The Metric System:

 The metric system is a system of measurement which uses a set of BASE UNITS and a system of prefixes based on POWERS of TEN to create a very convenient measurement system. The metric system is the official system of measurement in nearly every country in the world, the most notable exception being the United States.

 The base units are for fundamental quantities and are summarized below:

|  |  |  |
| --- | --- | --- |
| **Quantity** | **Symbol** | **Base Unit** |
| Length/Distance/Displacement | l,d,$\rightharpoonaccent{d}$ | metre (m) |
| Time | t | second (s) |
| Mass | m | gram (g) |
| Thermodynamic temperature | T | Kelvin (K) |
| Amount | N | mole (mol) |
| Electric Current | I | Ampere (A) |
| Luminous intensity | Iv | candela (cd) |

The metric prefixes are as follows. You should be quite familiar with many of them, but some are likely new to you.

|  |  |  |
| --- | --- | --- |
| **Name** | **Abbreviation** | **Meaning** |
| Giga | G | 109 |
| Mega | M | 106 |
| Kilo | k | 103 |
| Hector | h | 102 |
| Deka | da | 10 |
| Deci | d | 10-1 |
| Centi | c | 10-2 |
| Milli | m | 10-3 |
| Micro | µ | 10-6 |
| Nano | n | 10-9 |

So from the tables above we can see that the unit of length that we know as the kilometre (km) is the same as 103 metres, or 1000 metres. The unit of time known as a millisecond is equal to 10-3 seconds, or one one-thousandth of a second.

What makes the metric system so popular, and the only system used by scientists (even American ones) is the ease it provides in converting units from small to large or *vise versa*.

Because each prefix represents a power of ten we can convert units by simply changing the power of ten without altering the lead.

Many of you may have learned how to convert metric unite by “moving the decimal point” to the left or the right, which will indeed work. What I would like to do is explain the mathematical logic behind why this happens

**Converting Metric Units:**

To see how this works we need a little common sense together with a little algebra. First the common sense: If I wish to convert from a large unit (like a Megagram) to a smaller unit (like a milligram) my number should get LARGER (decimal moves right). Why? Because for every megagram there should be a whole lot of milligrams. Conversely if I convert from a small unit (like a cetimetre) to a larger unit (like a kilometre) my number should SMALLER (decimal moves left). Why? Because I can only have a fraction of a kilometre for every whole centimetre.

Now we will use our definitions of the metric prefixes, coupled with some algebra and logic to figure out how this works mathematically.

 **Q: If I walk 6.4km, how many meters have I walked?**

**A: First the common sense part. Did I walk more than 6.4m, or less than 6.4m? That’s right: More, much more. So my answer must be larger than 6.4.**

Now definitions: By definition k stand for kilo which means 1000, or 103. So 1km = 103m.

Now algebra: We know that $\frac{5}{5}$ = $\frac{18}{18}$ = $\frac{U}{U} $ = $\frac{x}{x}$ = 1.

 ***Any number divided by itself is one.***

We can take this one step further. . .

If A=B, then $\frac{A}{B}$ = $\frac{B}{A}$ =1.

Any value divided by a value EQUAL to itself is 1. By definition, 1km=103m, so…

$\frac{1km}{10^{3}m}$ =$ \frac{10^{3}m}{1km}$ = 1.

Next, I know that if I multiply any number by 1 it stays the same (*even a fancy-lookin’ 1*).

5x1=5, 9x1=9, βx1=β, 8 x$ \frac{14-2}{ 4(3)} $= 8

and so on.

Now put it all together: I want to CONVERT the measurement 6.4km into a measurement in metres. The new measurement is meant represent the exact same distant, that is to say, the two values should be EQUAL. In order to convert I need to multiply the original measurement (6.4km) by a fancy-lookin’ 1 called a CONVERSION FACTOR ($\frac{1km}{10^{3}m}$ OR $\frac{10^{3}m}{1km}$ ). Which conversion factor do I use? Well my goal is to cancel out the km and end up with m. To cancel and quantity is math I divide it by itself which leaves 1. This works with units as well\*. So the proper conversion is:

6.4 km × $\frac{10^{3}m}{1km}$= $\frac{6.4km×10^{3}m}{1km}$=6.4x103m=6400m

 \* Notice how the km on the top CANCELS the km on the bottom and leaves m as the final unit.

My guess is that a lot of you could have done that conversion in your head. The point is to attempt to get you to see *why* the answer works with a simple case, so we can try a harder one.

 **Q: A chemical reaction produces 126µg of sodium chloride. How many kg of sodium chloride are produced?**

 **A: First predict: Is the answer larger or smaller than 126?**

**Here I am going to use two conversion factors (it can be done with one, but two allows me to use my definitions directly.**

1. $\frac{1µg}{10^{-6}g}$ =$ \frac{10^{-6}g}{1µg}$ = 1 OR $\frac{10^{6}µg}{1g}$ =$ \frac{1g}{10^{6}µg}$ = 1

 2. $\frac{1kg}{10^{3}g}$ = $\frac{10^{3}g}{1kg}$ = 1

 126~~µg~~ × $\frac{10^{-6}g}{1µg}$ × $\frac{1kg}{10^{3}g}$ = 126 x10-9 kg (This is bad notation as the lead is greater than ten)

 (126) x10-9 kg = (1.26x102) x 10-9kg = 1.26 x (102 x 10-9)kg = 1.26 x 10-7kg

126µg = 1.26 x 10-7 kg.

**Q: The radius of a proton 8.4184x10-7 nm. What is the radius in Mm?**

 **A:**

8.4184x10-7~~nm~~ × $\frac{10^{-9}m}{1nm}$ × $\frac{1Mm}{10^{6}m}$ = 8.4184 x 10-22 Mm

**Q: The mass of the sun is estimated as 7.35 x1022kg. What is that mass Gg?**

 **A:**

7.35x1022~~kg~~ × $\frac{10^{3}g}{1kg}$ × $\frac{1Gg}{10^{6}g}$ = 7.35x1019 Gg

**Q: The time it takes light to travel 1.000m is 3.33ns. How many ks does it take?**

 **A:**

3.33~~ns~~ × $\frac{10^{-9}s}{1ns}$ × $\frac{1ks}{10^{3}s}$ = 3.33x10-12 ks

Try these on your own. For each please show the work including the conversion factor you are using. Your work sould look like the examples above.

 1. The distance from Vancouver to Calgary is 805km. What is the distance in cm?

 2. The approximate age of the universe is 1012Ms. How old is the universe in μs?

 3. The mass of a proton is 6.67 x 10-22cg. What is the proton mass in hg?

 4. Surprisingly, the mass of a unicorn is 4.2x1014kg. Convert the mass to dag.

 5. For this question, really think about how the units cancel. The area of sheet of paper is 602cm2. What is the area expressed in m2. (Hint: $\frac{x^{2}}{x}=x$)