# ADVANCED CHEMISTRY (Pre - A.P)
# SUMMER ASSIGNMENT

Welcome to Advanced Chemistry. We are glad you have selected this course and wish you great success in your academic pursuits. The summer assignment is designed to prepare you for a Pre-AP Chemistry course, above and beyond the Regents Chemistry curriculum.

The purpose of this assignment is to have you review some basic math skills that will be essential to this course and also begin to memorize important chemical formulas and rules.

**Please be prepared to hand in all completed math problems the first day of class and for a quiz on common elements the first week.**

## Directions:

a. Learn the names and symbols of the common elements. You do not need to memorize the atomic number.

b. Create flash cards for Tables E and F (attached). You will need to have these ions and rules committed to memory within the first semester. I will check flash cards the first day.

c. Review basic math concepts and complete all problems. Please bring problems to hand in on the first day.

d. Have a great summer and be ready to WORK come September! ☺

**If you would like to further prepare for the course, the following materials will be needed:**

1. A marble composition notebook. This will serve as your lab notebook.

2. A notebook or binder for notes – what you use is entirely up to you. Notes will be available to access and print on the Classroom, if that is your preference.

3. A folder for homework and lab work.

4. A scientific calculator. Graphing calculators are not permitted.

**Please email me with any questions** – vzumbo@nredlearn.org

## 2. MODERN CHEMICAL SYMBOLS

Listed below are the atomic numbers, names, and symbols of the most common elements. The atomic number is used to determine the place of the element in the periodic table, it also has other meaning as you will find out later in the course.

Become familiar with the names and symbols of these elements.

| Atomic Number | Name | Symbol | Atomic Number | Name | Symbol |
|---|---|---|---|---|---|
| 1 | hydrogen | H | 28 | nickel | Ni |
| 2 | helium | He | 29 | copper | Cu |
| 3 | lithium | Li | 30 | zinc | Zn |
| 4 | beryllium | Be | 33 | arsenic | As |
| 5 | boron | B | 35 | bromine | Br |
| 6 | carbon | C | 36 | krypton | Kr |
| 7 | nitrogen | N | 37 | rubidium | Rb |
| 8 | oxygen | O | 38 | strontium | Sr |
| 9 | fluorine | F | 47 | silver | Ag |
| 10 | neon | Ne | 48 | cadmium | Cd |
| 11 | sodium | Na | 50 | tin | Sn |
| 12 | magnesium | Mg | 51 | antimony | Sb |
| 13 | aluminum | Al | 53 | iodine | 1 |
| 14 | silicon | Si | 54 | xenon | Xe |
| 15 | phosphorus | P | 55 | cesium | Cs |
| 16 | sulfur | S | 56 | barium | Ba |
| 17 | chlorine | Cl | 74 | tungsten | W |
| 18 | argon | Ar | 78 | platinum | Pt |
| 19 | potassium | K | 79 | gold | Au |
| 20 | calcium | Ca | 80 | mercury | Hg |
| 21 | scandium | Sc | 82 | lead | Pb |
| 22 | titanium | Ti | 83 | bismuth | Bi |
| 23 | vanadium | V | 86 | radon | Rn |
| 24 | chromium | Cr | 87 | francium | Fr |
| 25 | manganese | Mn | 88 | radium | Ra |
| 26 | iron | Fe | 92 | uranium | U |
| 27 | cobalt | Co | | | |

Use these tables to complete task B.
Make flash cards for each ion and rule.
These will need to be memorized for use in the first semester.

## Table E
## Selected Polyatomic Ions

| Formula | Name |
|---|---|
| $H_3O^+$ | hydronium |
| $Hg_2^{2+}$ | mercury(I) |
| $NH_4^+$ | ammonium |
| $C_2H_3O_2^-$ / $CH_3COO^-$ | acetate |
| $CN^-$ | cyanide |
| $CO_3^{2-}$ | carbonate |
| $HCO_3^-$ | hydrogen carbonate |
| $C_2O_4^{2-}$ | oxalate |
| $ClO^-$ | hypochlorite |
| $ClO_2^-$ | chlorite |
| $ClO_3^-$ | chlorate |
| $ClO_4^-$ | perchlorate |

| Formula | Name |
|---|---|
| $CrO_4^{2-}$ | chromate |
| $Cr_2O_7^{2-}$ | dichromate |
| $MnO_4^-$ | permanganate |
| $NO_2^-$ | nitrite |
| $NO_3^-$ | nitrate |
| $O_2^{2-}$ | peroxide |
| $OH^-$ | hydroxide |
| $PO_4^{3-}$ | phosphate |
| $SCN^-$ | thiocyanate |
| $SO_3^{2-}$ | sulfite |
| $SO_4^{2-}$ | sulfate |
| $HSO_4^-$ | hydrogen sulfate |
| $S_2O_3^{2-}$ | thiosulfate |

## Table F
## Solubility Guidelines for Aqueous Solutions

| Ions That Form *Soluble* Compounds | Exceptions |
|---|---|
| Group 1 ions ($Li^+$, $Na^+$, etc.) | |
| ammonium ($NH_4^+$) | |
| nitrate ($NO_3^-$) | |
| acetate ($C_2H_3O_2^-$ or $CH_3COO^-$) | |
| hydrogen carbonate ($HCO_3^-$) | |
| chlorate ($ClO_3^-$) | |
| halides ($Cl^-$, $Br^-$, $I^-$) | when combined with $Ag^+$, $Pb^{2+}$, or $Hg_2^{2+}$ |
| sulfates ($SO_4^{2-}$) | when combined with $Ag^+$, $Ca^{2+}$, $Sr^{2+}$, $Ba^{2+}$, or $Pb^{2+}$ |

| Ions That Form *Insoluble* Compounds* | Exceptions |
|---|---|
| carbonate ($CO_3^{2-}$) | when combined with Group 1 ions or ammonium ($NH_4^+$) |
| chromate ($CrO_4^{2-}$) | when combined with Group 1 ions, $Ca^{2+}$, $Mg^{2+}$, or ammonium ($NH_4^+$) |
| phosphate ($PO_4^{3-}$) | when combined with Group 1 ions or ammonium ($NH_4^+$) |
| sulfide ($S^{2-}$) | when combined with Group 1 ions or ammonium ($NH_4^+$) |
| hydroxide ($OH^-$) | when combined with Group 1 ions, $Ca^{2+}$, $Ba^{2+}$, $Sr^{2+}$, or ammonium ($NH_4^+$) |

*compounds having very low solubility in $H_2O$

# Math Skills for Chemistry Students

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. You can review now and get comfortable with the math or you can struggle with it for the rest of the year. The choice is yours!

## Algebra and Rearranging Equations[1]

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.
4)

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 $15a$ to the side with $2a$ you must add $15a$ to both sides of the equation.

$$\begin{array}{r} 2a = 135 - 15a \\ \underline{+15a \quad\quad +15a} \\ 17a = 135 \end{array}$$

***Multi-variable problems***

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 formulas: Solve for the requested variable***

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

What is $V_1$ when $P_1$ = 1.00 atm, $P_2$ = 0.983 atm, $V_2$ = 500.0 mL, $T_1$ = 334K, and $T_2$ = 348K?

9. 2t + y = ab + m **find a**

10. bc – ad = 3c + r **find c**

## Rounding Numbers[2]

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

$$20 / 3 = 6.666666666666666666.........$$

The 6 repeats forever. How do we report this number? We **round** to some usually pre-determined 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

In our 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. $2.16347 \times 10^5$ ____________________
2. $4.000574 \times 10^4$ ____________________
3. 3.682417 ________________________
4. 375.6523 ________________________

To the nearest whole number:

5. 56.912 __________________________
6. 3.4125 __________________________
7. 40.5 ____________________________
8. $2.75 \times 10^4$ ________________________

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 _______________________

Rounding Rules for Chemistry

# Rules for Significant Figures (sig figs, s.f.)

**A. Read from the left and start counting sig figs when you encounter the first non-zero digit**

1. All non zero numbers are *significant* (meaning they count as sig figs)
   - 613 has three sig figs
   - 123456 has six sig figs

2. Zeros located between non-zero digits are *significant* (they count)
   - 5004 has four sig figs
   - 602 has three sig figs
   - 6000000000000002 has 16 sig figs!

3. Trailing zeros (those at the end) are *significant* only if the number contains a decimal point; otherwise they are *insignificant* (they **don't** count)
   - 5.640 has four sig figs
   - 120000. has six sig figs
   - 120000 has two sig figs – unless you're given additional information in the problem

4. Zeros to left of the first nonzero digit are *insignificant* (they **don't** count); they are only placeholders!
   - 0.000456 has three sig figs
   - 0.052 has two sig figs
   - 0.000000000000000000000000000000000052 also has two sig figs!

**B. Rules for addition/subtraction problems**

Your calculated value cannot be more precise than the *least precise quantity* used in the calculation. The *least precise quantity* has the fewest digits to the right of the decimal point. **Your calculated value will have the same number of digits to the right of the decimal point as that of the least precise quantity.**

In practice, find the quantity with the fewest digits to the right of the decimal point. In the example below, this would be 11.1 (this is the *least precise quantity*).

7.939 + 6.26 + 11.1 = 25.299 (this is what your calculator spits out)

In this case, your final answer is limited to one sig fig to the right of the decimal or 25.3 (rounded up).

**C. Rules for multiplication/division problems**

**The number of sig figs in the final calculated value will be the same as that of the quantity with the fewest number of sig figs used in the calculation.**

In practice, find the quantity with the fewest number of sig figs. In the example below, the quantity with the fewest number of sig figs is 27.2 (three sig figs). Your final answer is therefore limited to three sig figs.

(27.2 x 15.63) ÷ 1.846 = 230.3011918 (this is what you calculator spits out)

In this case, since your final answer it limited to three sig figs, the answer is 230. (rounded down)

**D. Rules for combined addition/subtraction and multiplication/division problems**

First apply the rules for addition/subtraction (determine the number of sig figs for that step), then apply the rules for multiplication/division.

**E. Practice Problems**

1. Provide the number of sig figs in each of the following numbers:

(a) 0.0000055 g _____ (c) 1.6402 g _____

(b) $3.40 \times 10^3$ mL ______ (d) 1.020 L _____

2. Perform the operation and report the answer with the correct number of sig figs.

(a) (10.3) x (0.01345) = ____________________ (b) (10.3) + (0.01345) = ____________________

(c) [(10.3) + (0.01345)] ÷ [(10.3) x (0.01345)] ____________________

## Percentage Calculations[3]

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.

$$percentage = \frac{part}{total} * 100\%$$

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.

$$\frac{\textbf{17 males}}{\textbf{30 people}} \times 100\% = 56.66667\% = 56.7\%$$

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?

## Scientific Notation[3]

There are many very large and very small numbers in scientific studies. How would you like have to calculate with:

1 Dalton = 0.000,000,000,000,000,000,000,00165 g

or

1 mol = 602,200,000,000,000,000,000,000 atoms

You can streamline large or small numbers with scientific notation. The standard is that you move the decimal point to the left or right until you get a number greater than 1 but less than 10. Adjust the exponent of ten ($10^x$) to reflect the number of times the decimal place was moved. The only question you might have trouble with is WHICH WAY to move the decimal. The easy way to remember that is: numbers that are less than one have negative exponent numbers in the scientific notation form, and numbers that are larger than one have positive exponent numbers.

Think of the change as creating a new number with two parts, a digit part and an exponent part, from the old number.

To change 0.000,000,000,000,000,000,000,00165 into scientific notation, move the decimal to the right 24 times so it is between the 1 and 6 (1.65 is greater than 1 but less than 10). Since the number began as a value less than 1 (a decimal), the decimal was moved to the right and the sign of the exponent is negative.

$$0.000,000,000,000,000,000,000,00165 = 1.65 \times 10^{-24}$$

$$602,200,000,000,000,000,000,000 = 6.022 \times 10^{23}$$

Here are some examples of scientific notation:

| | |
|---|---|
| $10000 = 1 \times 10^4$ | $24327 = 2.4327 \times 10^4$ |
| $1000 = 1 \times 10^3$ | $7354 = 7.354 \times 10^3$ |
| $100 = 1 \times 10^2$ | $482 = 4.82 \times 10^2$ |
| $10 = 1 \times 10^1$ | $89 = 8.9 \times 10^1$ (not usually done) |
| $1 = 10^0$ | |
| $1/10 = 0.1 = 1 \times 10^{-1}$ | $0.32 = 3.2 \times 10^{-1}$ (not usually done) |
| $1/100 = 0.01 = 1 \times 10^{-2}$ | $0.053 = 5.3 \times 10^{-2}$ |
| $1/1000 = 0.001 = 1 \times 10^{-3}$ | $0.0078 = 7.8 \times 10^{-3}$ |
| $1/10000 = 0.0001 = 1 \times 10^{-4}$ | $0.00044 = 4.4 \times 10^{-4}$ |

Scientific notation can also be written in another form. Using the values from above:

0.000,000,000,000,000,000,000,00165 = $1.65 \times 10^{-24}$ or **1.65 E-24**

602,200,000,000,000,000,000,000 = $6.022 \times 10^{23}$ or **6.022 E23**

The "E" in the number stands for exponent. Your scientific calculator will use the numbers in the shortened form, usually best represented by the "E" form.

**Scientific Notation on Your Calculator**[4]

When you are using your calculator, typing "something times ten to the something" over and over again gets to be a pain. Most calculators have an "EE" button, to help you out. (Note that when you type the EE key, most calculators simply display "E"! Do not be alarmed by this. This is not the E that means error.)

Be careful! It's easy to make the following common mistake: Remember that EE -- times ten to the -- is not the same as ^ -- "to the"!

**Make sure that the number in scientific notation is put into your calculator correctly. Read** the directions for your particular calculator. For inexpensive scientific calculators:

1. Punch the number (the digit number) into your calculator.
2. Push the EE or EXP button. Do **NOT** use the x (times) button!!
3. Enter the exponent number. Use the +/- button to change its sign.
4. Voila! Treat this number normally in all subsequent calculations.

To check yourself, multiply $6.0 \times 10^5$ times $4.0 \times 10^3$ on your calculator. Your answer should be $2.4 \times 10^9$.

**If you don't have a scientific calculator:** You will need to be familiar with exponents since your calculator cannot take care of them for you.

**Addition and Subtraction:**

- All numbers are converted to the same power of 10, and the digit terms are added or subtracted.
- Example: $(4.215 \times 10^{-2}) + (3.2 \times 10^{-4}) = (4.215 \times 10^{-2}) + (0.032 \times 10^{-2}) = 4.247 \times 10^{-2}$
- Example: $(8.97 \times 10^4) - (2.62 \times 10^3) = (8.97 \times 10^4) - (0.262 \times 10^4) = 8.71 \times 10^4$

**Multiplication:**

- The digit terms are multiplied in the normal way and the exponents are added. The end result is changed so that there is only one nonzero digit to the left of the decimal.
- Example: $(3.4 \times 10^6)(4.2 \times 10^3) = (3.4)(4.2) \times 10^{(6+3)} = 14.28 \times 10^9 = 1.428 \times 10^{10}$
- Example: $(6.73 \times 10^{-5})(2.91 \times 10^2) = (6.73)(2.91) \times 10^{(-5+2)} = 19.58 \times 10^{-3} = 1.958 \times 10^{-2}$

**Division:**

- The digit terms are divided in the normal way and the exponents are subtracted. The quotient is changed (if necessary) so that there is only one nonzero digit to the left of the decimal.
- Example: $(6.4 \times 10^6)/(8.9 \times 10^2) = (6.4)/(8.9) \times 10^{(6-2)} = 0.719 \times 10^4 = 7.2 \times 10^3$ (to 2 significant figures)
- Example: $(3.2 \times 10^3)/(5.7 \times 10^{-2}) = (3.2)/(5.7) \times 10^{3-(-2)} = 0.561 \times 10^5 = 5.6 \times 10^4$ (to 2 significant figures)

**Scientific Notation Practice Problems**[5]:

Write the following numbers in *scientific notation*

**1.** 1001

**2.** 53

**3.** 6,926,300,000

**4.** -392

**5.** 0.00361

**6.** 0.13592

**7.** -0.0038

**8.** 0.00000013

**9.** -0.567

Take the numbers out of *scientific notation*

**1.** $1.92 \times 10^3$

**2.** $3.051\times10^1$

**3.** $-4.29 \times 10^2$

**4.** $6.251 \times 10^9$

**5.** $8.317 \times 10^6$

**6.** $1.03 \times 10^{-2}$

**7.** $8.862 \times 10^{-1}$

**8.** $9.512 \times 10^{-8}$

**9.** $-6.5 \times 10^{-3}$

**10.** $3.159 \times 10^2$

Use Scientific Notation (and only the scientific notation!) to find the answer to the following problems:

**1.** $4.1357 \times 10^{-15} * 5.4 \times 10^2 = ?$

**2.** $1.695 \times 10^4 \div 1.395 \times 10^{15} = ?$

**3.** $4.367 \times 10^5 * 1.96 \times 10^{11} = ?$

**4.** $6.97 \times 10^3 * 2.34 \times 10^{-6} + 3.2 \times 10^{-2} = ?$

**5.** $5.16 \times 10^{-4} \div 8.65 \times 10^{-8} + 9.68 \times 10^4 = ?$

# Units of Measure[5]

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.

Most 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 | $10^{12}$ |

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.

$$(1.53\ \text{g}) \cdot (\frac{100\ \text{cg}}{1\ \text{g}}) = 153\ \text{cg}$$

**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.

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

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.

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

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 $m^2$.

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

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

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

**Dimensional Analysis Practice Problems[3]:**

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)

# Making Line Graphs[7]

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:

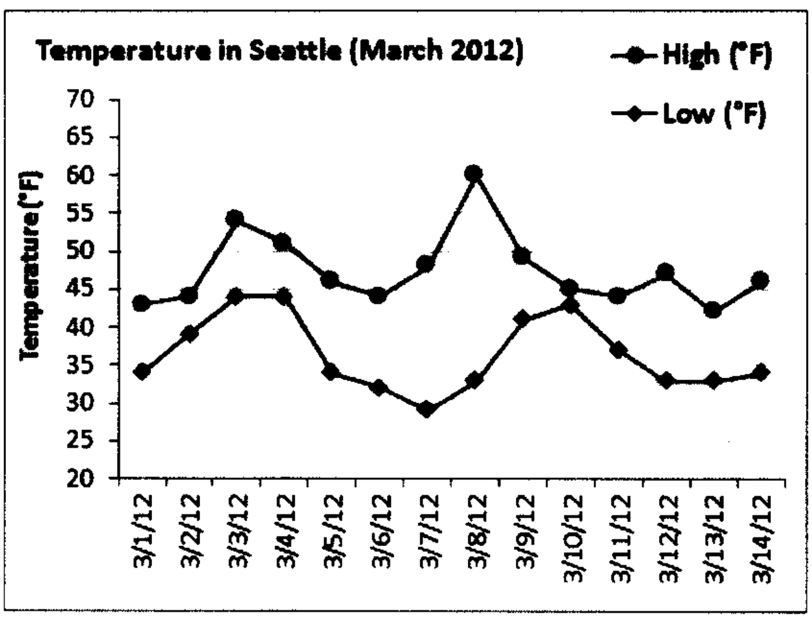
1. Graphs should have titles.
2. Each axis should have a label with units (where appropriate).
3. Select the scale for each axis.
4. Label each line on the graph (if there is more than one line).

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.

**Temperature Data for Seattle**

| Date | High (°F) | Low (°F) |
|---|---|---|
| 3/1/12 | 43 | 34 |
| 3/2/12 | 44 | 39 |
| 3/3/12 | 54 | 44 |
| 3/4/12 | 51 | 44 |
| 3/5/12 | 46 | 34 |
| 3/6/12 | 44 | 32 |
| 3/7/12 | 48 | 29 |
| 3/8/12 | 60 | 33 |
| 3/9/12 | 49 | 41 |
| 3/10/12 | 45 | 43 |
| 3/11/12 | 44 | 37 |
| 3/12/12 | 47 | 33 |
| 3/13/12 | 42 | 33 |
| 3/14/12 | 46 | 34 |

Chart type in Excel: 




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

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

**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.