

Problem 8-15 Buffers

System dihydrogen phosphate (H_2PO_4^-)/hydrogen phosphate (HPO_4^{2-}) represents a classical buffer significantly involved in keeping the intracellular value of pH. For the equilibrium constant of the reaction



applies $\text{p}K = 7.2$ (standard state of infinite dilution, $c^{\text{st}} = 1 \text{ mol dm}^{-3}$). pH inside the cell is 7.4 and the total concentration of phosphate 0.02 mol dm^{-3} . What are the concentrations of single components of this buffer? Instead of the activities you can use the relative concentrations.

$$[[\text{HPO}_4^{2-}] = 7.737 \text{ mmol dm}^{-3} ; [\text{H}_2\text{PO}_4^-] = 12.263 \text{ mmol dm}^{-3}]$$

Solution:

Designation:

Symbols in square brackets \equiv Relative concentrations, which are approximately equal to activities

$$[\text{A}] \equiv c_{\text{A}}/c^{\text{st}} \cong a_{\text{A}}$$

$$\text{p}K = 7.2 \quad , \quad K = 10^{-7.2}$$

$$K = \frac{[\text{H}_2\text{PO}_4^-] \cdot [\text{H}^+]}{[\text{HPO}_4^{2-}]} \Rightarrow \frac{[\text{H}_2\text{PO}_4^-]}{[\text{HPO}_4^{2-}]} = \frac{K}{[\text{H}^+]} = \frac{10^{-7.2}}{10^{-7.4}} = 1.585$$

Total concentration of phosphates:

$$[\text{H}_2\text{PO}_4^-] + [\text{HPO}_4^{2-}] = 0.02 \text{ mol dm}^{-3}$$

$$1.585 \cdot [\text{HPO}_4^{2-}] + [\text{HPO}_4^{2-}] = 0.02 \quad \Rightarrow \quad [\text{HPO}_4^{2-}] = 7.737 \cdot 10^{-3}$$

$$[\text{H}_2\text{PO}_4^-] = 1.585 \cdot 7.737 \cdot 10^{-3} = 12.263 \cdot 10^{-3}$$

$$[\text{HPO}_4^{2-}] = 7.737 \text{ mmol dm}^{-3}$$

$$[\text{H}_2\text{PO}_4^-] = 12.263 \text{ mmol dm}^{-3}$$