 Date _____

Dimensional Analysis

(a.k.a. the Factor-Label Method a.k.a. the Unit Cancellation Method)
(Yes, I am now definitely pulling rank and telling you that you must do it this way! for now …)

Temporarily, we are going to take an aside from a specific "topic" and work on some problem solving skills using everybody's new favorite method! We need to do a little math. Actually, we need to do a lot of math. Free response questions on the AP are notorious for making you do mathematical conversions in the context of environmental science, but I will admit that I have used dimensional analysis many times in non-academic scenarios. Maybe you may have to figure out the gas efficiency of your car, the gas usage in your weekly commute, or even your possible savings for trading in your gas-guzzler for a more fuel-efficient model. You could possibly have to compare the cost difference of heating a home using oil or natural gas. Maybe you might have to calculate number of BTU's of heat needed to generate the electricity produced by a coal-fired power plant. The possibilities are almost endless… So how are you going to accomplish such tasks? Some of you are going to remind me that you have your own way of doing things, but for now you **must** show you work dimensional analysis style. Remember: you have to bring some prior skills and knowledge to the table. You should already have the acquired knowledge of basic math functions, **and** have the ability to convert to and from scientific notation if necessary, **and** know the conversions of simple metric prefixes (milli, centi, kilo.) Now you just have to use those skills in conjunction with the dimensional analysis style of problem solving.

Example 1:
Convert 1 day into minutes. Be sure to show all labels and numbers in your work.

Example 2:
Convert 10 gallons of water into pounds of water.
Given: 1 gallon of water = 8 pounds of water

Example 3:
Convert one year into minutes. Be sure to show all labels and numbers in your work. (no quick use of song lyrics allowed!)

Example 4:
Convert 2 days into seconds. Be sure to show all labels and numbers in your work.

Example 5:
Convert 0.500 kWh into BTUs (British Thermal Units).
Given: 3,400 BTU's = 1 kWh

Example 6:
Convert 4 Kilocalories to Joules
Given: 1 Kilocalorie = 4184 joules

Example 7:
How many inches are there in 1 meter?
Given: there are approximately 2.5cm in 1 inch

Example 8:
Convert 2,000 ft^3 of natural gas into dollars ($)
Given: Natural gas is available at a cost of $5.00 per 1000 ft^3

Example 9:
Convert 160km/hr into miles/hr
Given: there are 1.6 km in 1 mile

Example 10:
How many square feet are there in a 200 square meter house?
1 square meter = 10.76 square feet

Example 11:

A clerk can sort 400 sheets per hour. If there are 200 sheets in an inch, how many hours will it take her to file 100 inches of loose sheets?

Example 12:
Determine the average fuel consumption in gallons (per year) of the average American car given the following:
Given: The average car is driven 10,000 miles per year. The mileage rate for the average car is 25 miles per gallon of gasoline.

Example 13:
1 milliliter of ink can print 50 pages of text. If you had 10 gallons of ink then how many pages could you print?
Given: 1 gallon = 3.79 liters

Example 14:
The new kid in school has been heard bragging that he can bench press 145,000 grams.
If 1kg = 2.2 pounds, should you be impressed? Convert to pounds to find out.

Example 15:
Determine the amount of BTU's needed to heat 1,000 square feet of space in a home.
Given: 80,000 BTUs of heat are needed to heat one square foot

Example 16:
You find 1 x 10^3 pennies in the cushions of your couch. If each penny weighs 4 grams, how much did all that loot weigh in lbs.?
(2.2 lbs = 1 Kilogram)

Example 17:
You decide that you want to heat your attached 2½ car garage/workout area during the winter. You saved a bunch of money on gas by purchasing a hybrid car the previous year, so you have enough money to extend your present heating ducts into the garage. You just want to make sure that the cost of heating the garage doesn't exceed your monthly budget. The garage area is 500 sq. ft. Your house is heated by natural gas, which has a current price of $15.00 per 1000 cubic feet. You already know that one square foot requires 80,000 BTUs of heat energy to cover the winter season. You also know that 1 cubic foot of natural gas supplies 1000 BTUs of heat energy. (Even though no such system exists, assume that this heating system is 100% efficient)

(a) Calculate number of cubic feet of natural gas required to heat the garage for the winter.
Show all the steps of your calculations, including units.

(b) Calculate the cost of heating the garage area for the winter.

Example 18:
Every three times I clean my room, my mom makes me an apple pie.
I cleaned my bedroom nine times. How many apple pies does she owe me?

Example 19:
A Syosset High School senior was applying to college and wondered how many applications she needed to send. Her counselor explained that with the excellent grade she received in her APES class, she would probably be accepted to one school out of every three to which she applied. (3 applications = 1 acceptance). She realized that for each application, she would have to write 3 essays (1 application = 3 essays), and each essay would require 2 hours worth of work (1 essay = 2 hours). As we know, writing essays is no simple matter. For each hour of serious essay writing, she would need to expend 500 calories (1 hour = 500 calories), which she could obtain by eating her mom's apple pies (1 pie = 1000 calories). How many times would she have to clean her room in order to be accepted at 10 colleges? (Don't forget to refer back to Problem #18..).

Example 20:
A large, coal-fired electric power plant produces 12 million kilowatt-hours of electricity each day. Assume that an input of 10,000 BTUs of heat is required to produce an output of 1 kWh of electricity.

(a) Calculate the number of BTUs of heat needed to generate the electricity produced by the power plant each day.

(b) Calculate the number of pounds of coal consumed by the power plant each day, assuming that one pound of coal yields 5,000 BTUs of heat.

(c) Calculate the number of pounds of sulfur released by the power plant each day, assuming that the coal contains one percent sulfur by weight.