

**Exercise 9: Equilibrium**

1. An ionic substance dissolving into its component ions in water can be written as a chemical equation.

a. Consider the dissolution of calcium hydroxide. Complete and balance the chemical equation describing this **dissolution**, and don't forget to indicate charges on ionic species:



b. Write the **equilibrium constant expression** of the equation in part a. Hint: is a pure substance supposed to be included in the expression?

c. For dissolved ionic substances,  $K_{\text{eq}}$  is written as  $K_{\text{sp}}$  and is read "the solubility product constant", but means exactly the same thing as an equilibrium constant. In any table of  $K_{\text{sp}}$ 's, the value of  $K_{\text{sp}}$  at 25°C for calcium hydroxide is  $1.3 \times 10^{-6}$ . For a 1.0 M solution of calcium hydroxide at 25°C, and given the equilibrium expression in part b, determine the concentration of the **calcium** ion and the **hydroxide** ion at equilibrium of this solution. Hint: these two numbers will not be the same!

d. Suppose sodium hydroxide solution were poured into the calcium hydroxide solution. The sodium hydroxide solution, of course, contains a lot of hydroxide ions. According to **LeChatelier's Principle**, what macroscopic changes would be visible in the mixture? In other words, what happens?

2. a. Write the chemical equation that shows the **dissociation** of acetic acid ( $\text{HC}_2\text{H}_3\text{O}_2$ ) into hydrogen and acetate ions. Don't forget to indicate species charges, as appropriate, and make sure the equation is balanced.

b. Write the **equilibrium constant expression** for the dissociation of acetic acid.

c. For acids,  $K_{\text{eq}}$  is written as  $K_{\text{a}}$  and is read "the acid dissociation constant", but means exactly the same thing as an equilibrium constant. In any table listing  $K_{\text{a}}$ 's, the value of  $K_{\text{a}}$  at  $25^\circ\text{C}$  for acetic acid is  $1.8 \times 10^{-5}$ . For a 1.0 M solution of acetic acid at  $25^\circ\text{C}$ , and the equilibrium expression in part b, determine the **concentration of the hydrogen ion** at equilibrium of this solution. Hint: there is a significant amount of algebra, including the use of the **quadratic formula**.