For many purposes, the use of molarity is very convenient. However, when we want to know the concentration of solute present in situations where there are temperature changes, molarity won’t work. The volume of the solution will change somewhat with temperature, enough to make accurate data observations and calculations in error. Another parameter is needed, one not affected by the temperature of the material we are studying.

### Molality

A final way to express the concentration of a solution is by its molality. The **molality** $m$ of a solution is the moles of solute divided by the kilograms of solvent. A solution that contains $1.0 \text{ mol}$ of $\ce{NaCl}$ dissolved into $1.0 \text{ kg}$ of water is a “one-molal” solution of sodium chloride. The symbol for molality is a lower-case $m$ written in italics.

\[
\text{Molality} (m) = \frac{\text{moles of solute}}{\text{kilograms of solvent}} = \frac{\text{mol}}{\text{kg}}
\]

Molality differs from molarity only in the denominator. While molarity is based on the liters of solution, molality is based on the kilograms of solvent. Concentrations expressed in molality are used when studying properties of solutions related to vapor pressure and temperature changes. Molality is used because its value does not change with changes in temperature. The volume of a solution, on the other hand, is slightly dependent upon temperature.

**Example 16.11.1**

Determine the molality of a solution prepared by dissolving $28.60 \text{ g}$ of glucose ($\ce{C_6H_{12}O_6}$) into $250. \text{ g}$ of water.

**Solution:**

**Step 1: List the known quantities and plan the problem.**

**Known**

- Mass solute $= 28.60 \text{ g}$ of $\ce{C_6H_{12}O_6}$
- Mass solvent $= 250. \text{ g} = 0.250 \text{ kg}$
- Molar mass of $\ce{C_6H_{12}O_6} = 180.18 \text{ g/mol}$

**Unknown**

- Molality $m = \ ? \text{ mol/kg}$

Convert grams of glucose to moles and divide by the mass of the water in kilograms.

**Step 2: Solve.**

\[
\begin{align}
28.60 \text{ g} \ce{C_6H_{12}O_6} \times \frac{1 \text{ mol} \ce{C_6H_{12}O_6}}{180.18 \text{ g} \ce{C_6H_{12}O_6}} &= 0.1587 \text{ mol} \ce{C_6H_{12}O_6} \times \frac{0.1587 \text{ mol} \ce{C_6H_{12}O_6}}{0.250 \text{ kg} \ce{C_6H_{12}O_6}}
\end{align}
\]
\[ \ce{C_6H_{12}O_6}[0.250 \ \text{kg} \ \ce{H_2O}} \ &= \ 0.635 \ \text{m} \ \ce{C_6H_{12}O_6} \ \] 

Step 3: Think about your result.

The answer represents the moles of glucose per kilogram of water and has three significant figures.

Molality and molarity are closely related in value for dilute aqueous solutions because the density of those solutions is relatively close to \(1.0 \ \text{g/mL}\). This means that \(1.0 \ \text{L}\) of solution has nearly a mass of \(1.0 \ \text{kg}\). As the solution becomes more concentrated, its density will not be as close to \(1.0 \ \text{g/mL}\) and the molality value will be different than the molarity. For solutions with solvents other than water, the molality will be very different than the molarity. Make sure that you are paying attention to which quantity is being used in a given problem.

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Summary

- The calculation of molality is described.

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Contributors

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