CHEM 361A - Lecture 12 Activity

Ions in Solution

In Class

1. The equilibrium constant for the dissociation of AgCl is $K_{sp} = 1.8 \times 10^{-10}$. Determine the $[Ag^+]$ in a

   (a) solution where we don't consider ionic effects ($\gamma_\pm = 1$)

   (b) 0.020 M KNO_3 solution

   (c) 5.0 M KNO_3 solution

   (d) 0.020 M KCl solution

2. Since colligative properties are dependent on the number of particles in solutions, solids that dissociate add a layer of complexity since they multiply colligative properties. For example, we would expect NaCl to have twice the effect as a similar amount of sugar added to a solution since the NaCl dissociates into Na^+ and Cl^-.

   To account for this, we will modify our equations for colligative properties such that:

$$\Delta T = K_b(im_{solute})$$
$$\Delta T = -K_f(im_{solute})$$
$$\pi = i\frac{n_{solute}RT}{V} \qquad \pi = cRT$$

   where

$$i = \frac{\text{actual number of particles in solution at equilibrium}}{\text{number of particles in solution before dissociation}}$$

   We will explore this change using the Donnan Effect which describes the equilibrium distribution of small diffusible ions on the two sides of a semipermeable membrane. The membrane in this case will allow the diffusion of water and small ions, but is impermeable to large macromolecular molecules like proteins.

   (a) Case 1: Consider a neutral protein placed in the left compartment and pure water in the right compartment. The two compartments are separated by a semipermeable membrane like the one described above. If the concentration of the protein in the left compartment is the value 'c', write an expression that describes the osmotic pressure produced by this system.

   (b) Case 2: The protein (denoted as P) is now the anion of a sodium salt such that when it is dissociated in water:

$$NaP\,(aq) + H_2O\,(l) \rightleftharpoons Na^+(aq) + P^-(aq)$$

In this case, a concentration, 'c', of NaP is placed in the left compartment, and pure water is placed in the right compartment, and the two are separated by the semipermeable membrane described above.

i = 2

$\Pi = 2cRT$

i. What is i in this case assuming complete dissociation of the protein salt?

ii. Write an expression that describes the osmotic pressure produced by this system.

iii. Pretend that you were going to measure the concentration (an ultimately the molar mass) of the protein using the osmotic pressure produced. If the protein were originally dissolved as a salt, what piece of information would you need to know, in order to get an accurate concentration of the protein.

Homework

3. Calculate the equilibrium concentrations of the ions of $CaCO_3$ ($K_{sp} = 3.4 \times 10^{-9}$)

   (a) in pure H_2O (6.26×10^{-5} M)

   (b) In an aqueous solution with other ions already present so that the Ionic Strength of the solution is 0.0250 mol kg^{-1}. (1.23×10^{-4} M - A lot more!)