

## Solubility and Complexation Equilibria

Oxalic acid,  $\text{H}_2\text{C}_2\text{O}_4$ , is a diprotic weak acid ( $\text{pK}_{\text{a}1} = 1.252$ ,  $\text{pK}_{\text{a}2} = 4.266$ ) found in the leaves of the rhubarb plant. Although the stalks of rhubarb are edible, the leaves are quite toxic. For many years this toxicity was believed to be due to oxalic acid's acidity. More recent work, however, suggests that its toxicity is due to its ability to form the insoluble calcium salt,  $\text{CaC}_2\text{O}_4$  ( $K_{\text{sp}} = 1.3 \times 10^{-8}$ ), which crystallizes in the renal tubes, leading to kidney failure. The pH of urine is around 5, but calculating the solubility of  $\text{CaC}_2\text{O}_4$  at this pH is not possible for us because at this pH oxalate is present as both  $\text{HC}_2\text{O}_4^-$  and  $\text{C}_2\text{O}_4^{2-}$ . Instead, establish some limits for the solubility of  $\text{CaC}_2\text{O}_4$  by calculating its molar solubility at buffered pH levels of 7.00 and 3.00.

For a pH of 7.00, what reaction governs the solubility of  $\text{CaC}_2\text{O}_4$ , what is the equilibrium constant for this reaction and what is the solubility of  $\text{CaC}_2\text{O}_4$ ?

For a pH of 3.00, what reaction governs the solubility of  $\text{CaC}_2\text{O}_4$ , what is the equilibrium constant for this reaction and what is the solubility of  $\text{CaC}_2\text{O}_4$ ?

One possible treatment for oxalic acid poisoning is to give the patient an oral dose of EDTA, which we abbreviate as  $Y^{4-}$ . Because EDTA forms a strong complex with  $Ca^{2+}$  ( $K_1 = 4.90 \times 10^{10}$ ) it may be capable of dissolving  $CaC_2O_4$  crystals. As a test of the efficacy of this method, 1.00 g of  $CaC_2O_4$  is placed in a beaker with exactly 100 mL of 0.050 M  $Y^{4-}$ . What percentage of the  $CaC_2O_4$  dissolves and what is the equilibrium concentration of  $CaY^{2-}$ ? You may assume that the pH is greater than 7 where the only important form of oxalic acid is  $C_2O_4^{2-}$ .