

20 Minute Review Quizlet—Answers

1. Calculate the activity of 0.100 m $\text{Ti}(\text{NO}_3)_2$. The result should be expressed in terms of γ_{\pm} . (Don't bother to find γ_{\pm} explicitly).

Answer: Note that $m_+ = m_{\text{Ti}^{2+}} = m$ and $m_- = m_{\text{NO}_3^-} = 2m$. The overall activity is then:

$$a(\text{Ti}(\text{NO}_3)_2) = a_{\text{Ti}^{2+}} (a_{\text{NO}_3^-})^2 = \gamma_{\pm}^3 \left(\frac{m_+}{m^\circ}\right) \left(\frac{m_-}{m^\circ}\right)^2 = \gamma_{\pm}^3 \left(\frac{m}{m^\circ}\right) \left(\frac{2m}{m^\circ}\right)^2 = 4 \gamma_{\pm}^3 (m/m^\circ)^3$$

2. Calculate the solubility of PbCl_2 . The $K_{\text{sp}} = 1.7 \times 10^{-5}$. Use the Debye-Hückel equation to calculate the mean ionic activity coefficient.

Answer: Note that $m_+ = m_{\text{Pb}^{2+}} = m_s$ and $m_- = m_{\text{Cl}^-} = 2m_s$. The K_{sp} expression is then:

$$K_{\text{sp}} = a_{\text{Pb}^{2+}} (a_{\text{Cl}^-})^2 = \gamma_{\pm}^3 \left(\frac{m_+}{m^\circ}\right) \left(\frac{m_-}{m^\circ}\right)^2 = \gamma_{\pm}^3 \left(\frac{m_s}{m^\circ}\right) \left(\frac{2m_s}{m^\circ}\right)^2 = 4 \gamma_{\pm}^3 (m_s/m^\circ)^3$$

Neglecting activity coefficients gives $m_s = (K_{\text{sp}}/4)^{1/3} = 0.01620$ m. The ionic strength is then approximately:

$$I = \frac{1}{2} (z_+^2 m_+/m^\circ + z_-^2 m_-/m^\circ) = \frac{1}{2} ((2)^2 (0.01620 \text{ m}) + (-1)^2 2 (0.01620 \text{ m}))/m^\circ = 0.04860$$

Using the Debye-Hückel approximation leads to:

$$\log \gamma_{\pm} = -0.509 |z_+ z_-| I^{1/2} = -0.509 |(2)(-1)| (0.04860)^{1/2} = 0.2244 \quad \text{and} \quad \gamma_{\pm} = 0.5965$$

Solving for the solubility gives:

$$m_s = (1.7 \times 10^{-5} / 4 / (0.5965)^3)^{1/3} m^\circ = 0.02716 \text{ m} = 0.027 \text{ m}$$

for a 40% difference over the value neglecting activity coefficients. Since the K_{sp} is only known to two significant figures, this final result is fine. If the K_{sp} were known more accurately then the new solubility should be used to recalculate the ionic strength in a second iteration.

3. The pure vapor pressure of substance A is 28.2 torr. For A, the mole fraction for A in the vapor above a solution is 0.0432 with the mole fraction of the solution of 0.672. Calculate the activity coefficient for A in this solution. The total vapor pressure is 760.0 torr.

Answer: The activity of A is given as: $a_A = P_A/P_A^*$, where P_A^* is the vapor pressure of pure A and then $a_A = \gamma_A X_A$. The partial pressure of A in the vapor phase is given by Dalton's Law of partial pressures: $P_A = Y_A P$, where Y_A is the mole fraction in the vapor phase and P is the total pressure:

$$a_A = Y_A P / P_A^* = 0.0432 (760.0 \text{ torr}) / 28.2 \text{ torr} = 1.164$$

$$\gamma_A = a_A / X_A = 1.164 / 0.672 = 1.732 = 1.73$$

showing strong positive deviations from ideality.