Calculations of Solution Concentration

California State Standard: *Students know how to calculate the concentration of a solute in terms of molarity, parts per million, and percent composition*.

Objective: Determine the concentration of each of the following solutions in terms of molarity, % by mass, and parts per million (ppm).

Solution #1: 20 grams of NaOH is dissolved in enough water to make 1 liter of solution
Solution #2: 45 grams of glucose, $C_6H_{12}O_6$ is dissolved in enough water to make 0.500 liters of solution
Solution #3: 116 grams of KF is dissolved in enough water to make 4 L of solution
Solution #4: 63 grams of HNO_3 is dissolved in enough water to make 100 liters of solution
Solution #5: 280 grams of CaO is dissolved in enough water to make 10 L of solution

Molarity describes the concentration of a solution in moles of solute divided by liters of solution. Masses of solute must first be converted to moles using the molar mass of the solute. This is the most widely used unit for concentration when preparing solutions in chemistry and biology. The units of molarity, mol/L, are usually represented by a scripted capital "$\mathcal{M}$". Calculate the concentration, in moles of solute per liter of solution, of each of the following:

Example:

10 grams of NaOH is dissolved in enough water to make 2 L of solution

Step #1 - Convert grams of solute to moles of solute:

$$\frac{10\,g\ NaOH}{}\left|\frac{1\,mol\ NaOH}{40\,g\ NaOH}\right.=0.250\,mol\ NaOH$$

Step #2 – Divide moles of solute by liters of solution:

$$\frac{0.250\,mol\ NaOH}{2\,L}=0.125\,M\ NaOH$$

Percent composition is the ratio of one part of solute to one hundred parts of solution and is expressed as a percent. Determine the mass of solute and solution and then divide the mass of the solute by the total mass of the solution. This number is then multiplied by 100 and expressed as a percent. In dilute water solutions, we can assume that 1 mL of water-based solution has a mass of 1 gram, so 1 liter of solution has a mass of 1000 grams.

Example:

10 grams of NaOH is dissolved in enough water to make 2 L of solution

$$\frac{10\,g\ NaOH}{2000\,g\ solution}x100=0.5\%\ NaOH$$

Parts per million (ppm), is a ratio of parts of solute to one million parts of solution, and is usually applied to very dilute solutions. It is often found in reports of concentration of water contaminants.
To calculate parts per million, divide the mass of the solute by the total mass of the solution. This number is then multiplied by 10^6 and expressed as parts per million (ppm). In dilute water solutions, we can assume that 1 mL of water-based solution has a mass of 1 gram, so 1 liter of solution has a mass of 1000 grams.

***Notice that calculations of ppm are the same as percent composition, except that you multiply by 1 million instead of by 100. In other words, all you have to do is take your answer from % composition and move the decimal point 4 places to the right (4 powers of ten, the difference between 10^2 and 10^6).

Example:

10 grams of NaOH is dissolved in enough water to make 2 L of solution

$$\frac{10\,g\ NaOH}{2000\,g\ solution}x10^6=5000\ ppm\ NaOH$$