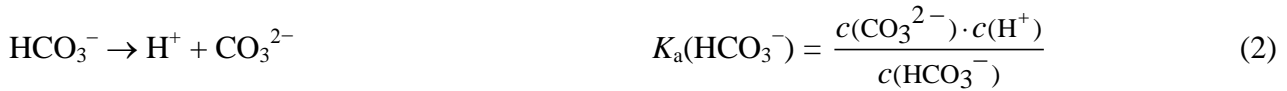
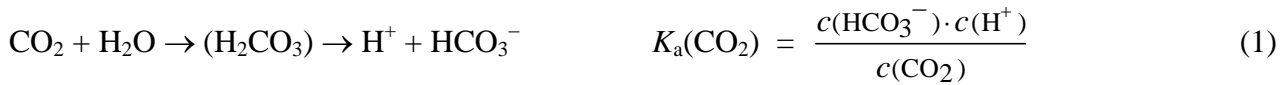


Problem 8-09 Charge numbers

Find the equilibrium concentration ratio $c(\text{CO}_2) : c(\text{HCO}_3^-) : c(\text{CO}_3^{2-})$ in blood ($\text{pH} = 7.4$)? The acidity constants are: $\text{p}K_a(\text{CO}_2) = 6.37$ (including H_2CO_3), $\text{p}K_a(\text{HCO}_3^-) = 10.25$.

$$[c(\text{CO}_2) : c(\text{HCO}_3^-) : c(\text{CO}_3^{2-}) = 0.0933 : 1 : 0.00141]$$

Solution:



$$\text{from Eq. (1) : } c(\text{HCO}_3^-) = c(\text{CO}_2) \cdot \frac{K_a(\text{CO}_2)}{c(\text{H}^+)}$$

$$\text{from Eq. (2) : } c(\text{CO}_3^{2-}) = \frac{K_a(\text{HCO}_3^-)}{c(\text{H}^+)} \cdot c(\text{HCO}_3^-) = \frac{K_a(\text{HCO}_3^-)}{c(\text{H}^+)} \cdot c(\text{CO}_2) \cdot \frac{K_a(\text{CO}_2)}{c(\text{H}^+)}$$

$$\begin{aligned} c(\text{CO}_2) : c(\text{HCO}_3^-) : c(\text{CO}_3^{2-}) &= c(\text{CO}_2) : \left[c(\text{CO}_2) \cdot \frac{K_a(\text{CO}_2)}{c(\text{H}^+)} \right] : \left[c(\text{CO}_2) \cdot \frac{K_a(\text{HCO}_3^-) \cdot K_a(\text{CO}_2)}{c(\text{H}^+)^2} \right] \\ &= c(\text{CO}_2) : \left[c(\text{CO}_2) \cdot \frac{10^{-6.37}}{10^{-7.4}} \right] : \left[c(\text{CO}_2) \cdot \frac{10^{-10.25} \cdot 10^{-6.37}}{(10^{-7.4})^2} \right] \end{aligned}$$

$$c(\text{CO}_2) : c(\text{HCO}_3^-) : c(\text{CO}_3^{2-}) = 1 : 10.715 : 0.0151 = 0.0933 : 1 : 0.00141$$