When (Chemical) Solutions are the Problem

Scientists aim to get numerical values to describe biochemical phenomena, like enzyme activity, so math (arithmetic and simple algebra) skills are helpful for the biochemist.

Because research methods for enzymes were developed over a long time period, the units used to describe chemicals have varied, from percent composition in a solution (g/100 ml) to molarity (moles/liter). Thus, a researcher often finds the need to convert weights to moles. An historical example in enzyme purification is the way sucrose concentration is presented for cell biology vs. when the sucrose is the substrate for an enzyme assay.

A 20% solution of sucrose helps to better separate the different cell organelles when a tissue is "broken open." For this, you weigh out 20 grams of sucrose. In a beaker, add less than 100 ml of water, and dissolve the sucrose. Then, using a 100 ml graduated cylinder, bring the volume up to a total to 100 ml.

> Convention/Definition: A 1% (weight per volume) solution contains 1 gram of solute (solid) per 100 ml. Typically, the solvent is water. ANY 1% solution will have 1 gram of solid per 100 ml.

A solution of 0.5M sucrose is often the high level substrate concentration when using sucrose in an enzyme assay for invertase (which converts sucrose to fructose, reducing the calories while maintaining the sweetness). To prepare a 0.5M solution of sucrose, you must first find the formula weight of sucrose. You can inspect the formula for sucrose ($C_{12}H_{24}0_{11}$),count all the atoms and add up their weights, or check the formula weight on the label (F.W. or G.M.W., gram molecular weight). For sucrose, the F.W. is 342.3. This means that every mole of sucrose weighs 342.3 grams.

> Definition: A MOLE of ANY chemical has Avogadro's number of molecules of the substance, or 6.02 X 10^{23} molecules or 1 gram formula weight of the substance.

Thus 0.5 moles of sucrose would weigh 171.15 grams. A 0.5 M solution would have 171.15 g of sucrose dissolved in water to a total of 1 liter. Or, we would probably make up only 100 ml of sucrose solution, using 17.2 grams per 100 ml.

Hydrogen peroxide solution from the store is 3% w/v or 3g/100 ml. How would you calculate the molarity of the H_20_2? The FW of H_20_2 is 34g, so a 3% solution, having 3 g/100 ml, would have 30 g/liter. The molarity is the ratio of grams/formula weight per liter, or 30/34, so the peroxide solution is nearly 1M. Use this estimate and calculate the exact molarity. (Answer = 0.88M).

> A 3% solution of hydrogen peroxide and a 3% solution of sucrose will have the identical weight of chemical per 100 ml of water.

However, these peroxide and sucrose solutions will have vastly different molar concentrations (or number of molecules), because their formula weights are very different (34g/mole for peroxide and 342.3 g/mole for sucrose).