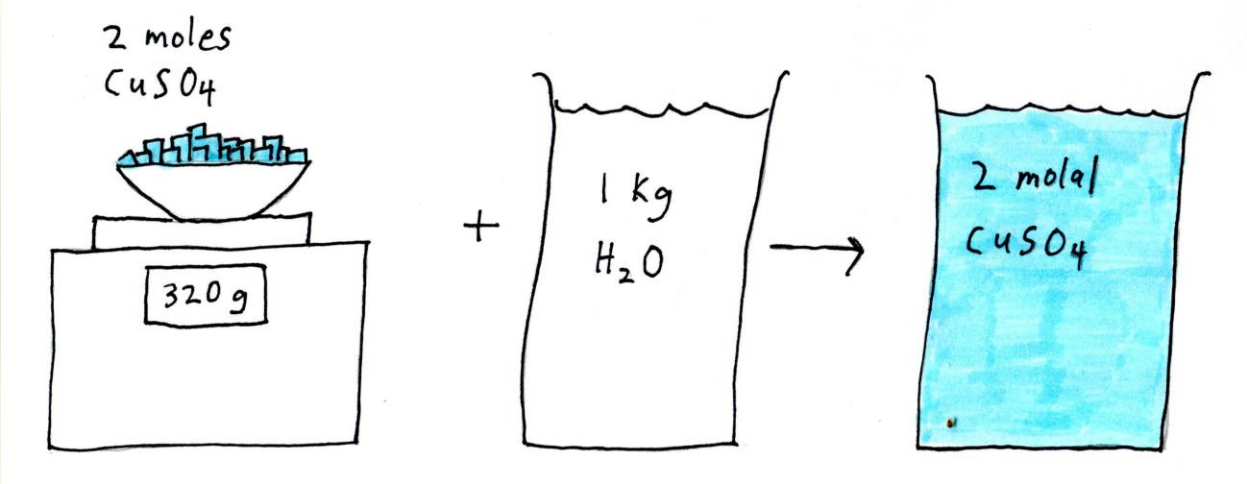
Chemistry Lecture #79: Molality

One way to measure the concentration of a solution is to use molality (*m*). Molality describes the moles of solute added to kilograms of a solvent (usually water).

For example, if I add 320 g of $CuSO_4$ (or 2 moles of $CuSO_4$) to 1 kg of water, I would have a 2 molal $CuSO_4$ solution.



Mathematically, molality is expressed as

$$m = \frac{\text{moles of solute}}{\text{kg solvent}}$$

Just to keep things simple, we'll assume that water will be the solvent in all the problems we do.

If 52.0 g of K_2CO_3 are dissolved in 518 g of H_2O, what is the molality?

Answer

Molality is moles of solute per kg of solvent. We've been given grams of solute per gram of solvent/water. We need to convert grams of solute into moles of solute, and convert grams of water into kg of water.

To make the conversions, we need to use the following equalities:

1 mole K_2CO_3 = 138 g 1000 g H_2O = 1 kg H_2O

We now use the factor label method to convert grams of solute per grams of water into moles of solute per kg of water.

$$\frac{52.0\text{ g } K_2CO_3}{518\text{ g } H_2O} \times \frac{\text{moles } K_2CO_3}{138\text{ g } K_2CO_3} \times \frac{1000\text{ g } H_2O}{\text{kg } H_2O} = \frac{0.727\text{ moles } K_2CO_3}{\text{kg } H_2O}$$

$$\frac{0.727\text{ moles } K_2CO_3}{\text{kg } H_2O} = 0.727\text{ molal } K_2CO_3 \text{ or } 07.27\ m\ K_2CO_3$$

For the next problem, we'll calculate the grams of solute needed to make a solution with a specific molality.

What mass of NaCl must be added to 8.00×10^2 g of water to make a 0.750 *m* solution?

Answer

We're given grams of water and the concentration. We'll use these convert grams of water into kg of water. Then we'll convert kg of water into moles of solute or NaCl. Finally, we'll convert moles of NaCl into grams of NaCl.

To convert g of water to kg, we use 1000 g H_2O = 1 kg H_2O.

0.750 *m* means that 1 kg of water will contain 0.750 moles of solute. To convert kg of water to moles of solute, we'll use 1 kg H_2O = 0.750 moles NaCl.

To convert moles of NaCl to grams, we'll use 1 mole NaCl = 58.5 g.

g H_2O ➡ kg H_2O ➡ moles NaCl ➡ g NaCl

1000 g H_2O = 1 kg H_2O
1 kg H_2O = 0.750 moles NaCl
1 mole NaCl = 58.5 g NaCl

$$\frac{800 \text{ g } H_2O}{1} \times \frac{\text{kg } H_2O}{1000 \text{ g } H_2O} \times \frac{0.750 \text{ moles NaCl}}{\text{kg } H_2O} \times \frac{58.5 \text{ g NaCl}}{\text{mole NaCl}} =$$

35.1 g NaCl