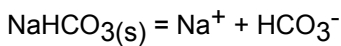




OLI Tips #39 What is a Scaling Tendency?

A scaling tendency is the ratio of the real-solution solubility product to the thermodynamic limit based on the thermodynamic equilibrium constant.

For Example, Consider this dissolution



The Ion Activity Product (IAP) is defined as the product of specific ions (in this case the ions resulting from the dissociation of a particular solid).

Let's consider a 1.0 molal NaHCO₃ solution:

$$\text{IAP} = \gamma_{\text{Na}} m_{\text{Na}} \gamma_{\text{HCO}_3} m_{\text{HCO}_3}$$

Assuming Ideal Solution Activities

$$\gamma_{\text{Na}} = 1.0 \qquad \gamma_{\text{HCO}_3} = 1.0$$

$$m_{\text{Na}} = 1.0 \qquad m_{\text{HCO}_3} = 1.0$$

$$\text{IAP} = (1.0)(1.0)(1.0)(1.0)$$

$$\text{IAP} = 1.0$$

The Solubility Product (K_{SP}) is the thermodynamic limit of ion availability

$$\text{K}_{\text{sp}} = \gamma_{\text{Na}} m_{\text{Na}} \gamma_{\text{HCO}_3} m_{\text{HCO}_3}$$

$$\text{K}_{\text{SP}} = 0.403780$$

The Scaling Tendency is then the ratio of available ions to the thermodynamic limit.

$$\text{ST} = \text{IAP}/\text{K}_{\text{SP}}$$

$$\text{ST} = 1.0/0.403780$$

$$\text{ST} = 2.48$$

Was assuming ideal conditions valid??

The actual species concentration and activity coefficients are:

$$\begin{array}{lcl} \gamma_{\text{Na}} & = & 0.598 \\ m_{\text{Na}} & = & 0.894 \end{array} \qquad \begin{array}{lcl} \gamma_{\text{HCO}_3} & = & 0.596 \\ m_{\text{HCO}_3} & = & 0.866 \end{array}$$

This results in a different IAP

$$\begin{aligned} \text{IAP} &= (0.598)(0.894)(0.596)(0.866) \\ \text{IAP} &= 0.276 \end{aligned}$$

The new Scaling Tendency is therefore:

$$\begin{aligned} \text{ST} &= \text{IAP}/K_{\text{sp}} \\ \text{ST} &= 0.276/0.40378 \\ \text{ST} &= 0.683 \end{aligned}$$

Why are the concentrations not equal to 1.0? Speciation and chemical equilibria tend to form complexes which provide a "Sink" for carbonate species. In this example:

$$\begin{array}{lcl} \text{CO}_2^0 & = & 0.016 \text{ molal} \\ \text{NaHCO}_3^0 & = & 0.101 \text{ molal} \\ \text{CO}_3^{2-} & = & 0.012 \text{ molal} \\ \text{NaCO}_3^- & = & 0.004 \text{ molal} \end{array}$$

What does the Scaling Tendency Mean?

If $\text{ST} < 1$, then the solid is under-saturated
If $\text{ST} > 1$, then the solid is super-saturated
If $\text{ST} = 1$, then the solid is at saturation
Scaling Index = $\text{Log}(\text{ST})$