10.15: Solutions

Up to this point we have discussed only the properties of pure solids and liquids. Of more importance to a chemist, though, are the properties of solutions. Very few chemical reactions involve only pure substances—almost all involve a solution of some sort.

We defined a solution as a homogeneous mixture of two or more substances previously, that is, a mixture which appears to be uniform throughout. Under this definition we would refer to sugar or salt dissolved in water as solutions, but we would not apply the term to muddy water or to milk. A close inspection of muddy water reveals that it is not uniform in appearance but consists of small solid particles dispersed in water. We refer to such a mixture as a **suspension**. Under the microscope, milk can also be seen to be nonuniform, It consists of small drops of milk fat dispersed throughout an aqueous phase. A more obvious example of a suspension is chia seeds in water, seen below. The chia seeds are randomly suspended in the cup of water, a perfect example of a suspension.

Our definition of a solution in terms of the homogeneity of a mixture is somewhat unsatisfactory since it does not tell us where to draw the line. Field-emission microscopes and electron microscopes have now been developed which can just about ”see” a single atom. With such a microscope virtually *all* matter looks nonuniform and hence not homogeneous. If our definition extends to such microscopes, then true solutions do not exist. In practice we draw the line somewhere around the 5 nanometer (nm) mark, even though some molecules are larger than this.

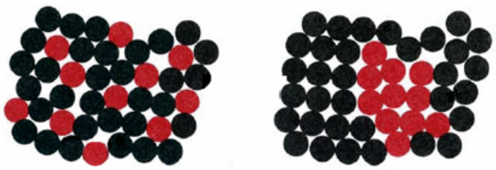

Figure 10.15.2 Suspensions and solutions viewed on the microscopic level. (a) A solution corresponds to a random arrangement of one kind of molecule around the other. (b) In a suspension there are small regions of space where only one kind of molecule exists.

On the molecular level a solution corresponds to the random arrangement of one kind of molecule or ion around another. In the accompanying figure, the illustration on the left corresponds to a solution since each black molecule is randomly surrounded by black and red molecules, and vice versa. The illustration on the right is a suspension. The distribution is not random, and most red molecules have red neighbors, while most black molecules have black neighbors.

Strictly speaking, the term *solution* applies to any homogeneous mixture, but we will concentrate our discussion on those solutions which involve liquids since these are the most common. It should be realized, though, that other types of solutions also exist. Air is a solution of a large number of gases (oxygen is the most concentrated) in another gas (nitrogen). A 5-cent coin is made from an alloy in which one solid (nickel) is dissolved in another (copper). Solutions of hydrogen gas in solid palladium and some other metals are also possible.

As mentioned in the brief discussion of solutions earlier, it is sometimes difficult to decide which component of a solution is the solute and which is the solvent. Usually the amount of solvent is much larger than that of the solute. If the pure components were initially in separate phases (a gas and a solid, for example), the phase corresponding to the state of the solution is taken to be the solvent. In the case of $H_2(g)$ and Pd(s) mentioned above, for example, Pd would be the solvent because the solution is a solid phase.