Name: ___________________________________ Date: _________________ Pd: ___________

Math Skills for Chemistry Students

I. Rearranging Equations

Mathematics is used widely in chemistry as well as all other sciences. Mathematical calculations are absolutely necessary to explore important concepts in chemistry. Without some basic mathematics skills, these calculations, and therefore chemistry itself, will be extremely difficult. However, with a basic knowledge of some of the mathematics that will be used in your chemistry course, you will be well prepared to deal with the concepts and theories of chemistry.

This document describes the math skills you will need to be successful this year in chemistry. You will be expected to do algebra, scientific notation, unit conversions, dimensional analysis and graphing. You will be tested on these skills on Friday of the 2nd week of school. After the test, the skills are not done with. **THESE SKILLS WILL BE USED ALL YEAR.** It is **EXPECTED** and **TAKEN FOR GRANTED** that all students have the necessary math skills.

When solving chemistry problems you will often be required to rearrange an equation to solve for an unknown. Three things to remember:

1) Use the opposite Function to move something from one side to the other.
2) What you do to one side, you must do to the other side of the equation.
3) Get the variable on the top and by itself.

The following examples will help illustrate these points:

Example 1

$$2a = (27 - 3a)5$$

To solve:

1) Expand the right side by multiplying each term.

$$5 \times 27 = 135$$
$$5 \times 3a = 15a$$

Rewritten Equation:
$$2a = 135 - 15a$$

2) Group Like terms together.

The main idea here is to get all the *a* terms on one side and the terms without *a* on the other side by using the opposite function to move terms from one side of the equation to the other side of the equation. Remember that whatever you do to one side you must do to the other side of the equation. In this case, to “move” the 15*a* to the side with 2*a* you must add 15*a* to both sides of the equation.

$$\begin{array}{rcl} 2a & = & 135 - 15a \\ \underline{+\,15a} & & \underline{+15a} \\ 17a & = & 135 \end{array}$$

3) Isolate unknown.
   Divide both sides by the *a*’s coefficient (opposite of multiplying 17 x *a*).

$$\frac{17a}{17} = \frac{135}{17}$$

4) Solve.

a = 7.94

Example 2

Using the formula $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Do the following:
Rearrange the equation to isolate P_1

Given: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

First, P_1 is already on the top so we don't need to move it. We just need to move everything else away from it. To begin let's multiply both sides by T_1. (This is the opposite function and will enable us to move T_1 to the other side of the equation:

$$\frac{\cancel{(T_1)}P_1V_1}{\cancel{T_1}} = \frac{(T_1)P_2V_2}{T_2}$$

Rewritten:

$$\frac{P_1V_1}{} = \frac{T_1P_2V_2}{T_2}$$

Now we need to divide both sides by V_1

$$\frac{P_1\cancel{V_1}}{\cancel{V_1}} = \frac{T_1P_2V_2}{V_1T_2}$$

Rewritten:

$$\frac{P_1}{} = \frac{T_1P_2V_2}{V_1T_2}$$

Example 3

Starting over with the original equation, let's isolate T_2

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Since T_2 is on the bottom, let's multiply both sides by T_2 to get it on the top

$$\frac{(T_2)P_1V_1}{T_1} = \frac{\cancel{(T_2)}P_2V_2}{\cancel{(T_2)}}$$

Rewritten:

$$\frac{T_2 P_1 V_1}{T_1} = \frac{P_2 V_2}{}$$

Multiply both sides by T_1 to move it to the right side (away from T_2)

$$\frac{T_2 P_1 V_1 \cancel{(T_1)}}{\cancel{(T_1)}} = \frac{P_2 V_2 (T_1\ )}{}$$

Rewritten:

$$\frac{T_2 P_1 V_1}{} = \frac{P_2 V_2 T_1}{}$$

Divide both sides by what you need to take away from T_2 on the top, P_1 and V_1

$$\frac{T_2 \cancel{P_1 V_1}}{\cancel{P_1 V_1}} = \frac{P_2 V_2 T_1}{P_1 V_1}$$

Rewritten

$$\frac{T_2}{} = \frac{T_1 P_2 V_2}{P_1 V_1}$$

Algebra Practice Problems
Single Variable

Solve for X:

1) $30X = (60)(40)$

2) $15X + 2 = 10X + 4$

3) $15X - 2 = 10X - 4$

Multi Variable

4) $-14y = 1x - 1$ If x has a value of 15 what is the value of **y**?

5) $y = -1x + 7$ If y has a value of -24 what is the value of **x**?

6) $y = 4x - 2$ If y has a value of 6 what is the value of **x**?

7) $0.66y = 0.9x + 0.48$ If y has a value of 108.45 what is the value of **x**?

Variable Formula: Solve for the requested variable

8) $2t + y = ab + m$ **find a**

9) $bc - ad = 3c + r$ **find c**

10) $3mx = t + y$ **find m**

11) $t + d = b + d$ **find b**

12) $3z + 4x - d = 4d + e$ **find x**

Answers to Problems 1-3

1) 30X = (60)(40)

a) multiply numbers on the right side of the equation

30X = 240

b) divide both sides by 30

$$\frac{\cancel{30}X}{\cancel{30}} = \frac{240}{30}$$

X = 8

2) $15X + 2 = 10X + 4$

a) Move all the X containing terms to the left side

(subtract 10X from both sides of the equation)

15X-10X +2 = 10X – 10X + 4

5X + 2 = 4

b) Move all the non X containing terms to the right side of the equation

(subtract 2 from both sides of the equation)

5X + 2 – 2 = 4 – 2

5X = 2

c) Isolate X

(divide both sides by 5)

$$\frac{\cancel{5}X}{\cancel{5}} = \frac{2}{5}$$

X = 2/5

3) 15X – 2 = 10X – 4

a) Move all the X containing terms to the left side

(subtract 10X from both sides of the equation)

15X-10X - 2 = 10X – 10X - 4

5X - 2 = -4

b) Move all the non X containing terms to the right side of the equation

(add 2 to both sides of the equation)

5X - 2 + 2 = -4 + 2

5X = -2

c) Isolate X

(divide both sides by 5)

$$\frac{\cancel{5}X}{\cancel{5}} = -\frac{2}{5}$$

X = - 2/5

Answers to problems 4-13:

4. $y=-1$
5. $x=31$
6. $x=2$
7. $x=79.0$
8. $a = (2t + y – m)/b$
9. $c = (bc – ad – r)/3$
10. $m = (t + y)/3x$
11. $b = t$
12. $x = (5d + e – 3z)/4$

II. Rounding Numbers

Another issue we need to deal with when we perform operations is how to state the answer. For example, if we are dividing a 20-centimeter wire into 3 equal pieces, we would divide 20 by 3 to get the length of each piece. If we took the time to work this division out by hand -- ack! – we would get 20 / 3 = 6.66666666666666666.........

The 6 repeats forever. How do we report this number? We **round** to some usually predetermined number of digits or decimal places. By "digits" we mean the total number of numbers both left and right of the decimal point. By "decimal places" we specifically refer to the number of numbers to the **right** of the decimal point.

For comparison, let's try rounding this number to 2 **decimal places** -- two numbers to the right of the point. To round, look at the digit *after* the one of interest -- in this case the third decimal place -- and use the rule:

if the digit is 0, 1, 2, 3 or 4 round down
if the digit is 5, 6, 7, 8 or 9 round up

Example:6.666666666666.....the next digit is 6 so we round up, giving 6.67 as the desired answer. If instead we had been asked to round the number 20/3 to 2 **digits** the answer would have been 6.7 (two digits, one of which is a "decimal place").

Sometimes rounding is the result of an approximation. If you had 101 or 98 meters of some wire, in each case you would have "about 100 meters." We will round many of our answers in science because the numbers will often be reporting *measurements*. Numbers representing measurements are only as accurate as the device used for measuring. For example, we could use a standard meter stick marked off in centimeters to measure the length of a wire as 15 cm.

If sometime later we cut the wire in pieces, reporting the size of a piece of the wire to nine or ten decimal places would not make sense.

It is just as important to know WHEN to round as HOW to round. In any math problem you should wait until the end to round; only the final answer should be rounded. Carry as many significant digits as you can throughout the problem. On a calculator, the most efficient way to carry the maximum is to do all the calculation on the calculator. Arrange the problem so that you do not have to copy an intermediate answer only to re-enter it into the calculator. If you do find yourself needing to save numbers outside the calculator, copy several more significant digits than you think you need.

Rounding Practice Problems: Round the following numbers as indicated.

To four figures:
1. 2.16347×10^5 _____________________ 2. 4.000574×10^4 _____________________
3. 3.682417 _________________________ 4. 375.6523 __________________________

To the nearest whole number:
5. 56.912 ___________________________ 6. 3.4125 __________________________
7. 40.5 _____________________________ 8. 2.75×10^4 _________________________

To one decimal place:
9. 54.7421 __________________________ 10. 100.0925 _________________________
11. 1.3511 __________________________ 12. 0.9741 ___________________________

To the nearest thousand*th*:
13. 5.687524 ________________________ 14. 39.861214 ________________________
15. 104.97055 _______________________ 16. 41.86632 _________________________

Answers to Rounding Problems:

1. 2.163×10^5 2. 4.001×10^4 3. 3.682 4. 375.7 5. 57
6. 3 7. 41 8. 3×10^4 9. 54.7 10. 100.1
11. 1.4 12. 1.0 13. 5.688 14. 39.861 15. 104.971
16. 41.866

III. Percentage Calculations

Converting raw numbers to percentages is easy once the parts are defined. A percentage is the target over the total multiplied by one hundred percent.

$$percentage = part/total \times 100$$

Ex: There are thirty people in the classroom. Of them, seventeen are male. What is the percentage of males in the classroom?
'Seventeen males' is the part we have defined. 'Thirty people' is the total. Seventeen divided by thirty times one hundred is 56.66667. Males are people, so we cancel the units. The answer is 56.7 percent.

In many cases, the most difficult part of using percentages is identifying the part and the total. Percentages do not have any other unit attached to them other than the percent. After dividing one unit by the same type of unit and cancelling the units, which should make sense.

Percentage Practice Problems:
1. In 1995, 78 women were enrolled in chemistry at a certain high school while 162 men were enrolled. What was the percentage of women taking chemistry? The percentage of men?

2. A penny has a total mass of 3.1g. Zinc makes up 2.9g of the penny. What is the percentage of zinc in the penny?

Answers to Percentage Problems:

1. In order to do this problem, you needed to figure out that the total number of people taking chemistry was 240. So the percentages were 32.5 % women and 67.5% men.
2. 93.5% zinc

IV. Units of Measurement

In science, when quantities are measured or calculated, they must be given proper units. A measurement without a unit specification really does not make much sense. Imagine if someone told you that Mt. Everest is 10^4 tall. Without a unit specification this number should mean nothing to you. There is a set of fundamental physical quantities - some of which you might already have some experience with - which form a sort of "building block" for measurements and calculation. The THREE fundamental or standard "building blocks" that are needed are: Length, Mass, and Time.

You are probably familiar with the fundamental units of length, mass and time in the American system: the yard, the pound, and the second. The other common units of the American system are often strange multiples of these fundamental units such as the ton (2000 lbs.), the mile (1760 yds.), the inch (1/36 yd.) and the ounce (1/16 lb.). Most of these units arose from accidental conventions, and so have few logical relationships.

The vast majority of the world uses a much more rational system known as the **metric system** (the SI, *Systeme International d'Unites*, internationally agreed upon system of units) with the following fundamental units:

- The **meter** for length. Abbreviated "m".
- The **kilogram** for mass. Abbreviated "kg". (Note: kilogram, not gram, is the standard.)
- The **second** for time. Abbreviated "s".

Base 10 System of Units
All of the unit relationships in the metric system are based on multiples of 10, so it is very easy to multiply and divide. The SI system uses prefixes to make multiples of the units. All of the prefixes represent powers of 10. The table below gives prefixes used in the metric system, along with their abbreviations and values.

Metric Prefixes

Prefix	Abbreviation	Value		Prefix	Abbreviation	Value
deci	d	10^{-1}		deca	da	10^{1}
centi	c	10^{-2}		hecto	h	10^{2}
milli	m	10^{-3}		kilo	k	10^{3}
micro	m	10^{-6}		mega	M	10^{6}
nano	n	10^{-9}		giga	G	10^{9}
pico	p	10^{-12}		tera	T	10^{12}

V. Conversion Factors

A **conversion factor** is a factor used to convert one unit of measurement into another unit. A simple conversion factor can be used to convert meters into centimeters, or a more complex one can be used to convert miles per hour into meters per second. Since most calculations require measurements to be in certain units, you will find many uses for conversion factors. What must always be remembered is that a conversion factor has to represent a fact; because the conversion factor is a fact and not a measurement, the numbers in a conversion factor are exact. This fact can either be simple or complex. For instance, you probably already know the fact that 12 eggs equal 1 dozen. A more
complex fact is that the speed of light is 3.00×10^{8} meters/sec. Either one of these can be used as a conversion factor, depending on the type of calculation you might be working with.

VI. Dimensional Analysis

Frequently, it is necessary to convert units measuring the same quantity from one form to another. For example, it may be necessary to convert a length measurement in meters to millimeters. This process is quite simple if you follow a standard procedure called dimensional analysis (also known as unit analysis or the factor-label method). **Dimensional analysis** is a technique that involves the study of the dimensions (units) of physical quantities. It is a convenient way to check mathematical equations. (There are other names for the very same idea, for instance, unit conversion or factor label or factor-unit system.)

Dimensional analysis involves considering the units you presently have and the units you wish to end up with, as well as designing conversion factors that will cancel units you don't want and produce units you do want. The conversion factors are created from the equivalency relationships between the units.

Suppose you want to convert 0.0856 meters into millimeters. In this case, you need only one conversion factor that will cancel the meters unit and create the millimeters unit. The conversion factor will be created from the relationship 1000mL = 1m.

$$(0.0856\ \mathrm{m}) \cdot \left(\frac{1000\ \mathrm{mm}}{1\ \mathrm{m}}\right) = (0.0856\ \cancel{\mathrm{m}}) \cdot \left(\frac{1000\ \mathrm{mm}}{1\ \cancel{\mathrm{m}}}\right) = 85.6\ \mathrm{mm}$$

In the above expression, the meter units will cancel and only the millimeter unit will remain.

Example 1: Convert 1.53 g to cg. The equivalency relationship is 1.00g = 100 cg, so the conversion factor is constructed from this equivalency in order to cancel grams and produce centigrams.

$$(1.53\ \mathrm{g}) \cdot \left(\frac{100\ \mathrm{cg}}{1\ \mathrm{g}}\right) = 153\ \mathrm{cg}$$

Example 2: Convert 1000. in. to ft. The equivalency between inches and feet is 12in = 1 ft. The conversion factor is designed to cancel inches and produce feet.

$$(1000.\ \mathrm{in.}) \cdot \left(\frac{1\ \mathrm{ft}}{12\ \mathrm{in.}}\right) = 83.33\ \mathrm{ft}$$

Each conversion factor is designed specifically for the problem. In the case of the conversion above, we need to cancel inches, so we know that the inches component in the conversion factor needs to be in the denominator. Sometimes, it is necessary to insert a series of conversion factors. Suppose we need to convert miles to kilometers, and the only equivalencies we know are 1mi = 5,280ft, 12in = 1ft, 2.54 cm = 1 in, 100 cm = 1m, 1000m = 1km. We will set up a series of conversion factors so that each conversion factor produces the next unit in the sequence.

Example 3: Convert 12 mi to km.

$$(12\ \text{mi}) \cdot \left(\frac{5280\ \text{ft}}{1\ \text{mi}}\right) \cdot \left(\frac{12\ \text{in.}}{1\ \text{ft}}\right) \cdot \left(\frac{2.54\ \text{cm}}{1\ \text{in.}}\right) \cdot \left(\frac{1\ \text{m}}{100\ \text{cm}}\right) \cdot \left(\frac{1\ \text{km}}{1000\ \text{m}}\right) = 19\ \text{km}$$

In each step, the previous unit is canceled and the next unit in the sequence is produced. Conversion factors for area and volume can also be produced by this method.

Example 4: Convert 1500 cm^2 to m^2.

$$(1500\ \text{cm}^2) \cdot \left(\frac{1\ \text{m}}{100\ \text{cm}}\right)^2 = (1500\ \text{cm}^2) \cdot \left(\frac{1\ \text{m}^2}{10{,}000\ \text{cm}^2}\right) = 0.15\ \text{m}^2$$

Example 5: Convert 12 in^3 to cm^3.

$$(12.0\ \text{in}^3) \cdot \left(\frac{2.54\ \text{cm}}{1\ \text{in}}\right)^3 = (12.0\ \text{in}^3) \cdot \left(\frac{16.4\ \text{cm}^3}{1\ \text{in}^3}\right) = 197\ \text{cm}^3$$

Dimensional Analysis Practice Problems:

1. What is 1.50 mm in km?

2. How many nanoseconds are in 1.50 days?

3. A car is going 60.0 MPH. How fast is that in ft/sec?

4. A car is going 62.0 MPH. How fast is that in KPH?

5. Light travels at 3.00 E8 m/sec. How fast is that in MPH?

6. A light year is the distance that light goes in a year. Using data from #6, how long is a light year in miles? (Rate times time = distance)

Answers to Dimensional Analysis Problems[3]:

1. 1.5 E-6 km   2. 1.30 E14 nsec   3. 88.0 ft/sec   4. 99.8 KPH   5. 6.71E8 MPH

6. If we use that velocity of light in the answer in #10 in miles per hour, the only unit that needs changing is the year to hours so that the hours in the denominator of the velocity can cancel. The number in the velocity of light is used with more significant digits than we will need. Rounding should only be done at the end of a problem.

1 year = 365.24 days 1 day = 24 hours

Begin with what you know and use the definitions as conversion factors so you can cancel the units you don't want and leave the units you do.

$$\overset{\text{GIVEN}}{\left(\frac{(6.7108\text{ E8 mi})(\cancel{\text{yr}})}{\cancel{\text{hour}}}\right)}\overset{\text{DEF.}}{\left(\frac{365.24\ \cancel{\text{days}}}{\cancel{\text{year}}}\right)}\overset{\text{DEF.}}{\left(\frac{24\ \cancel{\text{hr}}}{\cancel{\text{day}}}\right)} = \overset{\text{RAW ANSWER}}{\boxed{5.8825\text{ E12 mi}}} = \overset{\text{ANSWER}}{\boxed{5.88\text{ E12 mi}}}$$

The math is done by multiplying everything on top (in the numerator) and dividing by everything on the bottom (in the denominator).

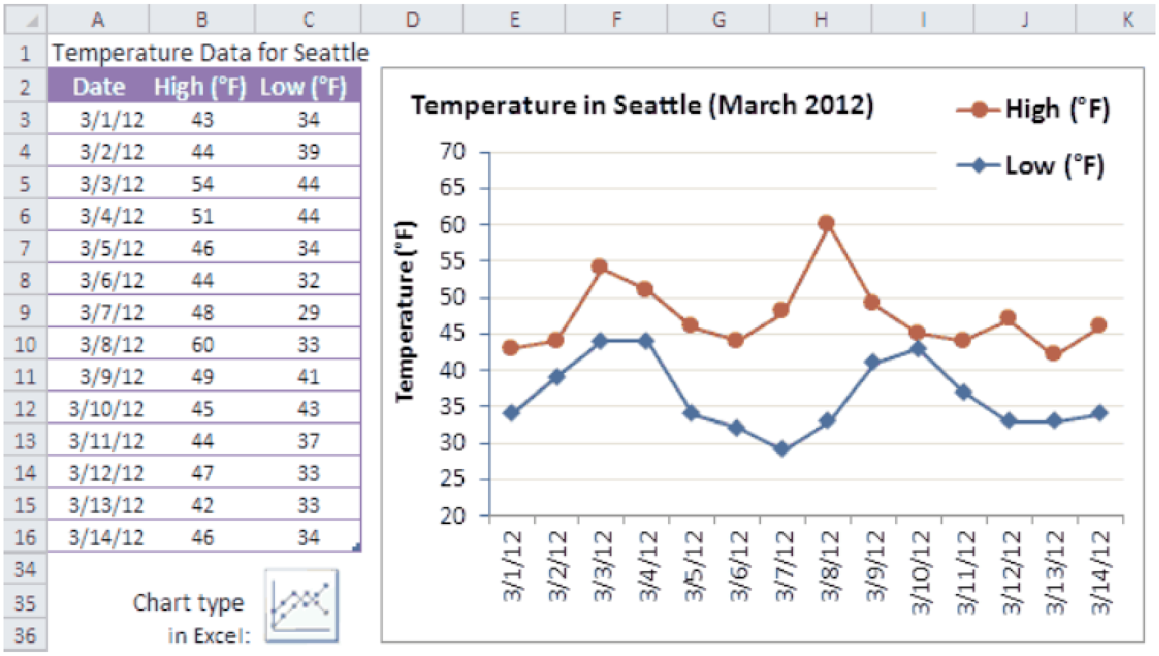
VII. Making Line Graphs

A line graph is commonly used to show how one variable affects another. Line graphs show data plotted as points that are connected by a line or a “best fit” line. Before a line graph can be made, the independent and dependent variables must be determined.

The independent variable is the one being changed (usually on purpose) during the experiment. It is always placed on the x-axis. The dependent variable is affected by the independent variable. It is placed on the y-axis. There are a few rules when graphing:

1. Graphs should have titles.
2. Each axis should have a label with units (where appropriate).
3. Select the scale for each axis.
4. Label each line on the graph (if there is more than one line).

For example, you could use a line graph to watch the changes in temperature in the month of March[8]. If it is hotter one day than on the day before, the line will go up. If it is cooler, it will go down. By analyzing the line graph, you can get a better idea of the changes that took place as time went on. You can also easily determine when the value you are graphing was highest or when it was lowest. Including 2 lines on the same graph lets you visualize comparisons, such as the difference between the High and Low temperatures for each day.

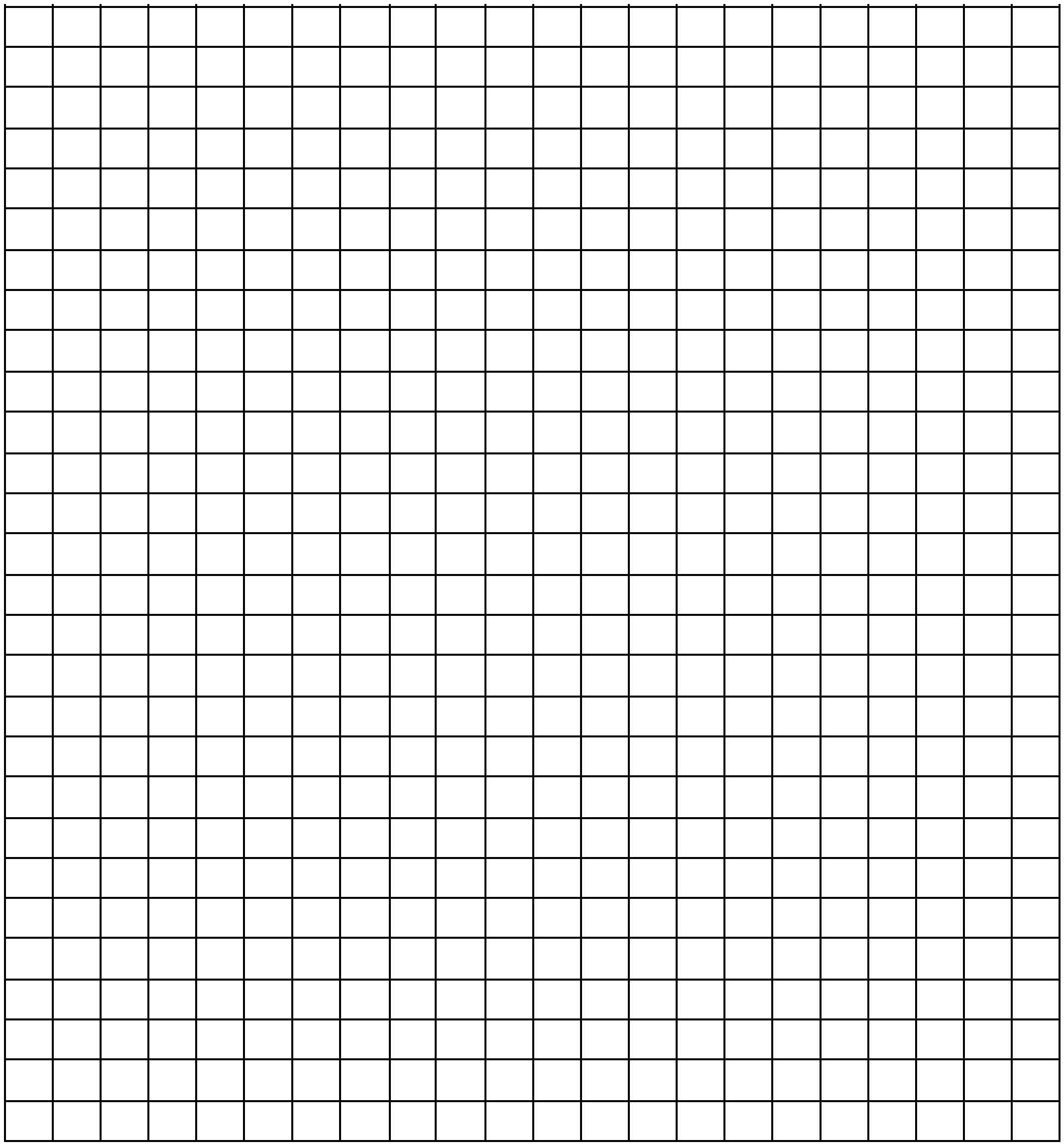


Example of a line graph in Excel
Data Source: http://www.beautifulseattle.com/mthsum.asp

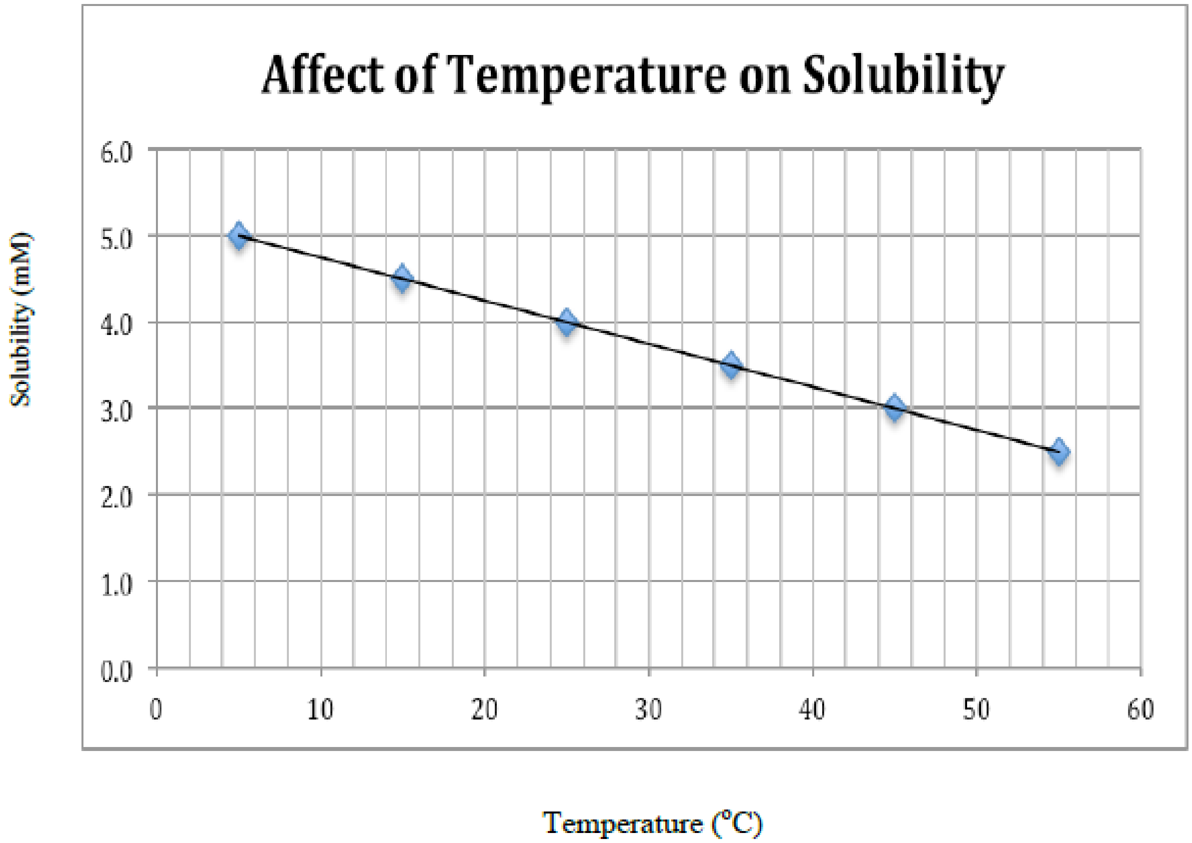
Graphing Practice Problems:

A group of students completed an experiment to determine the effect of temperature on the solubility of a substance. Use the data given in the table to graph the results of the experiment.

Temperature (°C)	Solubility (*mM*)
5	5.0
15	4.5
25	4.0
35	3.5
45	3.0
55	2.5



Answers to graphing problem:



References

1. "SLC Wiki and e-File cabinet of Study Materials." *Science Learning Center [licensed for non-commercial use only] /*. N.p., n.d. Web. 4 July 2014. <http://sciencelearningcenter.pbworks.com>.
2. "Mathematics in Chemistry." *Mathematics in Chemistry*. N.p., n.d. Web. 4 July 2014. <http://www.shodor.org/unchem-old/math/index.html>.
3. "CHEMTUTOR NUMBERS." *CHEMTUTOR NUMBERS*. N.p., n.d. Web. 4 July 2014. <http://www.chemtutor.com/numbr.htm#sig>.
4. "Math Skills - Scientific Notation." *Math Skills - Scientific Notation*. N.p., n.d. Web. 4 July 2014. <http://www.chem.tamu.edu/class/fyp/mathrev/mr-scnot.html>.
5. "Math Reminder." *Math Reminder*. N.p., n.d. Web. 4 July 2014. <http://lasp.colorado.edu/~bagenal/MATH/main.html>."
6. <http://www.ck12.org/na/Using-Algebra-in-Chemistry-2/lesson/user%3Ac3RlaW51c0BtaWxsdmlsbGUuazEyLnBhLnVz/Using-Algebra-in-Chemistry-%253A%253Aof%253A%253A-Measurement-in-Chemistry/>.
7. <http://bees4work.pbworks.com/f/Drawing&interpreting+graphs.pdf>.
8. "Charts and Graphs in Excel." *Charts and Graphs in Excel*. N.p., n.d. Web. 6 July 2014. <http://www.vertex42.com/edu/charts-and-graphs-in-excel.html>.