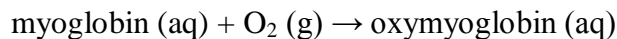


Problem 6-05 Equilibrium in liquid and gaseous phases

Standard Gibbs energy of the reaction



at the temperature of 25 °C is $\Delta_r G_m^\ominus = -30 \text{ kJ mol}^{-1}$ standard state infinite dilution at given temperature and pressure, $c^{\text{st}} = 1 \text{ mol dm}^{-3}$). Henry constant of oxygen solution in water at the same conditions has the value $K_H = 769 \text{ bar (mol kg}^{-1})^{-1}$. What amount of myoglobin (%) will be present in equilibrium in the form of oxymyoglobin at the pressure of 1 bar? Take that the air contains 21 vol. % of oxygen.

[98 % myoglobin is in the form of oxymyoglobin]

Solution:

Concentration of oxygen dissolved in water – from Henry law $p_{\text{O}_2} = \underline{m}_{\text{O}_2} \cdot K_H$

Partial pressure of oxygen above the liquid is

$p_{\text{O}_2} = y_{\text{O}_2} \cdot p$, where $y_{\text{O}_2} = 0.21$ (in air), $p = 1 \text{ bar} (= 100 \text{ kPa})$

$$\underline{m}_{\text{O}_2} \cong \frac{y_{\text{O}_2} \cdot p}{K_H} = \frac{0.21 \cdot 1}{769} = 0.000273 \text{ mol kg}^{-1}$$

$$\underline{m}_{\text{O}_2} \cong c_{\text{O}_2} = 0.000273 \text{ mol dm}^{-3}$$

$$K = \exp \left(-\frac{\Delta_r G^\ominus}{RT} \right) = \exp \left(-\frac{(-30 \cdot 10^3)}{8.314 \cdot 298.15} \right) = 180328.786$$

$$K = \frac{\frac{c_{\text{oxymyoglobin}}}{c^{\text{st}}}}{\frac{c_{\text{myoglobin}}}{c^{\text{st}}} \cdot \frac{c_{\text{O}_2}}{c^{\text{st}}}} = \frac{x}{[(c_{\text{myoglobin}})_0 - x] \cdot c_{\text{O}_2}}, \quad c^{\text{st}} = 1 \text{ mol dm}^{-3}$$

where $c_{\text{myoglobin}} = (c_{\text{myoglobin}})_0 - x$
 $c_{\text{oxymyoglobin}} = x$

$$\frac{c_{\text{oxymyoglobin}}}{c_{\text{myoglobin}}} = \frac{x}{(c_{\text{myoglobin}})_0 - x} = K \cdot c_{\text{O}_2} = 180328.786 \cdot 0.000273 = 49.23$$

$$\frac{x}{(c_{\text{myoglobin}})_0} = 0.98$$

98 % of myoglobin is in the form of oxymyoglobin