

Chemistry 146 Lecture Problems

Sodium Nitrite Equilibrium

Calculate the H₃O, OH, acid, base pH and pOH when 1.00 g sodium nitrite is added to 250 mL water.

$$M := \text{mole} \cdot \text{liter}^{-1} \quad K_w := 1.0 \cdot 10^{-14} \cdot \text{M}^2 \quad K_a := 4.5 \cdot 10^{-4} \cdot \text{M} \quad i := 0, 1, \dots, 1$$

$$K_b := \frac{K_w}{K_a} \quad K_b = 2.222 \cdot 10^{-11} \cdot \text{M}$$

The concentration of the salt is):

$$\text{mass}_{\text{salt}} := 1.00 \cdot \text{gm}$$

$$\text{MW}_{\text{salt}} := ((22.990) + (14.007)) + (2 \cdot 15.999) \cdot \text{gm} \cdot \text{mole}^{-1}$$

$$\text{mole}_{\text{salt}} := \frac{\text{mass}_{\text{salt}}}{\text{MW}_{\text{salt}}} \quad \text{mole}_{\text{salt}} = 0.014 \text{ mol}$$

$$\text{volume}_{\text{salt}} := 250 \cdot \text{mL}$$

$$C_{\text{salt}} := \frac{\text{mole}_{\text{salt}}}{\text{volume}_{\text{salt}}} \quad C_{\text{salt}} = 0.058 \cdot \text{M}$$

The equilibrium solution for	A ⁻	+	H ₂ O	<->	OH ⁻	+	HA
Initial Concentraion	C _{salt}						
Equilibrium Concentration	C _{salt} - X				X		X

Equilibrium expression:

$$K_b = \frac{X^2}{C_{\text{salt}} - X}$$

Assuming X is smaller than [acid], this reduces to:

$$K_b = \frac{X^2}{C_{\text{salt}}}$$

Solving for X:

$$X := \sqrt{K_b \cdot C_{\text{salt}}}$$

$$X = 1.135 \cdot 10^{-6} \cdot \text{M}$$

Equilibrium Concentrations:

$$\begin{array}{ll}
 C_{\text{HA}} := X & C_{\text{HA}} = 1.135 \cdot 10^{-6} \cdot \text{M} \\
 C_{\text{OH}} := X & C_{\text{OH}} = 1.135 \cdot 10^{-6} \cdot \text{M} \\
 C_{\text{A}} := C_{\text{salt}} - X & C_{\text{A}} = 0.058 \cdot \text{M} \\
 \text{pOH} := -\log(C_{\text{OH}} \cdot \text{M}^{-1}) & \text{pOH} = 5.945 \\
 \text{pH} := 14 - \text{pOH} & \text{pH} = 8.055
 \end{array}$$

Solving for X without assumptions:

$$K_{\text{b}} = \frac{X^2}{C_{\text{salt}} - X}$$

$$X := \left[\begin{array}{l} \frac{-1}{2} \cdot K_{\text{b}} + \frac{1}{2} \cdot \sqrt{K_{\text{b}}^2 + 4 \cdot K_{\text{b}} \cdot C_{\text{salt}}} \\ \frac{-1}{2} \cdot K_{\text{b}} - \frac{1}{2} \cdot \sqrt{K_{\text{b}}^2 + 4 \cdot K_{\text{b}} \cdot C_{\text{salt}}} \end{array} \right]$$

$$X = \left[\begin{array}{l} 1.135 \cdot 10^{-6} \\ -1.1351 \cdot 10^{-6} \end{array} \right] \cdot \text{M}$$

Equilibrium Concentrations (Calculated for both roots, select the reasonable answer [top or bottom in ()]):

$$\begin{array}{ll}
 C_{\text{HA}} := X & C_{\text{HA}} = \left[\begin{array}{l} 1.135 \cdot 10^{-6} \\ -1.135 \cdot 10^{-6} \end{array} \right] \cdot \text{M} \\
 C_{\text{OH}} := X & C_{\text{OH}} = \left[\begin{array}{l} 1.135 \cdot 10^{-6} \\ -1.135 \cdot 10^{-6} \end{array} \right] \cdot \text{M} \\
 C_{\text{A}} := C_{\text{salt}} - X & C_{\text{A}} = \left[\begin{array}{l} 0.058 \\ 0.058 \end{array} \right] \cdot \text{M} \\
 \text{pOH}_i := -\log(C_{\text{OH}_i} \cdot \text{M}^{-1}) & \text{pOH} = \left[\begin{array}{l} 5.945 \\ 5.945 - 1.364i \end{array} \right] \\
 \text{pH} := 14 - \text{pOH} & \text{pH} = \left[\begin{array}{l} 8.055 \\ 8.055 + 1.364i \end{array} \right]
 \end{array}$$