Colligative Properties

Some physical properties of liquid solutions differ from those of the pure solvent. A property that depends on the concentration of solute particles but is independent of their nature is called a **colligative property**. Colligative properties depend on the collective effect of the solute particles and not on their chemical identity.

Four colligative properties are vapor pressure reduction, boiling point elevation, freezing point depression, and osmotic pressure.

Vapor Pressure Reduction

In a pure liquid solvent, some molecules leave the surface and enter the gaseous state (vaporization). At the same time, molecules from the gaseous state return to the liquid (condensation). The gas pressure resulting from the vapor molecules over the liquid is the vapor pressure.

Experiments have shown that the vapor pressure of a solvent containing a nonvolatile solute is lower than the vapor pressure of the pure solvent. Nonvolatile means that a substance has no tendency to vaporize or sublimate under existing conditions. Sugar is an example of a nonvolatile substance.

When a nonvolatile solvent is added to a pure solvent, the solute molecules take up space at the surface of the liquid. This prevents some solvent molecules from leaving the liquid. At the same time, there is no change in the rate at which gas molecules return to the liquid. Because more molecules leave the gas than enter it, the pressure of the gas is reduced. This is known as **vapor pressure reduction**.

The extent to which a nonvolatile solute lowers the vapor pressure is proportional to its concentration. Doubling the concentration of solute doubles its effect.

Boiling Point Elevation

The boiling point of a substance is the temperature at which the vapor pressure of a liquid is equal to the external pressure on its surface (the atmospheric pressure).

Because the addition of a nonvolatile solute reduces the vapor pressure of a solution, a higher temperature is necessary to get the vapor pressure of the solution up to the atmospheric pressure so that the solution boils. The amount by which the boiling point is raised is the **boiling point elevation** of the solution.

The boiling point elevation is the difference between the boiling point of the solution and the boiling point of the pure solvent.

Freezing Point Depression

The freezing point of a substance is the temperature at which the vapor pressures of the solid and liquid phases are the same.

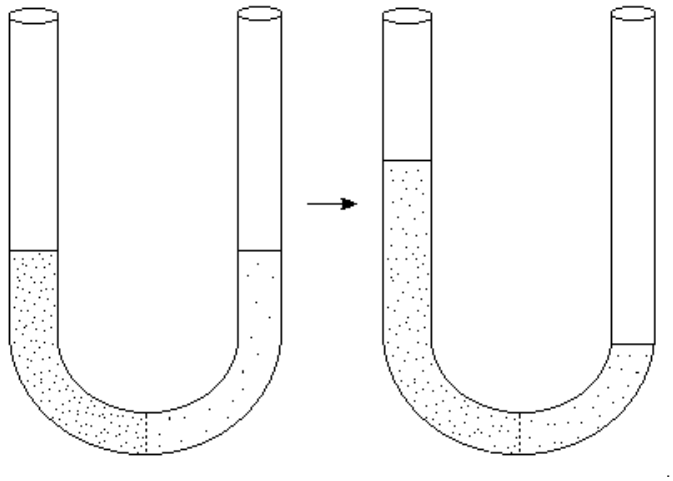
If a nonvolatile solute is added to a solvent, the vapor pressure of the solvent is reduced. Thus, the temperature at which the solution and the solid phase have the same vapor pressure is reduced. In other words, the solution will freeze at a lower temperature.

The ability of a dissolved solute to lower the freezing point of its solution is known as **freezing point depression**.

Osmotic Pressure

Some materials are semipermeable. This means that they will allow some particles to pass through, but not others. A semipermeable membrane may allow the passage of small solvent particles, but not larger solute particles.

If such a membrane is placed between two solutions of different concentration, solvent particles will move in both directions through the membrane, while solute particles will remain on one side of the membrane. The result is a net flow of solvent particles from the less concentrated solution to the more concentrated solution. This process is called **osmosis**.



The diagram on the left shows two solutions separated by a semipermeable membrane.

Solvent molecules move through the membrane from right to left. As a result, the liquid levels in the two sides become uneven.

Eventually, the pressure difference resulting from the uneven heights becomes so large that the net flow of solvent stops.

The pressure necessary to prevent osmosis is known as the **osmotic pressure**.

There are many examples of osmosis in our everyday lives. For example, did you ever notice that when you eat a lot of salty foods you tend to become bloated? This is because the salty solutions in your body fluids are more concentrated than usual. Your cells then tend to absorb water from surrounding solutions, resulting in what we call bloating.