SOLUTION PREPARATION

A **solution** is a homogeneous mixture created by dissolving one or more solutes in a solvent. The chemical present in a smaller amount, the solute, is soluble in the solvent (the chemical present in a larger amount). Solutions with accurately known concentrations can be referred to as **standard (stock) solutions**. These solutions are bought directly from the manufacturer or formed by dissolving the desired amount of solute into a volumetric flask of a specific volume. Stock solutions are frequently diluted to solutions of lesser concentration for experimental use in the laboratory.

Preparing a Standard Solution from a Solid

A solution of known concentration can be prepared from solids by two similar methods. Although inherent errors exist with each of the methods, with careful technique either will suffice for making solutions in General Chemistry Laboratory.

In the first method, the solid solute is weighed out on weighing paper or in a small container and then transferred directly to a volumetric flask (commonly called a "vol flask"). A funnel might be helpful when transferring the solid into the slim neck of the vol flask. A small quantity of solvent is then added to the vol flask and the contents are swirled gently until the substance is completely dissolved. More solvent is added until the meniscus of the liquid reaches the calibration mark on the neck of the vol flask (a process called “diluting to volume”). The vol flask is then capped and inverted several times until the contents are mixed and completely dissolved. The disadvantage of this method is that some of the weighed solid may adhere to the original container, weighing paper, or funnel. Also, solid may be spilled when it is transferred into the slim neck of the vol flask.

In the second method the solid is weighed out first in a small beaker. A small amount of solvent is added to the beaker and the solution is stirred until the solid is dissolved. The solution is then transferred to the vol flask. Again, a funnel may need to be inserted into the slim neck of the vol flask. Before adding additional solvent to the flask, the beaker, stirring rod, and funnel must be rinsed carefully and the washings added to the vol flask making sure all remaining traces of the solution have been transferred. Finally, the vol flask is diluted to volume (additional solvent is added to the flask until the liquid level reaches the calibration mark). The flask is capped and inverted as before until the contents are thoroughly mixed. The disadvantage to this method is that some of the solution may adhere to the beaker, stirring rod, or funnel if not washed thoroughly. Also, a possibility of contamination exists from the beaker, rod, or funnel if they have not been washed carefully.

In general chemistry **molarity** is the most commonly used concentration unit:

$$(1)\quad \text{Molarity} = \frac{\text{moles of solute}}{\text{liters of solution}} = \frac{\text{grams of solute}}{\text{molar mass solute x liters of solution}}$$

Example: A student weighs 0.563 g of $FeCl_3$ and dissolves it in enough deionized (DI) water to make 100.0 mL of solution. ($FeCl_3$ is the solute and water is the solvent; the mixture of $FeCl_3$ and water is called the solution.) The molarity of the $FeCl_3$ (aq) solution is:

$$\frac{0.563\text{ g }FeCl_3}{162.2\text{ g /mol }FeCl_3 \text{ x } 0.1000\text{ L}} = 3.47 \text{ x } 10^{-2}\text{ M}$$

Diluting a Solution of Known Concentration

Dilution is the addition of more solvent to produce a solution of reduced concentration. Most often a diluted solution is created from a small volume of a more concentrated stock solution. To make such a solution, a volumetric pipet is used to deliver an exact amount of the stock solution into a clean vol flask, which is then diluted to volume. To prevent extra dilution or contamination, prerinse the vol pipet with the stock solution to remove any water droplets or impurities. (The rinsings should be placed in an appropriate collection container.)

Caution: This procedure is reversed if the addition of the concentrated solution to solvent causes heating (an exothermic reaction). A notable example is the dilution of a concentrated acid. NEVER add water to concentrated acid. The reaction is very exothermic, heating the solution and potentially causing splattering. Always add the concentrated acid to water slowly with stirring. Place the beaker or flask in an ice bath to help cool the resulting solution and prevent spattering.

The diluted solution's molarity is less than the stock solution it was created from. The moles present in the volume of stock solution delivered by the volumetric pipet is equal to the moles present in the diluted solution created:

(2) $(\text{Moles of solute})_{\text{before dilution}} = (\text{Moles of solute})_{\text{after dilution}}$

The moles of solute is also equal to the molarity (M) of the solution times the volume (V) of the solution (note that the volume units cancel):

(3) Moles of solute = M x V = mol/liter x liter

So equation (2) can be rewritten:

(4) $M_1V_1 = M_2V_2$ (where 1 = "before dilution" and 2 = "after dilution")

Example: A student pipets exactly 5.00-mL of 3.47×10^{-2} M $FeCl_3$ solution into a vol flask and adds enough water to make 250.-mL of solution. What is the concentration of the diluted solution? Answer: Let M_2 be the concentration of the new solution. By using equation (4) and substituting known values for M_1, V_1 and V_2, solve for M_2:

$$M_2 = \frac{M_1V_1}{V_2} = \frac{(3.47 \times 10^{-2}\ \text{M})(5.00\ \text{mL})}{(250\ \text{mL})} = 6.94 \times 10^{-4}\ \text{M}$$