

## Buffers and pH

1. What is the pH of a buffer that is 0.55 M in formic acid, HCOOH, and 0.63 M in sodium formate, NaHCOO?

The  $K_a$  for formic acid is  $1.8 \times 10^{-4}$ , which corresponds to a  $pK_a$  of 3.75. Using the H-H equation, the pH of the solution is

$$\text{pH} = pK_a + \log \frac{[\text{HCOO}^-]}{[\text{HCOOH}]} = 3.75 + \log \frac{0.63}{0.55} = 3.81$$

2. What is the ratio of hypobromite,  $\text{BrO}^-$ , to hypobromous acid,  $\text{HBrO}$ , in a buffer with a pH of 7.88?

The  $K_a$  for hypobromous acid is  $2.4 \times 10^{-9}$ , which corresponds to a  $pK_a$  of 8.62. Using the H-H equation, we have

$$\text{pH} = pK_a + \log \frac{[\text{OBr}^-]}{[\text{HOBr}]} = 8.62 + \log \frac{[\text{OBr}^-]}{[\text{HOBr}]} = 7.88$$

Solving for the ratio of conjugate weak base-to-conjugate weak acid gives

$$-0.74 = \log \frac{[\text{OBr}^-]}{[\text{HOBr}]} \quad \text{or} \quad \frac{[\text{OBr}^-]}{[\text{HOBr}]} = 0.18$$

3. Human blood contains two buffer systems, one based on phosphate species and one on carbonate species. If blood has a normal pH of 7.4, what are the principle phosphate and carbonate species present? What is the ratio between the two phosphate species? At the temperature of human blood, the  $K_a$  values for phosphoric acid are  $1.3 \times 10^{-2}$ ,  $2.3 \times 10^{-7}$ , and  $6 \times 10^{-12}$ , respectively. The  $K_a$  values for carbonic acid are  $8 \times 10^{-7}$  and  $1.6 \times 10^{-10}$ , respectively.

At the temperature of human blood, the  $pK_a$  values for phosphate are 1.89, 6.64 and 11.22 and the  $pK_a$  values for carbonic acid are 6.10 and 9.80. A pH of 7.40 falls within  $\pm 1$  pH unit of phosphate's  $pK_{a2}$  of 6.63; thus, we expect there to be significant amounts of both  $\text{H}_2\text{PO}_4^-$  and  $\text{HPO}_4^{2-}$ . The relative abundance of these two species is given from the H-H equation; thus

$$7.4 = 6.64 + \log \frac{[\text{HPO}_4^{2-}]}{[\text{H}_2\text{PO}_4^-]} \quad \text{or} \quad \frac{[\text{HPO}_4^{2-}]}{[\text{H}_2\text{PO}_4^-]} = 5.8$$

A pH of 7.40 falls more than 1 pH unit above carbonic acid's  $pK_a$  of 6.10 and more than 1 pH unit below its  $pK_a$  of 9.80; thus, the only important form of carbonic acid is  $\text{HCO}_3^-$ .