9.5: Colligative Properties and Molality

Colligative properties are properties that differ based on the concentration of solute in a solvent, but not on the type of solute. What changes are the properties of the solvent. What causes this change is the number of solute particles in the solution. As we will see, solute particles refers to the number of particles as they exist in solution which may be different than the number of particles as they exist prior to being dissolved. For covalent compounds this will be the same, but for ionic compounds this will be different as the solvent falls apart the compound into ions.

There are several colligative properties, but we will be looking at just a few of them in this textbook. First we will look at changes in the temperatures of phase changes (both melting point and boiling point). Then we will look at changes related to flow across membranes. All three of these colligative properties are things that affect our everyday lives.

Before we begin this discussion, it is necessary to learn about a new concentration unit. It is called **Molality (*m*).**

$$\text{molality} = \frac{\text{number of moles of solute}}{\text{number of kilograms of solvent}} \tag{9.5.1}$$

Molality differs from other concentration units we have discussed in that the quantity on the bottom of the fraction is just the solvent mass, not the total solution.

Example 9.5.1

A solution is prepared by dissolving 42.23 g of $\mathrm{NH_4Cl}$ into 500.0 g of water. Calculate its molality.

Solution

Steps for Problem Solving	
Identify the "given" information and what the problem is asking you to "find."	Given: Mass Solute $= 42.23$ g $\mathrm{NH_4Cl}$ Mass Solvent $= 500.0$ g $= 0.5000$ kg Find: Molality = ? *m*
List other known quantities.	Molar mass $\mathrm{NH_4Cl} = 53.50$ g/mol
Plan the problem.	1. The mass of the ammonium chloride is first converted to moles.  $\frac{1\ mol\ NH_4Cl}{53.50g\ NH_4Cl}$ 2. Then the molarity is calculated by dividing by liters. Note the given volume has been converted to liters. $\mathrm{m} = \frac{\text{mol } \mathrm{NH_4Cl}}{\text{kg solvent}}$
Cancel units and calculate.	Now substitute the known quantities into the equation and solve. $42.23\ \text{g}\ \mathrm{NH_4Cl} \times \frac{1\ \text{mol}\ \mathrm{NH_4Cl}}{53.50\ \text{g}\ \mathrm{NH_4Cl}} = 0.7893\ \text{mol}\ \mathrm{NH_4Cl}$ (9.5.2) $\frac{0.7893\ \text{mol}\ \mathrm{NH_4Cl}}{0.5000\ \text{kg solvent}} = 1.579\ m$ (9.5.3)
Think about your result.	The molality is $1.579\ m$, meaning that a liter of water would contain 1.579 mol $\mathrm{NH_4Cl}$. Four significant figures are appropriate.