CHEMISTRY
Mr. Noble

NAME:
DATE:
PERIOD:

Dimensional Analysis

There are two rules that you must use when units are involved in problems. They are:
1. Only quantities with the same units can be added or subtracted. You cannot add or subtract apples and oranges.
2. When quantities are multiplied or divided, their units are also multiplied or divided.
To illustrate this, imagine trying to add 50.0 mm Hg to 3.50 atm. Both mm Hg and Atm are units of pressure. We know that the mathematical sum is 53.5, but what are the units? Are the units "mm Hg" (millimeters of mercury) or "atm" (atmospheres)? The answer of 53.5 has no meaning because the units on each number are not the same. Therefore, can we add the pressures in the forms given? No! However, if you know that 1 atm = 760 mm Hg, you can convert 3.50 atm to mm Hg and add the results to 50.0 mm Hg. This is done for you below.

$$3.50 \text{ atm} \times \frac{760 \text{ mm Hg}}{1 \text{ atm}} = 2660 \text{ mm Hg}$$

Units are a part of all problems. If the units cancel out correctly leaving you only with the units you want in the answer, you know you have set up the problem correctly. This powerful method of setting up problems is known as "dimensional analysis" or "unit analysis." Because of the way the set-up of the problem looks on paper, it is sometimes referred to as a "fencepost." Here is an example of the setup:

$$\text{What units you have} \left(\frac{\textbf{What units you want}}{\text{What units you have}}\right) = \text{What units you want}$$

You are ready to try some sample problems involving units and their cancellation. After you have some experience with these types of problems, you will realize that you are capable of working many types of problems without memorizing formulas. Dimensional analysis is not always the shortest way to solve a problem. However, as problems get more and more complex, dimensional analysis gets more and more powerful because it can guide you through the logic required, and it allows you to set up large parts of the problem at once, rather than doing a complicated problem in small parts - one at a time. In addition, you will find that you can solve problems without knowing anything about the meanings of the terms involved.
Work the following problems. The problems have been partially set up for you. Cancel out units and place the correct units on your answers. Never express answers as fractions!

Problem 1.

If 1 tree = 10 branches, and 15 nests = 15 eggs, and 1 baby bird = 1 egg, and 2 trees = 1 yard, and 5 branches = 5 nests, how many baby birds are there in 1 yard behind a house? (Start with the information given, 1 yard, and solve for baby birds.)

$$1 \text{ yard} \times \frac{2 \text{ trees}}{1 \text{ yard}} \times \frac{10 \text{ branches}}{1 \text{ tree}} \times \frac{5 \text{ nests}}{5 \text{ branches}} \times \frac{15 \text{ eggs}}{15 \text{ nests}} \times \frac{1 \text{ baby bird}}{1 \text{ egg}}$$

$= \_\_\_\_\_\_\_\_$ baby birds

Problem 2.
Two warts = 1 querk, 3 querks = 1 gag, 5 gags = 6 nerfs, and 4 nerfs = 5 wigs. How many warts are there in 1 wig? Don't panic! You are looking for warts, and you are given wigs. So, we start the fencepost with 1 wig and set up the units so that they cancel and leave you with warts. Finish the set-up below and calculate the answer.

$$1 \text{ wig } \times \frac{\text{nerfs}}{\text{wigs}} \ \ldots \qquad = \ \_\_\_\_\_\_ \text{ warts}$$

A word that we use a lot with units is per. We say miles per gallon (mi/gal) or miles per hour (mi/hr) or grams per mole (g/mol). These are common units, and they are used in the following problems. Solve these problems making certain that you show all of your work, including units.

Problem 3.
1.00 case of apples costs $16.00. What is the cost per dozen if a case contains 14.0 dozen apples. (You want to end with units of $/doz.)

$$\frac{1.00 \text{ case}}{14 \text{ dozen}} \times \qquad = \frac{\$\quad}{1 \text{ dozen}}$$

Problem 4. A car travels 300.0 miles on 11.0 gallons of gas. How many miles is the car able to travel when 143 gallons of gas are used? (Be sure to use dimensional analysis.)

$$143 \text{ gal } \times \frac{\qquad\qquad}{\qquad\qquad} = \ \_\_\_\_\_\_\_\_ \text{ miles}$$

The term "per" can be denoted by a single line. For example, miles per gallon can be written as mi/gal. The term also gives a clue as to the mathematical process that is involved. Is the process addition, subtraction, multiplication, or division? ___________________________

The following problems are designed for you to practice canceling out units as they fit into the problems. Note that singular and plural units that are otherwise the same are considered identical and can cancel each other. For example, apple can cancel apples.

Problem 5. Indicate for each problem, what units are left after all canceling has been done.

Examples:

$$L \times \frac{\text{mL}}{\text{L}} = \text{mL} \qquad\qquad \text{sec}^2 \times \frac{\text{feet}}{\text{sec}} = (\text{sec})(\text{feet})$$

Write down the units that you will end up with in each of the following:

a. $\text{mole} \times \dfrac{\text{g}}{\text{mole}} =$

b. $\text{hrs} \times \dfrac{\text{miles}}{\text{hr}} =$

c. $\dfrac{\text{feet}}{\text{sec}} \times \dfrac{\text{sec}}{\text{min}} \times \dfrac{\text{min}}{\text{hr}} =$

d. $\dfrac{\text{g}}{\text{mole}} \times \dfrac{\text{mole}}{\text{L}} =$

e. $\text{moles} \times \dfrac{\text{mole}}{\text{g}} =$

f. $\text{moles} \times \dfrac{\text{g}}{\text{mole}} =$

g. $\text{g} \times \dfrac{\text{mole}}{\text{g}} \times \dfrac{\text{g}}{\text{mole}} =$

h. $\text{mole} \times \dfrac{\text{mg}}{\text{L}} \times \dfrac{\text{L}}{\text{mole}} \times \dfrac{\text{atm}}{\text{mg}} =$

i. $\dfrac{\text{cm}^3}{\text{m}} \times \dfrac{\text{m}}{\text{dm}} \times \dfrac{\text{dm}}{\text{cm}} \times \dfrac{1}{\text{hec}} =$

j. $\dfrac{\text{g}}{\text{mole}} \times \dfrac{\text{mole}}{\text{g}} =$

If you can handle numbers and units, you should be able to do problems such as the following example. If a person can run 100 yards in 10.5 seconds, how fast is he/she running in miles per hour? (1760 yd = 1 mi). First set up the unit analysis for solving the problem:

$$\frac{\text{yd}}{\text{sec}} \times \frac{\text{mi}}{\text{yd}} \times \frac{\text{sec}}{\text{min}} \times \frac{\text{min}}{\text{hr}} = \frac{\text{mi}}{\text{hr}}$$

Notice how all units cancel except those we wanted to keep in the answer. Substitute the proper numbers and solve the problem in the space below. See if you get the answer given.

$$\frac{\_\_\_\_\_\ \text{yd}}{\text{sec}} \times \frac{\_\_\_\_\_\ \text{mi}}{\text{yd}} \times \frac{\_\_\_\_\_\ \text{sec}}{\text{min}} \times \frac{\_\_\_\_\_\ \text{min}}{\text{hr}} = \frac{19.5\ \text{mi}}{1.00\ \text{hr}}$$

Problem 6.
Make the following conversions using dimensional analysis. Show your work neatly.
a. Change 400.0 ounces to its comparable figure in tons.
(16 ounces = 1 pound, and 2000 pounds = 1 ton.)

b. Calculate the number of seconds in 1.000 week.

c. Convert 2.00 miles to fathoms. (1 fathom = 6 feet; 1 mile = 5280 feet)

d. Change 400 cubic feet per 1.00 second to quarts per minute.
(0.265 gallons = 0.0353 ft3; 4 quarts = 1 gallon)

$$\frac{400.\ \text{ft}^3}{1.00\ \text{sec}} \times$$