

Keep Track of Those Units

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We all know that anything (except zero) divided by itself equals 1. The same applies to units that we use during conversions from one form of notation to another. Pounds divided by pounds = 1 (with no units), grams divided by grams = 1, and gallons divided by gallons = 1, etc. But pounds divided by gallons = pounds per gallon (just another way of saying pounds divided by gallons) and pounds of salt divided by pounds of water = pounds of salt per pound of water. When we multiply or divide, the units also multiply and divide. If we divide pounds by pounds per gallon, we end up with just gallons. The pounds divided by pounds = 1 which has no units and dividing by 1 over gallons is just gallons. Another key to look for is when dividing by a fraction is the same as inverting (interchanging the numerator and denominator) and multiplying. That means that dividing by pounds per gallon is the same as multiplying by that same number of gallons per pound.

When we add or subtract, we can only add or subtract values that have the same units. For example, it would not make sense to try and add 1 pound of salt and 1 gallon of water. We could, however, just work with pounds and add 1 pound (of salt) to 8.33 pounds (of water) and end up with 9.33 pounds (of a salt and water mixture). If we are going to add something measured in grams to something measured in pounds, we have to convert them into some common set of units, i.e. convert the grams to pounds or the pounds to grams, or perhaps convert both to ounces. Just as we keep track of the values during a calculation, we must also keep just as accurate track of the units. If we multiply 1 gallon of water by 8.33 pounds per gallon of water, we get 8.33 as the value but what are the units? Note the units "gallon of water" are being divided by each other and hence, "cancel out", i.e. when gallon of water is divided by gallon of water, it is one and those units "go away". There is nothing to cancel out the pounds so the resulting answer is 8.33 pounds. The same holds true during any conversion.

We know that 1 milliliter of water weighs 1 gram so we sometimes take a shortcut and just say we have 1 gram of water when it is convenient. This is OK as long as it is realized that what we are really doing is multiplying 1 milliliter by 1 gram per milliliter (or dividing 1 milliliter by 1 milliliter per gram). The milliliter units cancel out and we are left with just grams. Watching those units closely can also help us determine how to make a conversion. We know that 1 pound of water weighs 8.33 pounds or we can say we have a conversion factor of 8.33 pounds of water per gallon. So, to convert 5000 pounds of water to gallons, should we multiply or divide by our conversion factor? If we multiply, our units come out as pounds of water squared over gallons. Definitely, not what we are looking for. If we divide 8.33 pounds of water per gallon by 5000 pounds of water, our units are "per gallon" (or one over gallons) which is not what we are looking for either. But, if we divide 5000 pounds of water by 8.33 pounds of water per gallon, the pounds of water units cancel out and we are left with gallons as units which indicates we properly made the conversion and 5000 pounds of water is equal to 600 gallons of water.

When we are talking about parts per million, it is implied that what we are really saying is parts per million parts. The units are one part divided by 1,000,000 parts. But what are parts? Whether ppm, ppt, or %, for almost anything we are concerned with, parts is a unit of weight. It can be pounds or ounces or grams or kilograms but parts must refer to the same weight measure. 1 gram per million grams but not 1 gram per million ounces. Note that the parts "cancel" out so what this means is we are talking about a ratio that has no units. Parts per million parts is the same as dividing by one million. One part per million is really just a number without units equal to 0.000001. If we want to convert 5 ppt (5 parts divided by one thousand parts) to ppm (parts divided by one million parts), we can see that 1 part per thousand is equal to 1000 parts per million or there are 1000 ppm per ppt. So we multiply 5 ppt by 1000 ppm per ppt. The ppt "cancel out" and we are left with a value of 5000 with units of ppm. Note that all we are doing with ppt, ppm, or % is trying to make the value easier to discuss and/or write down and it just indicates where the decimal point is located. Saying 1 ppm is the same as saying 0.000001 or 0.0001% or 0.001 ppt, Similarly, writing 1% is the same as if we wrote 10 ppt or 10000 ppm.