11.7: Colligative Properties of Solutions

the solvent. However, some of the properties of solutions differ from pure solvents in measurable and predictable ways. The differences are proportional to the fraction that the particles occupy in the . These properties are called ; the word comes from the Greek word meaning "related to the number," implying that these properties are related to the number of particles, not their identities. unit. The of the i^{th} component in a , χ_i, is the number of moles of that component divided by the total number of moles in the sample: is always a number between 0 and 1 (inclusive) and has no units; it is just a number. fractions of all substances in a mixture equals 1. Thus the of C_6H_6 in Example 11.7.1 could be calculated by evaluating the definition of a second time, or—because there are only two substances in this particular mixture—we can subtract the of the $C_{10}H_8$ from 1 to get the of C_6H_6. unit has been introduced, the first colligative property can be considered. As mentioned in Chapter 10, all pure liquids have a characteristic in equilibrium with the liquid phase, the of which is dependent on temperature. Solutions, however, have a lower than the pure solvent has, and the amount of lowering is dependent on the fraction of particles, as long as the itself does not have a significant (the term is used to describe such solutes). This colligative property is called (or). The actual of the can be calculated as follows: }\] of the , χ_{solv} is the of the solvent particles, and P^*_{solv} is the of the pure solvent at that temperature (which is data that must be provided). Equation ??? is known as (the approximate pronunciation is). is rationalized by presuming that particles take positions at the surface in place of solvent particles, so not as many solvent particles can evaporate. are related to as expressed in . As a review, recall the definition of : } =\frac{\text{moles of }}{\text{kilograms of solvent}}\nonumber \] of a with a nonvolatile is depressed compared to that of the pure solvent, it requires a higher temperature for the 's to reach 1.00 atm (760). Recall that this is the definition of the : the temperature at which the of the liquid equals 1.00 atm. As such, the of the is higher than that of the pure solvent. This property is called . of the and is called the which is a characteristic of the solvent. Several constants (as well as boiling point temperatures) are listed in Table 11.7.1 . is higher than the boiling point of the pure solvent, but the opposite occurs with the freezing point. The freezing point of a is lower than the freezing point of the pure solvent. Think of this by assuming that particles interfere with solvent particles coming together to make a solid, so it takes a lower temperature to get the solvent particles to solidify. This is called . is similar to the equation for the : of the and is called the which is also a characteristic of the solvent only. Several constants (as well as freezing point temperatures) are listed in Table 11.7.2 is one colligative property that we use in everyday life. Many antifreezes used in automobile radiators use solutions that have a lower freezing point than normal so that automobile engines can operate at subfreezing temperatures. We also take advantage of when we sprinkle various compounds on ice to thaw it in the winter for safety (Figure 11.7.1). The compounds make solutions that have a lower freezing point, so rather than forming slippery ice, any ice is liquefied and runs off, leaving a safer pavement behind. is a thin membrane that will pass certain small but not others. A thin sheet of cellophane, for example, acts as a . Consider the system in Figure 11.7.2 of a is easy to calculate: of a , M is the of the , R is the constant, and T is the absolute temperature. This equation is reminiscent of the discussed previously. is important in biological systems because cell walls are semipermeable membranes. In particular, when a person is receiving intravenous (IV) fluids, the of the fluid needs to be approximately the same as blood serum; otherwise there may be negative consequences. Figure 11.7.3 shows three red blood cells: is also the reason you should not drink seawater if you're stranded in a lifeboat on an ocean; seawater has a higher than most of the fluids in your body. You drink the water, but ingesting it will pull water out of your cells as osmosis works to dilute the seawater. Ironically, your cells will die of thirst, and you will also die. (It is OK to drink the water if you are stranded on a body of freshwater, at least from an perspective.) is also thought to be important in getting water to the tops of tall trees, in addition to capillary action.