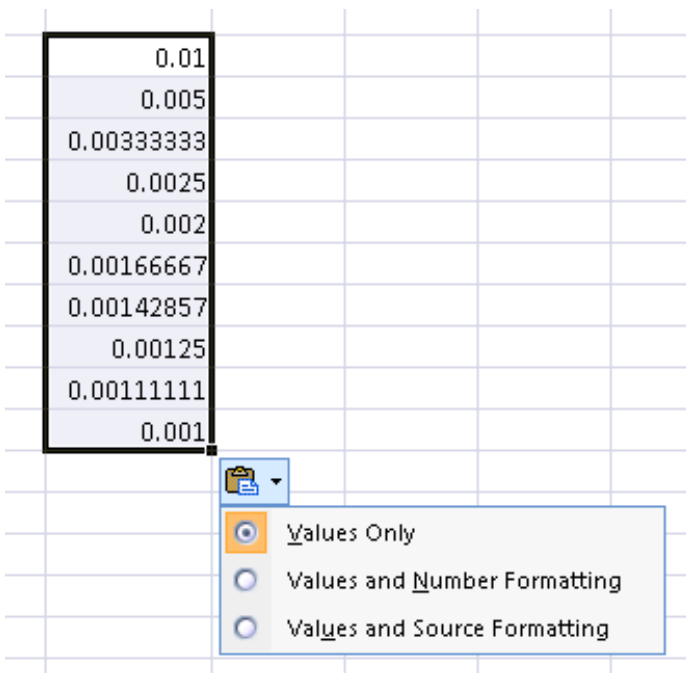


Figure 21c

1/P, mmHg ⁻¹	P, mmHg	V, mL
0.01000	100.0	1858.74
0.005000	200.0	862.07
0.003333	300.0	657.89
0.002500	400.0	480.77
0.002000	500.0	362.32
0.001667	600.0	303.03
0.001429	700.0	259.74
0.001250	800.0	238.10
0.001111	900.0	210.53
0.0010000	1000.0	182.48

Figure 21d

Figure 21e

Highlight the 1/P and V data (do not highlight the column labels) and graph it.

1. Click on the insert tab.
2. Click on Scatter in the Charts toolbar.
3. Click on the first graph icon in the Scatter flyout (Figure 22).
4. Click on the first graph icon in Chart Layouts (Figure 23).
5. Delete the Series Label and Fill in the Chart and Axis titles (figure 24).

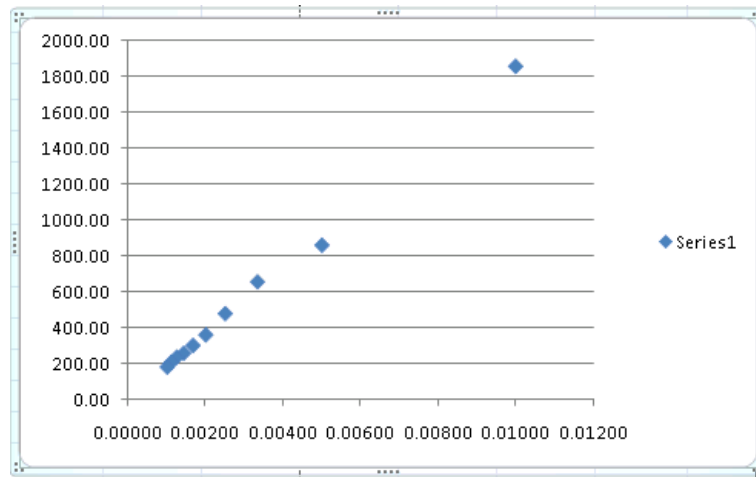


Figure 22

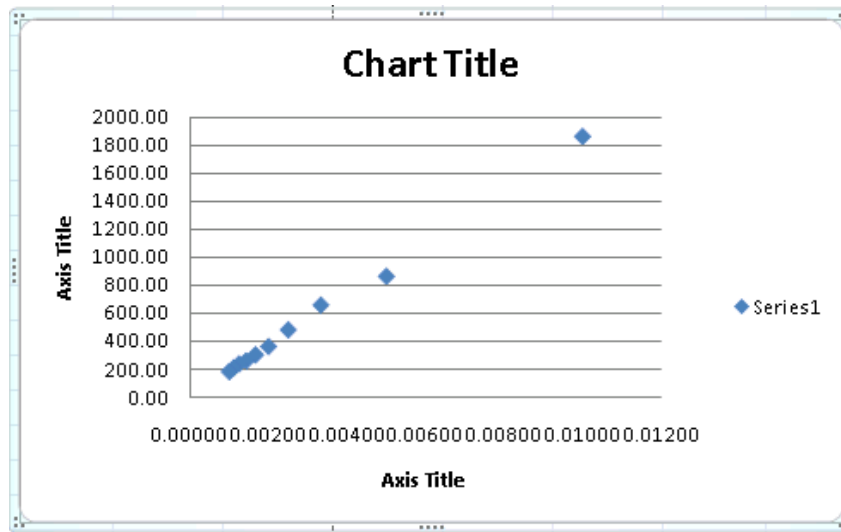


Figure 23

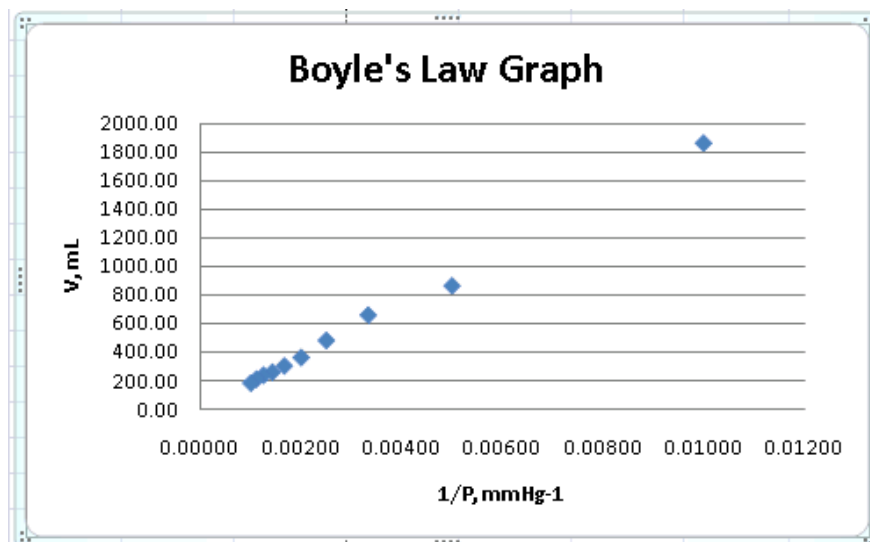


Figure 24

We now need to format this graph.

We need to format the x-axis title to convert -1 to a superscript. Left click on the x-axis title, high light the -1 (Figure 25a), right click in the axis title box, click on **F**ont.... (Figure 25b), check the Superscript box and click OK (Figure 25c & 25d).

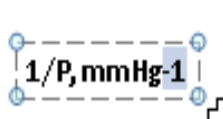


Figure 25a

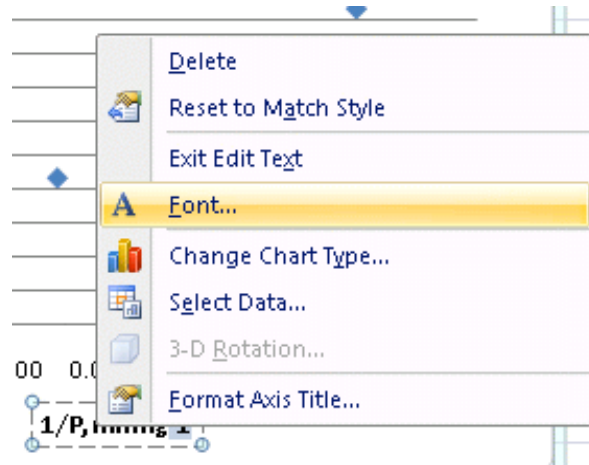


Figure 25b

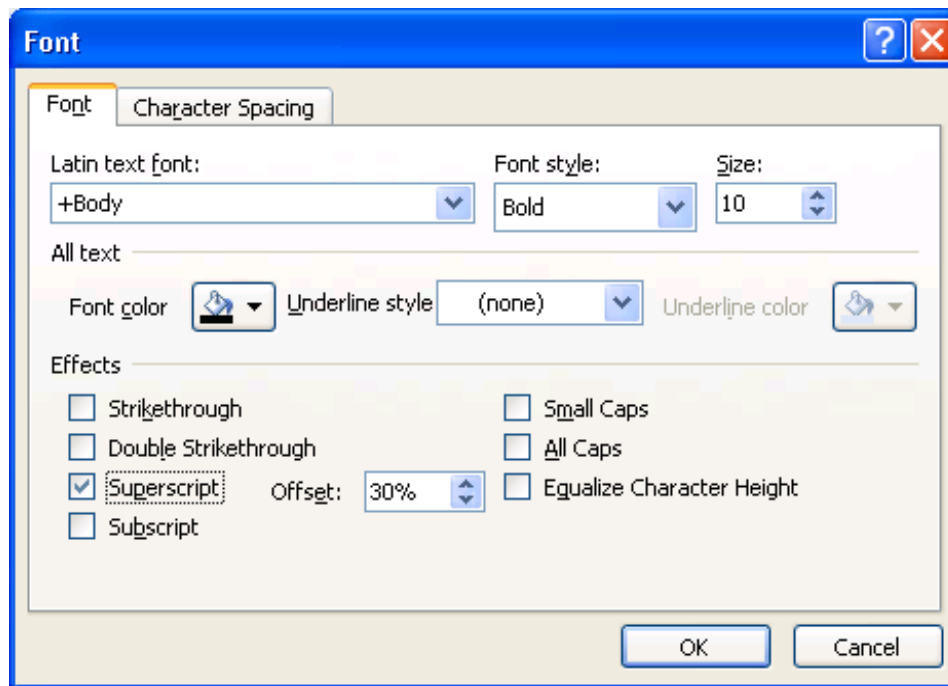


Figure 25c



Figure 25d

We will format grid lines for the x-axis. Right click on any value on the x-axis, click on Add Major Gridlines. Repeat the process but this time click on Add Minor Gridlines (Figures 26 & 27).

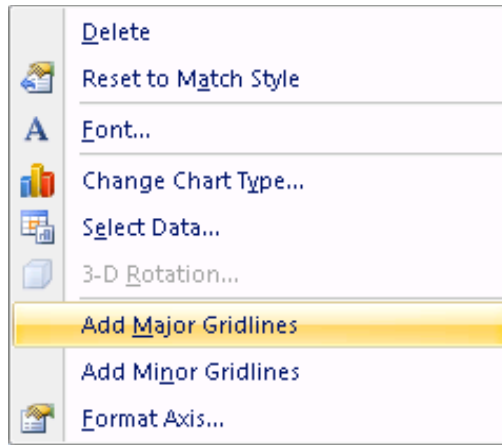


Figure 26

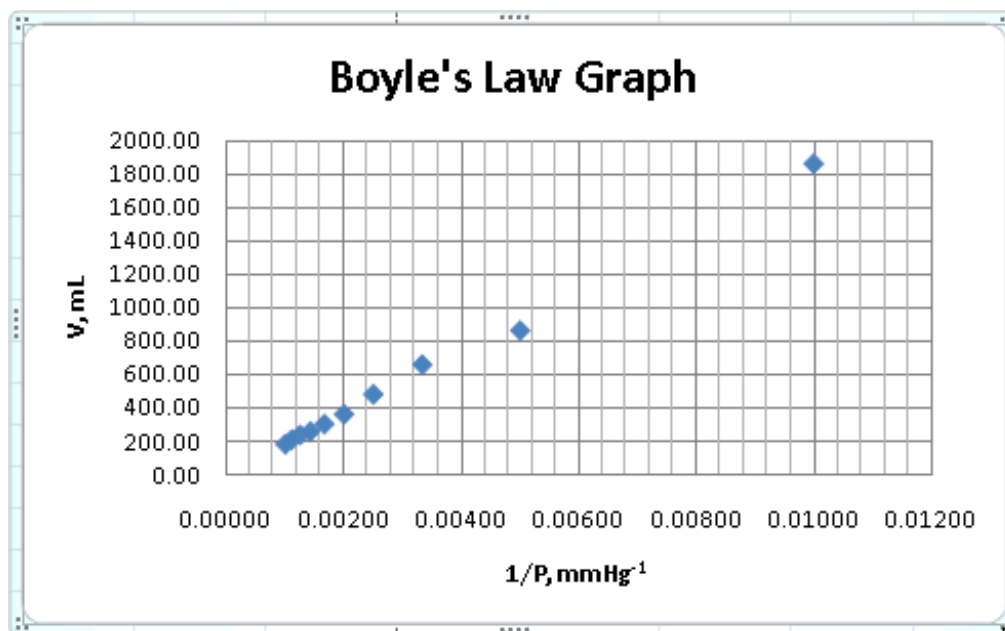


Figure 27

Now we will add a line through our data and have Excel calculate the slope, intercept and correlation coefficient squared (r^2).

Just as we did before, right click any data point but this time click on Linear and check Display Equation on chart and Display R-squared value on chart, click Close (Figures 28 & 29).

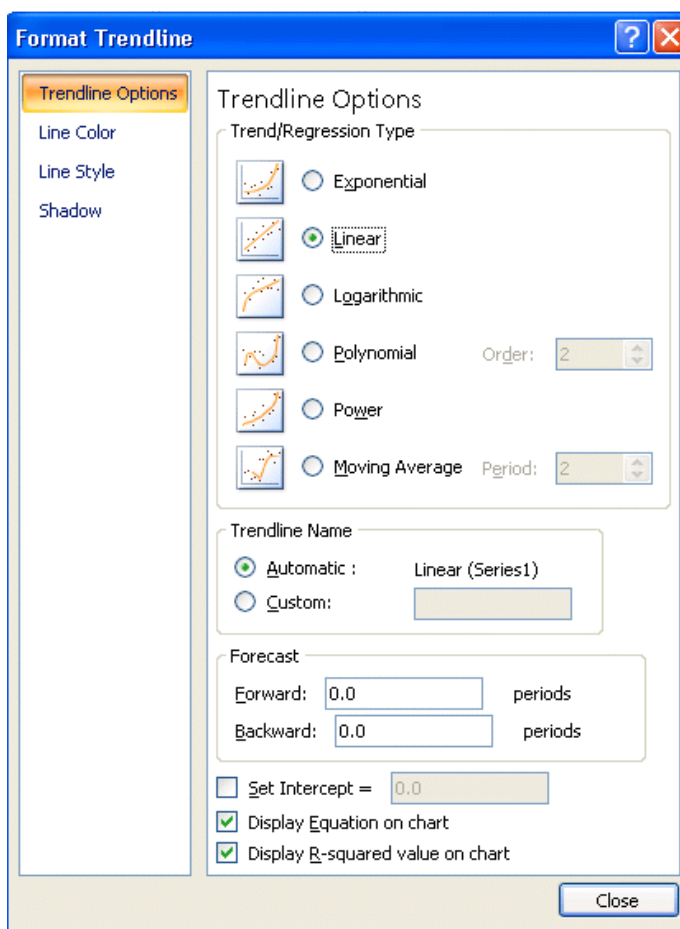


Figure 28

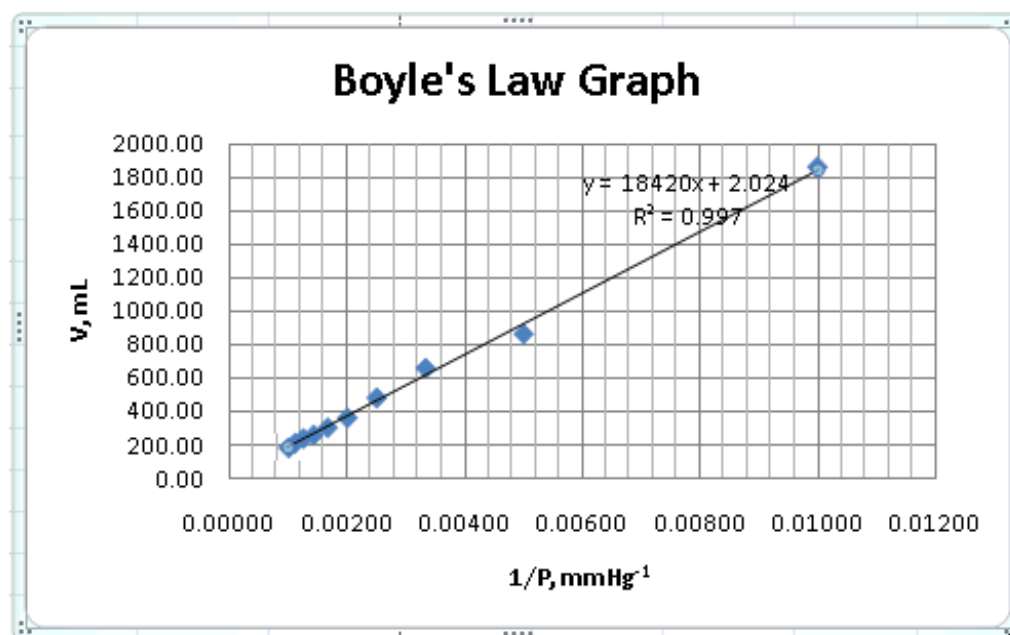


Figure 29

You will notice that the equation is in a region of the graph that makes it hard to read. We will move the equation to a clear region of the graph.

Left click on the equation, move the cursor to the boundary box until it turns into two double arrows at right angles to each other (Figure 30) and drag it to the right of the graph title.

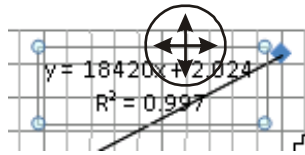
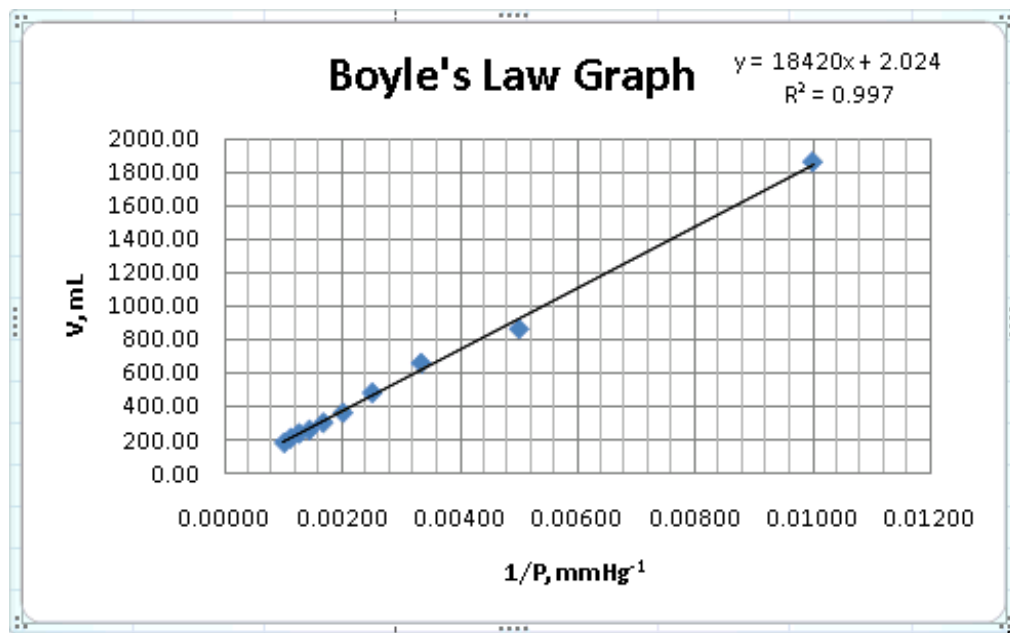


Figure 30



Our graph is now complete.

The relationship between the vapor pressure of aniline and its temperature was investigated, with the following results:

VP, mmHg	t, °C	VP, mmHg	t, °C
776.2	182.0	302.0	152.0
631.0	177.0	208.9	137.0
512.9	167.0	158.5	127.0
398.1	157.0	125.9	117.0

Enter this data into the spreadsheet. Set up a column to convert VP from mmHg to atm. This conversions accomplished by dividing the VP values in mmHg by 760. Set up a second column to convert t in °C to T in K (Kelvint). The conversion of °C to K is accomplished by adding 273.15 to the °C temperature. The conversion column should be arranged so as to plot T vs PV (T is on the x-axis and VP on the y-axis).

Your data should look like this:

t, °C	VP, mmHg	T, K	P, atm
182.0	776.2	455.2	1.021
177.0	631.0	450.2	0.8303
167.0	512.9	440.2	0.6749
157.0	398.1	430.2	0.5238
152.0	302.0	425.2	0.3974
137.0	208.9	410.2	0.2749
127.0	158.5	400.2	0.2086
117.0	125.9	390.2	0.1657

Don't forget to format the data to reflect the correct number of digits.

My data was entered into cells C3 to C10 for the temperature and D2 to D10 for the vapor pressure. The formula cells should look like this (based on where I placed my data - you may have entered the data in different cells):

`=C3+273.15`

Formula in cell E3 to convert °C to K.

`=D3/760`

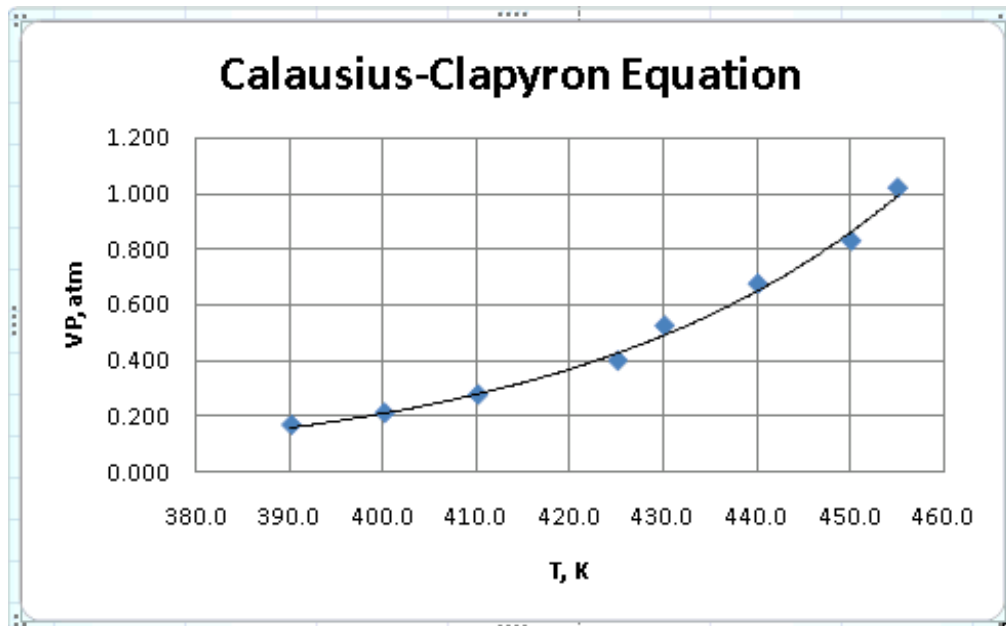
Formula in F3 to convert mmHg to atm.

There is a way that we can format numerical results by using a built in Excel function, ROUND. It looks like this when applied to the temperature conversion formula:

`=ROUND(C3+273.15,4)`

ROUND is followed by parentheses. The first term in the parentheses is the conversion formula folloled by a comma. The second term is a number that indicates how many digits should be displayed; here four.

Notice that, to set up the data correctly for the graph the column containing the T, K data is to the left of the column containing the VP, mmHg data. When these two columns are highlighted in this position, Excel will plot the temperature data on the x-axis and the vapor pressure on the y-axis. Your graph should look like this after formatting:



If you are wondering which line to check in the Trendline dialog box, there is an easy way to decide. Check the box to display R-squared and then click each line in turn. The correct line will yield the largest r^2 value. For this line the results of r^2 are as follows:

Exponential	$r^2 = 0.995$
Linear	$r^2 = 0.932$
Polynomial	$r^2 = 0.993$
Power	$r^2 = 0.994$

I chose Exponential. Don't forget to uncheck the R-squared box.

In order to obtain a straight line we have to plot $\ln(\text{VP})$, natural log of VP vs. $1/T$. In the column after the VP in atm enter the following formula:

P, atm	$1/T, K^{-1}$
1.021	<input type="text" value="=1/e3"/>
0.8303	

Note the column label, $1/T, K^{-1}$.

In the column after this enter the following formula:

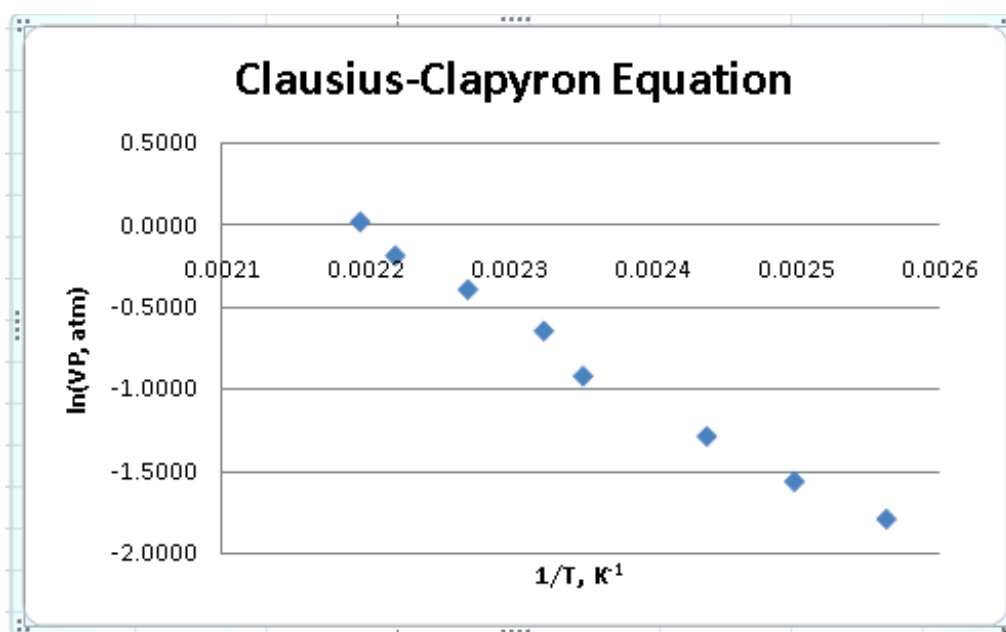
$1/T, K^{-1}$	$\ln(\text{VP, atm})$
0.002197	<input type="text" value="=ln(f3)"/>
0.002221	

Note the column label.

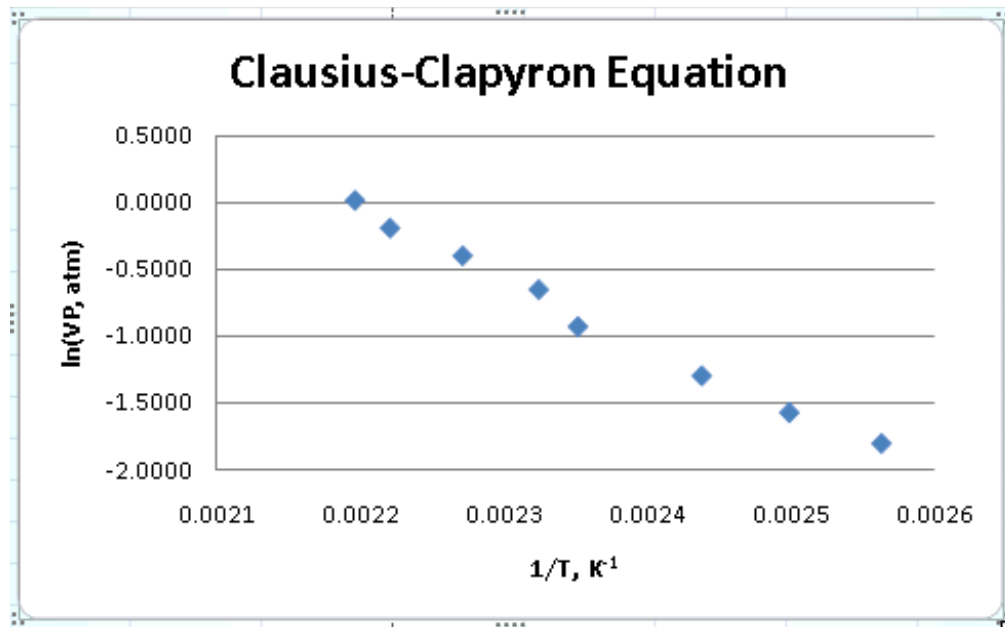
Your data should now look like this:

t, °C	VP, mm	T, K	VP, atm	1/T, K ⁻¹	ln(VP, atm)
182.0	776.2	455.2	1.021	0.002197	0.0211
177.0	631.0	450.2	0.8303	0.002221	-0.1860
167.0	512.9	440.2	0.6749	0.002272	-0.3932
157.0	398.1	430.2	0.5238	0.002325	-0.6466
152.0	302.0	425.2	0.3974	0.002352	-0.9229
137.0	208.9	410.2	0.2749	0.002438	-1.2915
127.0	158.5	400.2	0.2086	0.002499	-1.5676
117.0	125.9	390.2	0.1657	0.002563	-1.7978

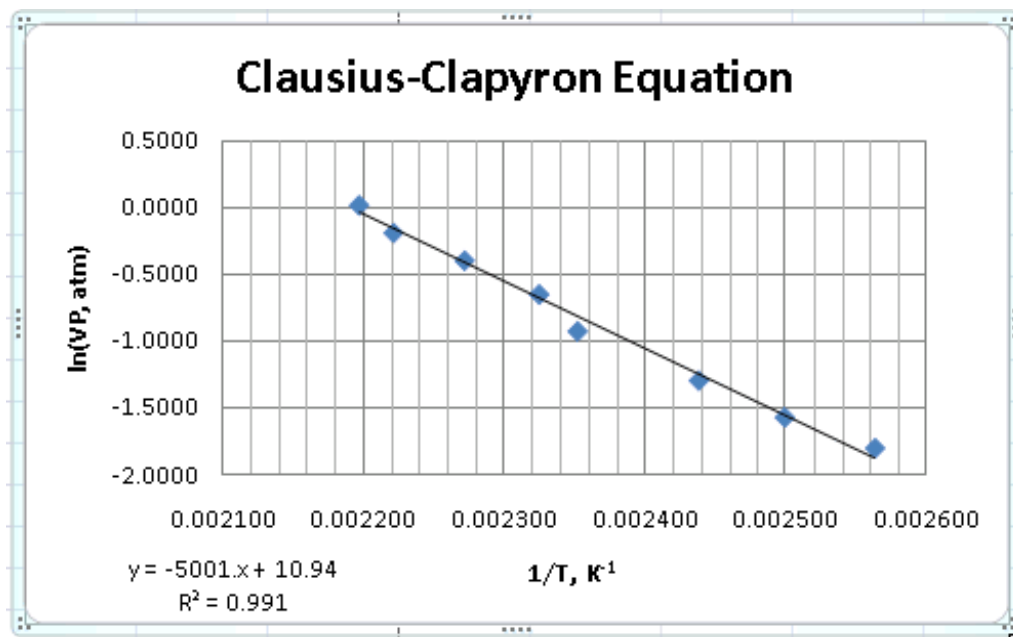
Plot 1/T vs. ln(VP):



We now have a formatting problem. We want the x-axis data labels to appear at the bottom of the graph and not in the middle. Right click on one of the y-axis data labels and select **F**ormat Axis. At the bottom of the Format Axis box you will see Horizontal axis crosses: Click on Axis value: and enter the lowest y-axis value in the box, here -2. If you are not sure what the lowest y-axis value is, look up on top at **A**XIS **O**PTIONS and across from **M**inimum: you will see its value (here -2.0); click **C**lose (see the graph on the next page).



We can now format the graph as before. Put in the gridlines, the trendline with is equations and format the number axis labels.



One last bit of formatting. Note that there is are no data points in about the first fifth of the graph. We can reformat the x-axis to remove this empty area. Right click on the x-axis and select Format Axis... For Minimum: click fixed and enter in a minimum value (do not enter a value higher that your lowest data point value) - here 0.00219. For Maximum: click fixed and enter a maximum value (do not enter a value lower than your highest data point value) - here 0.00257 (See next page)..

Axis Options

Minimum: Auto Fixed 0.00219

Maximum: Auto Fixed 0.00257

Major unit: Auto Fixed 5.0E-5

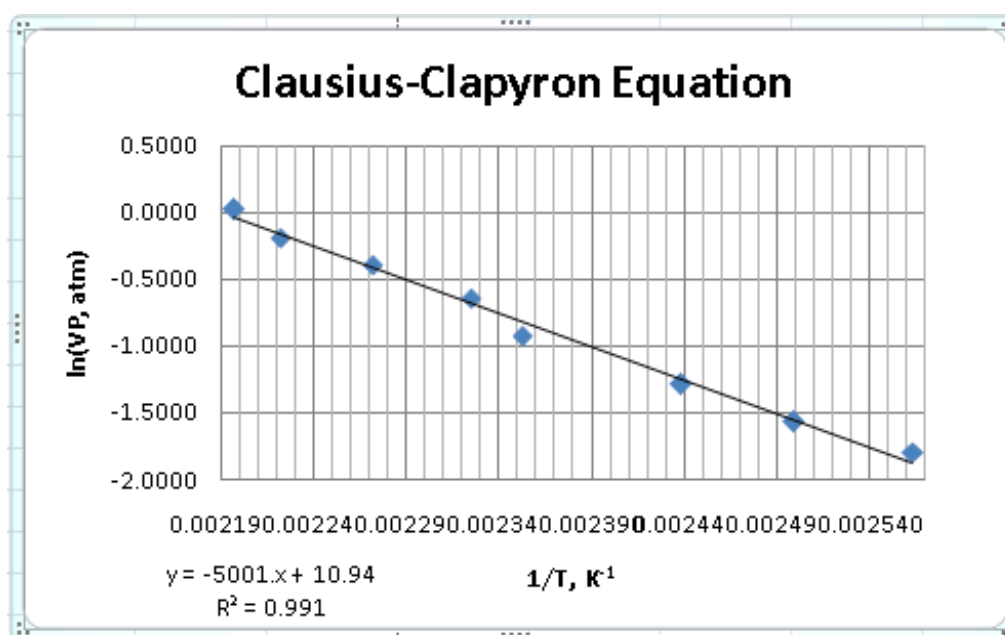
Minor unit: Auto Fixed 1.0E-5

Values in reverse order

Logarithmic scale Base: 10

Display units: None

Show display units label on chart



The graph is now complete!