

# Key for Buffers and pH

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. The pH of the solution is

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

What is the ratio of hypobromite,  $\text{BrO}^-$ , to hypobromous acid, 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. The pH of the solution is

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

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

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

$$\frac{[\text{OBr}^-]}{[\text{HOBr}]} = 0.18$$

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  $1.3 \times 10^{-2}$ ,  $2.3 \times 10^{-7}$ ,  $6 \times 10^{-12}$ , respectively. The  $K_a$  values for carbonic acid are  $8 \times 10^{-7}$  and  $1.6 \times 10^{-10}$ .

At the temperature of human blood, the  $pK_a$  values for the phosphate species are 1.89, 6.64, and 11.22, and the  $pK_a$  values for the carbonic acid species are 6.10 and 9.80. A pH of 7.40 falls within  $\pm 1$  pH unit of phosphate's  $pK_{a2}$  of 6.64; thus, we expect that there are significant amounts of both  $\text{H}_2\text{PO}_4^-$  and  $\text{HPO}_4^{2-}$  present, and that there is little  $\text{H}_3\text{PO}_4$  or  $\text{PO}_4^{3-}$  present. The relative abundance of these two species is

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

$$\frac{[\text{HPO}_4^{2-}]}{[\text{H}_2\text{PO}_4^-]} = 5.8$$

A pH of 7.40 is more than 1 pH unit above carbonic acid's  $pK_{a1}$  of 6.10 and more than 1 pH unit below its  $pK_{a2}$  of 9.80; thus, the only important form of carbonic acid is  $\text{HCO}_3^-$ .