**Molarity (M), molality (m) and the Colligative properties**

The molarity of a solution is the number of moles of solute per liter of solution. The symbol for molarity is M. Thus a 3.0 molar solution of nitric acid, abbreviated 3.0 M HNO3, contains 3.0 moles of HNO­3 per liter of solution.

**Sample problem #1:** What mass of sodium hydroxide, NaOH, is required to prepare 3.00 liters of 0.25 M solution ?

Solution: given volume of solution and molarity of solution find the mass of solute.

3.00 liters 0.25 moles NaOH 40.0 g NaOH = 30.0 g NaOH

1 liter 1 mole NaOH

**Sample Problem #2:** What volume of 1.25 M NaOH can be prepared using 60.0g of sodium hydroxide?

Solution: given mass of solute and molarity of solution find the volume of solution

60.0 g NaOH 1 mole NaOH 1 liter soln = 1.2 Liters of soln

40.0 g NaOH 1.25 moles NaOH

**Molarity Problems (moles / liter of solution)**

1. Calculate the molarity, M, of the following solutions:
   1. 1.5 moles of NaC2H3O2 dissolved in 750 ml of solution.
   2. 3.00 moles of H2SO4 dissolved in 1250 ml of solution.
   3. 66 grams of NaC2H3O2 dissolved in 500 ml of solution.
   4. 68.4 g of glucose, C6H12O6 in 500 ml of water solution.
2. What is the molarity of a solution that contains 125 g CH3OH in 0.25 L of solution?
3. What is the molarity of a solution that contains 85.0 grams of Na2SO4 in 325 ml of solution?
4. What is the molarity of a solution that contains 210 grams of Al2(SO4)3 in 2.75 liters of solution?

**Solve for mass:**

1. Determine the grams of solute required to prepare the following solutions:
   1. 1500 ml of 3M KOH
   2. 750 ml of a 0.50 M solution of HC2H3O2
   3. 2 liters of a 2.5 M solution of C6H12O6
   4. 250 ml of a 1.25 M solution of NaCl
2. What mass of K3PO4 is required to prepare 4.00 liters of 1.50M solution?
3. What mass of CH3OH is required to prepare 1.50 liters of 3.00M solution?

**Solve for volume:**

1. What volume of 0.750 M solution can be prepared using 90.0 grams of NH4Cl?
2. If a 0.75 M solution of NaOH is to be prepared using 18.5 g NaOH, how many ml of solution can be produced?
3. What volume of 1.40 M HC2H3O2 solution contains 0.400 mole of HC2H3O2?

The molality of a solution is the moles of solute dissolved in 1 kilogram (1000g) of solvent (often water). The symbol for molality is lower case “m”. Thus a 3.0 molal solution of nitric acid, abbreviated 3.0 m HNO3, contains 3.0 moles of HNO3 in 1 kg of water.

**MOLAL PROBLEMS** **(moles / kg of solvent )**

1. How many grams of AgNO3 are needed to prepare a 0.125 m solution in 250 grams of water?
2. What mass in grams of sucrose, C6H12O6, must be dissolved in 2000 grams of water to make a 0.1 molal solution?
3. Determine the molality (m) of a solution containing 42 grams of glycerin, C3H5(OH)3 in 750 grams of water.
4. A solution contains 85.0 grams of methanol, CH3OH, in 3000 grams of water. Calculate the molality of the solution.

**FREEZING POINT DEPRESSION AND BOILING POINT ELEVATION**

(for water B.P. elevation const. = 0.512 oC/m, F.P. depression const. = 1.86oC/m)

1. A solution contains 15 grams of sucrose, C12H22O11, in 250 grams of water. What is the freezing point of the solution? (determine the molality first)
2. What is the boiling point of the solution in problem 15 above?
3. Calculate the boiling point and freezing point of a solution that contains 30.0 grams of acetic acid, HC2H3O2, dissolved in 250 grams of water.
4. Calculate the freezing point of a solution containing 5.70 grams of sugar, C12 H22O11, in 50 grams of water.
5. Calculate the boiling point of the sugar solution in problem 18 above.
6. Calculate the freezing point of a solution containing 60. grams of NaOH in 500 grams of water.
7. Calculate the boiling point of the solution in the above problem.
8. How many grams of ethanol, CH3OH, must be dissolved in 500 grams of water to lower the freezing point to -6.51oC?

**Challenge Problem:**

How many grams of ethylene glycol, C2H4(OH)2, must be dissolved in 200 grams of water to lower the freezing point to -29.75oC?

If the density of ethylene glycol is 1.12 g/ml, how many milliliters of ethylene glycol are required?