Solutions and Collagative Properties

Solutions

A **solution** is a homogenous mixture composed of a **solvent**, the bulk material something is dissolved in, and the **solute** what is being dissolved. The **concentration** of the solution is the relative amount of solute in a solution. **Molarity** is a main unit of concentration in chemistry, which is defined as;

$$M = \frac{mol_{solute}}{L_{solution}}$$

The concentration of a solution can be **diluted** to a lower concentration by adding more solvent. A common formula used to solve for the amount of solution one needs to use to dilute to a lower concentration is;

$$C_1V_1 = C_2V_2$$

where C and V are concentration and volume. So if one was trying to prepare 100 mL of 0.5 M solution from a 5 M solution, one would perform the following calculation;

$$V_1 = \frac{100\ mL \cdot 0.5\ M}{5\ M} = 10\ mL$$

One would pipette 10 mL of the original solution into a vessel and then add 90 mL of solvent to dilute and create the 100 mL 0.5 M solution.

Other Concentration Units

Mass percentage is the ratio of a components mass to that of the solution;

$$Mass\ percentage = \frac{m_{solute}}{m_{solution}} \cdot 100\%$$

Parts per million (ppm) or **Parts per Billion (ppb)** is another common metric;

$$ppm = \frac{m_{solute}}{m_{solution}} \cdot 10^6\ ppm$$

$$ppm = \frac{m_{solute}}{m_{solution}} \cdot 10^9\ ppb$$

Solubility

A **saturated** solution is one in which the solute concentration is equal to its solubility.

For liquid-gas solutions, the solubility of the gas is related to its partial pressure via **Henry's Law**;

$$C_g = kP_g$$

Colligative Properties

mole fraction, X, is the moles of a solution component relative to the total moles;

molality is the moles of solute per kg of solvent.

Vapor Pressure lowering

Dissolving a non-volatile substance in a volatile liquid will result in the lowering of that solutions vapor pressure.

Raoults Law describes the relationship between the vapor pressure of a solutions components and that of the pure substance.

$$P_A = X_A * P_A*$$

where X_A* is the mole fraction of the component and P_A* is the partial presure of the pure component.

Boiling Point Elevation and Freezing Point Depression

Dissolution of solute in solvent will increase the boiling point of that solution;

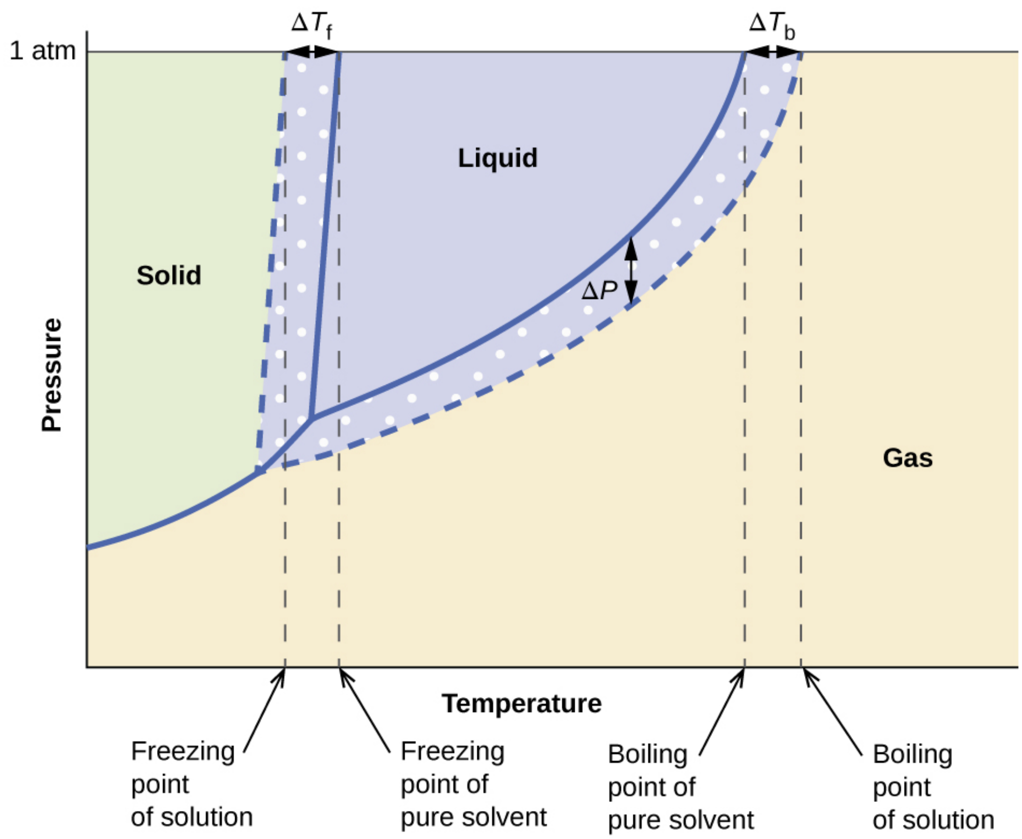
$$\Delta T_b = K_b m$$

where K_b is the **boiling point elevation constant** and m is the concentration of the solution in molality.

Analogously for freezing point depression;

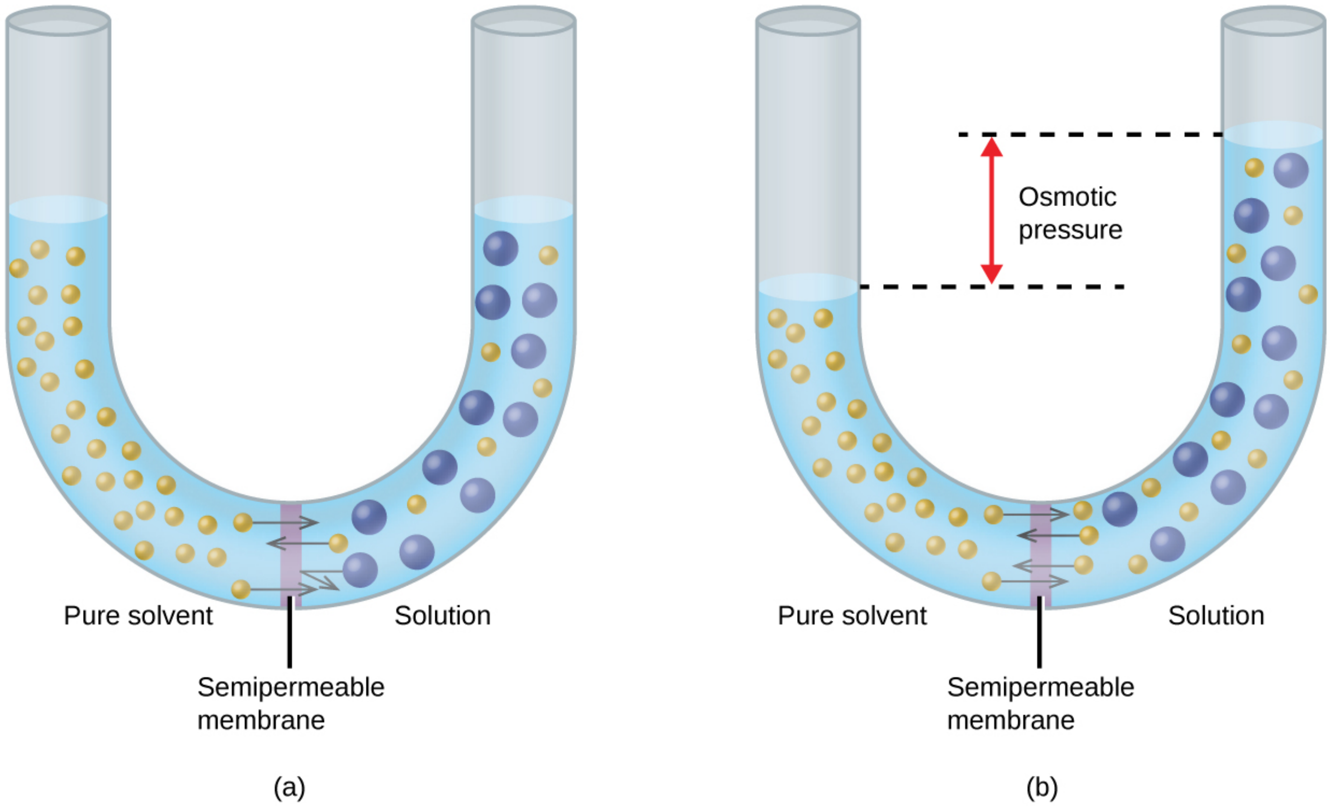
$$\Delta T_b = K_f m$$

The below phase diagram illustrates these effects.



Osmotic Pressure

Solvent can diffuse across semi-permiable membranes to dilute a solution in a process called **osmosis**. When forward and reverse solvent transfer rates are equal, bulk solvent transfer stops. The pressure due to the weight of the solution at this point is the **osmotic pressure (Π)**.



Osmotic pressure can be calculated by;

$$\Pi = MRT$$