

solute particles and not on the type of solute particles, it is a colligative property. The greater the concentration of a solution, the greater the osmotic pressure of the solution.

Regulation of osmosis is vital to the life of a cell because cell membranes are semipermeable. Cells lose water and shrink when placed in a solution of higher concentration. They gain water and swell when placed in a solution of lower concentration. In vertebrates, cells are protected from swelling and shrinking by blood and lymph that surround the cells. Blood and lymph are equal in concentration to the concentration inside the cell.

Electrolytes and Colligative Properties

Early investigators were puzzled by experiments in which certain substances depressed the freezing point or elevated the boiling point of a solvent more than expected. For example, a 0.1 *m* solution of sodium chloride, NaCl, lowers the freezing point of the solvent nearly twice as much as a 0.1 *m* solution of sucrose. A 0.1 *m* solution of calcium chloride, CaCl₂, lowers the freezing point of the solvent nearly three times as much as a 0.1 *m* solution of sucrose. The effect on boiling points is similar.

To understand why this is so, contrast the behavior of sucrose with that of sodium chloride in aqueous solutions. Sugar is a nonelectrolyte. Each sucrose molecule dissolves to produce only one particle in solution, so 1 mol of sucrose dissolves to produce only 1 mol of particles in solution. NaCl, however, is a strong electrolyte. Each mole of NaCl dissolves to produce 2 mol of particles in solution: 1 mol of sodium ions and 1 mol of chloride ions. **Figure 9** compares the production of particles in solution for three different solutes. As you can see, electrolytes produce more than 1 mol of solute particles for each mole of compound dissolved.

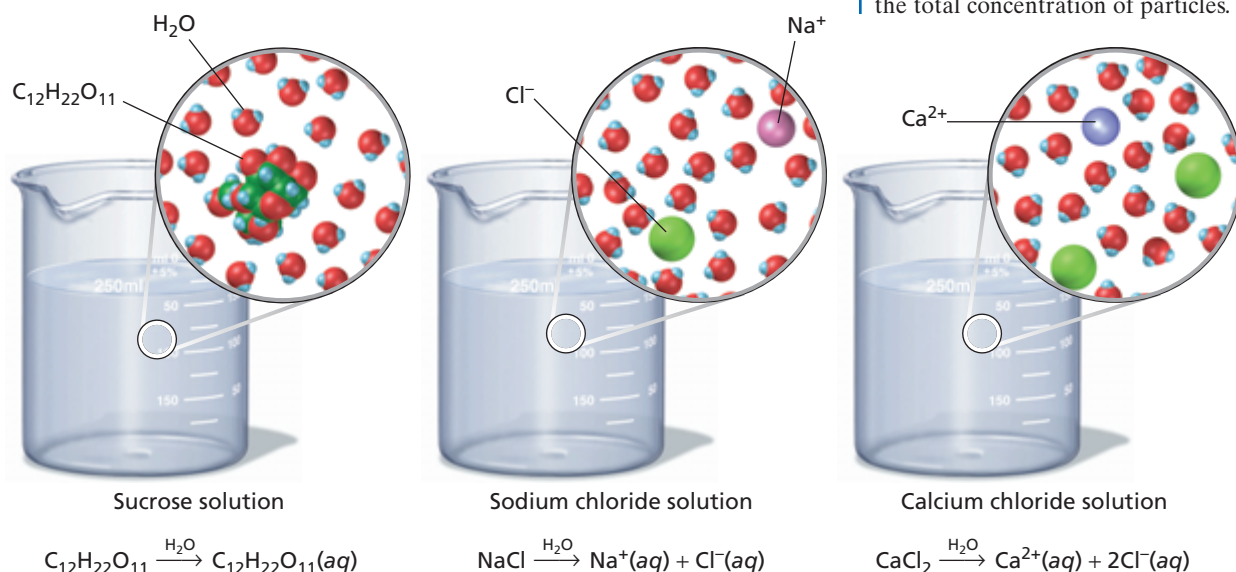


FIGURE 9 Compare the number of particles produced per formula unit for these three solutes. Colligative properties depend on the total concentration of particles.

Chemistry in Action

Water Purification by Reverse Osmosis

The process of reverse osmosis is used to purify water because it removes many contaminants at relatively low cost. The osmosis process can be reversed by applying a pressure greater than the osmotic pressure to an aqueous solution. This causes the water, but not the dissolved solutes, to flow from the solution through the semipermeable membrane. The largest municipal desalination plant in the United States is in Sarasota, Florida. It treats salt water by reverse osmosis to produce more than 12 million gallons of fresh water per day. Other applications include the desalination of sea water on ocean-going vessels and wastewater purification.