

# Chemistry 146 Lecture Problems

## Acetic Acid Equilibrium

Calculate the H<sub>3</sub>O<sup>+</sup>, OH<sup>-</sup>, acid, base pH and pOH when 1.00 g acetic acid added to 250 mL water

$$M := \text{mole} \cdot \text{liter}^{-1}$$

$$K_a := 1.8 \cdot 10^{-5} \cdot M$$

$$K_w := 1.0 \cdot 10^{-14} \cdot M^2$$

The concentration of the acid is

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

$$\text{MW}_{\text{acid}} := ((2 \cdot 12.001) + (4 \cdot 1.0079) + (2 \cdot 15.999)) \cdot \text{gm} \cdot \text{mole}^{-1}$$

$$\text{mole}_{\text{acid}} := \frac{\text{mass}_{\text{acid}}}{\text{MW}_{\text{acid}}}$$

$$\text{MW}_{\text{acid}} = 60.032 \frac{1}{\text{mol}} \text{gm}$$

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

$$C_{\text{acid}} := \frac{\text{mole}_{\text{acid}}}{\text{volume}_{\text{acid}}}$$

$$C_{\text{acid}} = 0.067 \text{M}$$

The equilibrium solution for	HA	+	H <sub>2</sub> O	<->	H <sub>3</sub> O <sup>+</sup>	+	A <sup>-</sup>
Initial Concentraion	C <sub>acid</sub>						
Equilibrium Concentration	C <sub>acid</sub> - X				X		X

Equilibrium expression:

$$K_a = \frac{X^2}{C_{\text{acid}} - X}$$

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

$$K_a = \frac{X^2}{C_{\text{acid}}}$$

Solving for X:

$$X := \sqrt{K_a \cdot C_{\text{acid}}}$$

$$X = 1.0952 \cdot 10^{-3} \text{M}$$

Equilibrium Concentrations:

$$C_{HA} := C_{acid} - X$$

$$C_{HA} = 0.066 \text{ M}$$

$$C_{H3O} := X$$

$$C_{H3O} = 1.095 \cdot 10^{-3} \text{ M}$$

$$C_A := X$$

$$C_A = 1.095 \cdot 10^{-3} \text{ M}$$

$$pH := -\log(C_{H3O} \cdot M^{-1})$$

$$pH = 2.961$$

$$pOH := 14 - pH$$

$$pOH = 11.039$$

Solving for X without assumptions:

$$K_a = \frac{X^2}{C_{acid} - X}$$

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

$$X = \left[ \begin{array}{l} 1.0862 \cdot 10^{-3} \\ -1.1042 \cdot 10^{-3} \end{array} \right] \text{ M}$$

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

$$C_{HA} := C_{acid} - X$$

$$C_{HA} = \left[ \begin{array}{l} 0.066 \\ 0.068 \end{array} \right] \text{ M}$$

$$C_{H3O} := X$$

$$C_{H3O} = \left[ \begin{array}{l} 1.086 \cdot 10^{-3} \\ -1.104 \cdot 10^{-3} \end{array} \right] \text{ M}$$

$$C_A := X$$

$$C_A = \left[ \begin{array}{l} 1.086 \cdot 10^{-3} \\ -1.104 \cdot 10^{-3} \end{array} \right] \text{ M}$$

$$i := 0, 1.. 1$$

$$pH_i := -\log(C_{H3O}_i \cdot M^{-1})$$

$$pH = \left[ \begin{array}{l} 2.964 \\ 2.957 - 1.364i \end{array} \right]$$

$$pOH := 14 - pH$$

$$pOH = \left[ \begin{array}{l} 11.036 \\ 11.043 + 1.364i \end{array} \right]$$