

Introduction to Ionic Strength

In order to quantify the effect of inter ionic interactions such as molecular attraction and repelling, one has to have a parameter that describes the size of these forces and what they mean to the properties of the solution in question.

The ionic strength (I) of a solution is calculated as follows:

$$I = \sum_{i=1}^n [i] \cdot z_i^2$$

In this equation 'n' is the number of ion in the solution and 'i' is each specific ion in the solution.

The equation states that the ionic strength is calculated as the squared sum of the valence and concentration of each individual ion in the solution.

The concentration is usually the molar concentration (mol/L) but the most accurate is actually the molal concentration (mol/kg). However, in most cases and for practical reasons, molarity is used.

The reason for using molalities (mol/kg), if that is the case, is that molalities do not change with temperature and as the density of water changes.

How Ionic Strength is used

Ionic strength is used to correct equations used in e.g. pH calculations and to get more accurate estimates of concentrations of ions and compounds in equilibriums.

It all stems from the fact that concentrations and activities are not the same. The relationship between the concentration and activity of e.g. the hydrogen ion (H^+) is

$$f_{H^+} \cdot [H^+] = \{H^+\}$$

In this equation f_{H^+} is the individual activity of the H^+ ion and $[H^+]$ the concentration of the hydrogen ion and $\{H^+\}$ the activity of H^+ .

The calculation of f_{H^+} is relatively straightforward. There is however a problem. It is not entirely clear which formula should be used for the calculation of f_{H^+} is solutions that are far from ideal. So if you are working with wastewater or a typical biological system you will have some trouble finding which equation to use and how to argue that you've picked the right equation for the calculation.

For this example I'll assume that the Güntelberg equation for calculating individual ion activities can be used to describe the relationship between $[H^+]$ and $\{H^+\}$.

The Güntelberg equation states that:

$$\log_{10}(f) = -0.51 \cdot z^2 \cdot \frac{\sqrt{I}}{1 + \sqrt{I}}$$

Lets in this example consider a 0.1 M solution of $MgSO_4$ with a pH of 7. We start by writing down the concentration of ions in that solution:

Ion	mol/L
Mg^{2+}	0.1 M
SO_4^{2+}	0.1 M
H^+	10^{-7} M

The ionic strength in the solution is then: $\frac{1}{2} \cdot (0.1 \cdot 2^2 + 0.1 \cdot 2^2 + 10^{-7} \cdot 1^2) \approx 0.40$. The concentration of $[H^+]$ can often be discarded in such calculations.

If 0.40 is entered into the Güntelberg equation and the necessary rearrangements are done, f_{H^+} is calculated to approx 0.634.

This value is used to calculate $\{H^+\}$ from $[H^+]$. This yields that $[H^+] = \frac{10^{-7}}{0.634}$ or $10^{-6.80}$.

Still the pH value is 7 as $\{H^+\}$ is 10^{-7} . However, if the concentration of some compound in a equilibrium is calculated a value of $[H^+]$ of $10^{-6.80}$ should be used.

Another disclaimer

Here's another: Ionization constants used in equilibrium calculations are also dependant on ionic strength and should be recalculated as well.

Read more about this and discuss it at www.phscale.net.

Nielsen, June 2007