Session 4: LECTURE OUTLINE (SECTIONS G.3 & G.4)

I. Molarity
   a. definition
   b. calculation of
   c. use of molarity as a conversion factor
      i. calculate mass of solute
      ii. calculate volume of solution
      iii. calculate moles of solute

II. Dilution
   a. calculate volume of stock solution needed
   b. calculate new concentration

suggested problems: pp F56-F57 G.5, G.9, G.11, G.13, G.21

Molarity- amount of solute molecules or formula units (in moles) divided by the volume of the solution (in liters)

Common terms:
Solution – homogenous mixture of two or more substances
(solute + solvent)
Solute – less amount
Solvent – greater amount
Aqueous solution – water is the solvent

$$\text{Molarity} = \frac{\text{mol solute}}{\text{liter solution}}$$

molarity	molar	M	$\frac{\text{mol}}{\text{liter}}$

Examples:
1. Calculate the molarity of 2 liters of a saline solution containing 4 moles of NaCl.

Solution:
Remember the definition of molarity. Molarity is a unit derived from two base units, moles and liters, so simply divide the number of given moles, by the given amount of solution to express the concentration of the solution in molar units.

$$\frac{4 \text{ moles NaCl}}{2 \text{ liters solution}} = 2 \text{ M NaCl solution}$$

2. Calculate the molarity of 250 mL saline solution containing 30 g NaCl.

Solution:

In this example we need to recognize that the solute amount is given in units of grams, thus we need those units to be converted to moles, to express the concentration in the desired molar unit. In addition, the solution is expressed in units of ml and it needs to be expressed in terms of liters, so we will also need to make that conversion. All conversions can be completed in one step:

$$\frac{30 \text{ g NaCl}}{250 \text{ ml solution}} \left| \frac{1 \text{ mol NaCl}}{58.5 \text{ g NaCl}} \right| \frac{1000 \text{ ml solution}}{1 \text{ L solution}} = .128 \text{ M}$$

3. How many grams of silver nitrate must be dissolved to prepare 500 mL of .150 M $AgNO_3$?

Solution:

In this example we will use the molar concentration, the derived unit, as a conversion factor to convert from volume of solution to amount of solute. This is analogous to using density, a derived unit, to convert between mass of a substance and volume of a substance.

Given: 500 mL of .150 M $AgNO_3$ solution (soln)
Wanted: g of $AgNO_3$ in 500 ml of solution to give .150 M soln
Conversion: mL $AgNO_3$ solution to L $AgNO_3$ soln to moles $AgNO_3$ in that soln to grams $AgNO_3$

Conv. factors: $\frac{1 \text{ L soln}}{1000 \text{ mL soln}}$ $\frac{.150 \text{ mol } AgNO_3}{1 \text{ L soln}}$ $\frac{170 \text{ g } AgNO_3}{1 \text{ mol } AgNO_3}$

$$\frac{500 \text{ mL soln}}{} \left| \frac{1 \text{ L soln}}{1000 \text{ mL soln}} \right| \frac{.150 \text{ mol } AgNO_3}{1 \text{ L soln}} \left| \frac{170 \text{ g } AgNO_3}{1 \text{ mol } AgNO_3} \right.$$

$$= \quad 12.75 \text{ g } AnNO_3$$

Dilution – is a common technique used in the chemistry laboratory. Often solutions are conveniently stored at higher concentration, then diluted down to the desired concentration, by carefully transferring the desired volume of the "stock" solution into a volumetric flask and diluting up to the level of the particular flask.

The following is a useful expression used for dilution problems:

$$M_1V_1 = M_2V_2$$

where,
M_1 = initial molar concentration of concentrated solution
V_1= volume of concentrated solution
M_2 = molar concentration of diluted solution
V_2 = volume of diluted solution

Examples:
1. Commercial concentrated hydrochloric acid is 12.0 M HCl. What volume of concentrated HCl is required to prepare 4.50 L of 2.25 M HCl solution?

Solution:
Simply determine the values of 3 of the variables from the expression and algebraically solve for the 4th.

M_1 = 12.0 M
V_1 = ?
M_2 = 2.25 M
V_2 = 4.50 L

$12.0\ M \times V_1 = 2.24\ M \times 4.50\ L$

$$V_1 = \frac{2.24\ M \times 4.50\ L}{12.0\ M}$$

V_1 = 0.84 L or 840 mL

2. If we take 250 mL of our 12.0 M concentrated stock HCl solution and dilute it to 1000 mL, what will the new concentration be?

Solution:
Again, simply determine the values of the 3 given variables and solve for the 4th.

M_1 = 12.0 M
V_1 = 250 mL
M_2 = ?
V_2 = 1000 mL

12.0 M X 250 mL = M_2 X 1000 mL

$$M_2 = \frac{12.0\ M \times 250\ mL}{1000\ mL}$$

M_2 = 3 M