

### THE METRIC SYSTEM

Remember: "King Henry Died, drinking chocolate milk."

#### SECTION A - The Metric System

Unlike our English (or US Customary) system of measurement with its feet and inches, quarts and gallons, the metric system is very orderly. All variations of the units of measure are really just the units multiplied by powers of 10. Converting to larger or smaller unit measurements is a matter of multiplying or dividing by 10, 100, 1000 and so forth. This can be simply accomplished by moving the decimal place to the left or right the appropriate number of spaces, as we will soon see.

The basic units of metric measure are the **meter** (length) **liter** (volume) and **gram** (weight). Larger and smaller metric measurements, which might appear awkward when expressed using the basic unit of measure (for example, did you know that there are 4,911,000 meters [4,911 kilometers] between Boston, MA and Los Angeles, CA?) can be expressed by adding the following prefixes to the basic units:

<b>Kilo</b> (multiply by 1000)	<b>deci</b> (multiply by .1)
<b>Hecto</b> (multiply by 100)	<b>centi</b> (multiply by .01)
<b>Deca</b> (multiply by 10)	<b>milli</b> (multiply by .001)

So there are, for example, Kilometers (abbreviated Km) and milliliters (ml) and decigrams (dg) and Decameters (Dam) and more. (NOTE: Generally speaking, abbreviations for metric units of measure are made using the first letter of the prefix and the first letter of the basic unit.)

To help you gain a basic understanding of their relative size, it is useful to learn to associate familiar everyday items of similar measurement with the basic units. While you probably know others, these are some commonly used examples:

A **meter** is approximately equal to the length of a **yardstick**.  
 A **liter** is approximately equal to the volume of a **quart**.  
 A **gram** is approximately equal to the weight of a **paper clip**.

*Do you know these two following? (see answer key on reverse)*

A **Kilometer** is approximately equal to a \_\_\_\_\_ .  
 A **Kilogram** is approximately equal to a \_\_\_\_\_ .

What does King Henry have to do with all this? Well... nothing actually, but this silly sentence IS a mnemonic device, a memory tool, to help you remember the relationships between the variations of these basic units. [**K**]ing [**H**]enry [**D**]ied, [**d**]rinking [**c**]hocolate [**m**]ilk; this is a representation of the units in descending order. Please consider the ruler or scale below. It is a graphical image of this important progression of the prefixes.

Kilo	Hecto	Deca	<unit> meter, liter, or gram	deci	centi	milli
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This chart can assist in the process of conversion of metric measurements from one sort of unit to another. Turn to the next page to see a series of examples and some problems (with the answers) for you to try.

Kilo	Hecto	Deca	<unit> meter, liter, or gram	deci	centi	milli
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Suppose we want to know how many **grams** there are in **6 Kilograms**. We can see that grams are 3 "steps" to the right of Kilograms; this tells us we should move the decimal point three places to the right (**6. Kg = 6000. g**) We can convert **850. cl** to **8.5 l** by moving the decimal point 2 places to the left since the chart shows us that liters are two "steps" to the left of centiliters.

**REMEMBER:** You can think of these prefixes as column headers in a grid upon which you can "place" the number you want to convert. The ones place of the number you are converting should appear under the unit name and the decimal is assumed to be to the right of the ones digit. For example:

6.0 Kilograms is equivalent to  
6000.0 grams

K	H	D	*	d	c	m
6.	0					
6	0	0	0.	0		
			8	5	0.	0
			8.	5		

850.0 centimeters is equivalent to 8.5 liters

**PRACTICE**

**Convert as indicated. Check your answers at the bottom of the page.**

- |                   |   |                   |                      |   |                   |
|-------------------|---|-------------------|----------------------|---|-------------------|
| 1) 268 grams      | = | _____ milligrams  | 6) 5,638 centimeters | = | _____ meters      |
| 2) 8 meters       | = | _____ Kilometers  | 7) .0096 Kilograms   | = | _____ decigrams   |
| 3) 13 liters      | = | _____ deciliters  | 8) 2.85 milliliters  | = | _____ centiliters |
| 4) 2.5 centigrams | = | _____ grams       | 9) 28 Decameters     | = | _____ Kilometers  |
| 5) .03 Kilometers | = | _____ centimeters | 10) 8 liters         | = | _____ deciliters  |

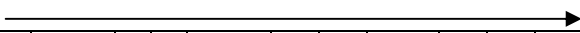
**Fill in the blank.**

- A football field is approximately \_\_\_\_\_ meters long.
- A half-gallon of milk is approximately \_\_\_\_\_ liters.
- A dime weighs approximately \_\_\_\_\_ gram(s).

Answers: 1) 268,000 2) .008 3) 130 4) .025 5) 3,000 6) 56.38 7) 96 8) .285 9) .28 10) 80 11) 100 12) 2 13) 2  
FROM PAGE ONE: 1kilometer is similar in distance to a mile. 1kilogram approximately equals 2 pound.

## SECTION B – Metrics for Chemistry 102 Students Only

Now that you have an understanding of the basic metric ruler using the “King Henry” mnemonic device, the discussion in Section B will extend this metric ruler to include the much smaller units or prefixes used in chemical calculations.

Comparison of Metric Measurement Units																					
Larger Units			Basic Units	Smaller Units 																	
K	-	-	g L m	d	c	m	-	-	μ	-	-	n	-	-	p	-	-	f	-	-	a
Kilo	-	-	gram liter meter	deci	centi	milli	-	-	micro	-	-	nano	-	-	pico	-	-	femto	-	-	atto

The smaller prefixes noted on the ruler above are often used in chemistry. For this course, you are responsible for knowing how to use the prefixes from “kilo” to “atto”. Remember, however, that the ruler extends even further in each direction. Take a moment to examine the ruler after “milli”. You will see that only every third place has a special prefix name. Because you are often dealing with such small or large numbers in chemistry, it is appropriate now to show your answers using scientific notation. For example, 268,000,000 will now be written as  $2.68 \times 10^8$ . *Note:* It is good practice to always use positive exponents when doing the conversions.

Let’s put together our skills of scientific notation and unit conversion to put these new ideas into practice.

*Example:* Convert 28 femtograms to kilograms.

First we must create a conversion factor. If we count backwards the number of decimal places between “femto” and “kilo”, we notice there are 18. Therefore, if we have 1 femtogram, we will have .000000000000000001 or  $1 \times 10^{-18}$  kilograms. But we really need a conversion factor written with positive exponents. If we convert one kilogram into femtograms we get 1 kilogram =  $1 \times 10^{18}$  femtograms. Below are the two conversion factors, the first written with a negative exponent and the second with a positive exponent. Do you understand the difference?

Written with a Negative Exponent

$$\frac{1 \text{ fg}}{1 \times 10^{-18} \text{ kg}}$$

Written with a Positive Exponent

$$\frac{1 \times 10^{18} \text{ fg}}{1 \text{ kg}}$$

Another way to think about this is you should always create the conversion factor by going from larger units of measure to smaller ones. The effect of this will always be positive exponents in scientific notation.

Here is the calculations for the above conversion:

$$28 \cancel{fg} \times \frac{1 kg}{1 \times 10^{18} \cancel{fg}} = 28 \times 10^{-18} kg = 2.8 \times 10^{-17} kg$$

Our answer is now in proper scientific notation and with the appropriate significant digits. Please Note: While the conversion factor should have positive exponents, the ANSWER to any particular conversion problem may have positive or negative exponents as appropriate.

When I was learning the metric system, I made up the following silly phrase (mnemonic device) to help me learn the right side of the ruler – “Deci cent milli and **mike** **nine** pairs of **female** **attorneys**” (Desi sent Millie and Mike nine pairs of female attorneys). The bolded letters helped me to recall the proper prefixes. The and between “milli and mike” reminded me that after the “milli” units, I would need to move three decimal places for each of the given units after that. Use this idea or make up one of your own to help you remember.

Practice: Convert as indicated. Remember to use scientific notation with a positive exponent when doing the conversions. Your final answer needs to be in proper scientific notation using the correct significant digits.

1) 25 mL = \_\_\_\_\_ nL

2) 13 cg = \_\_\_\_\_ ag

3) 50 pm = \_\_\_\_\_ cm

4) 346,000 nL = \_\_\_\_\_ kL

Answers: 1)  $2.5 \times 10^7$  nL    2)  $1.3 \times 10^{17}$  ag    3)  $5 \times 10^{-9}$  cm    4)  $3.46 \times 10^{-7}$  kL