Solution Calculations

Here are some common ways to express solution concentrations.

$$\text{Molarity (M)} = \frac{\text{moles solute}}{\text{liters of solution}} \text{ or } \frac{\text{mol solute}}{\text{L soln}}$$

$$\text{Molality (m)} = \frac{\text{moles solute}}{\text{kilograms of solvent}} \text{ or } \frac{\text{mol solute}}{\text{kg solvent}}$$

$$\text{Mole Fraction (X)} = \frac{\text{moles of component}}{\text{total moles in solution}} \text{ or } \frac{\text{mol component A}}{\text{mol component A} + \text{mol component B} .....}$$

$$\text{Mass or Weight Percent} = \frac{\text{grams of component}}{\text{total grams of solution}} \times 100\% \text{ or } \frac{\text{g component A}}{\text{g component A} + \text{g component B} .....} \times 100\%$$

When calculating concentrations, the basic relationships need to recognized (i.e. memorized). If the quantities needed are given in the problem, then they can be plugged directly into the formula. If not, various conversions and other operations will have to be performed.

General conversions used for solution-related calculations

mass to moles or moles to mass **g ↔ mol**

requires **molar masses** for solute or solvent

volume to mass or mass to volume **mL or L ↔ g**

requires **density**; generally applies to the entire solution (mixture) only unless you are given volumes as the starting point for liquid components

general metric conversions such as mL to L or g to kg

Strategies for converting between different units of solution concentration

When given a solution concentration term, the expression can thought of as a compound unit. By using the definition for that unit, the term can be expanded into its parts by assigning the various components and associated units to either the numerator or denominator in a ratio or fraction. Once done, it may be readily apparent how to translate the various terms using the appropriate conversion factors. For example,

- mass percent is grams of solute per 100 grams solution
- molality is moles of solute per 1 kilogram of solvent
- mole fraction (a unitless quantity) can be thought of as moles of component per 1 mole of total solution components
- molarity is moles of solute per 1 liter of solution

A useful starting point in a calculation is to translate the given concentration given based on these definitions. If each is expressed as a fraction or ratio, you can assume that you have enough material (solution) to match the bottom part of the fraction. Numbers can them be obtained that allow for conversion from one set of units to another.