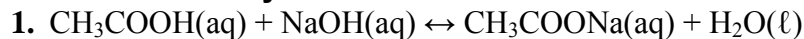# Investigation 17.A: Determining K_a for Ethanoic Acid Answer Key

Answer to Prediction Question

You know that ethanoic acid is a weak acid. Your prediction for the value of K_a should indicate this, and you should predict a small percent ionization.

Answers to Analysis Questions

1. $CH_3COOH(aq) + NaOH(aq) \leftrightarrow CH_3COONa(aq) + H_2O(\ell)$

2. The molar concentration of the ethanoic acid is given by:

$$\frac{\text{Volume NaOH(aq)} \times \text{Concentration NaOH(aq) mol/L}}{\text{Volume } CH_3COOH(aq)}$$

3. $[H_3O^+(aq)] = 10^{-pH}$. Measurements of the pH should be in the range 2.4 to 2.5. Therefore, the $[H_3O^+(aq)]$ should be between 4.0×10^{-3} and 3.0×10^{-3} mol/L.

4. $K_a = \dfrac{[H_3O^+(aq)][CH_3COO^-(aq)]}{[CH_3COOH(aq)]}$

5. Using a pH reading of 2.42, a typical ICE table for this experiment is:

	CH₃COOH(aq) + H₂O(ℓ) ↔ CH₃COO⁻(aq) + H₃O⁺(aq)			
	[CH₃COOH(aq)] (mol/L)	[H₂O(ℓ)] (mol/L)	[CH₃COO⁻(aq)] (mol/L)	[H₃O⁺(aq)] (mol/L)
Initial	0.80		0	~0
Change	-3.8×10^{-3}		$+3.8 \times 10^{-3}$	$+3.8 \times 10^{-3}$
Equilibrium	~0.80		3.8×10^{-3}	3.8×10^{-3}

$$K_a = \frac{[H_3O^+(aq)][CH_3COO^-(aq)]}{[CH_3COOH(aq)]} = \frac{(3.8 \times 10^{-3})(3.8 \times 10^{-3})}{0.80} = 1.8 \times 10^{-5}$$

$$\text{Percent ionization} = \frac{3.8 \times 10^{-3}}{0.80} \times 100 = 4.8\%$$

Answer to Conclusion Questions

6. $\text{Percent difference} = \dfrac{(\text{Measured } K_a - 1.8 \times 10^{-5})}{1.8 \times 10^{-5}} \times 100$

   Sources of error include error in the initial concentration of solution; measurement of the pH; measurement of the volume of base added to reach equivalence. Temperature might be mentioned, but the effect on the pH of the solution is negligible.

7. If there is an order of magnitude difference, you should look for a calculation error. Otherwise, you should identify whether the experimental value is larger or smaller than the accepted value. Then you should identify specific experimental errors that could account for the difference.

Answer to Application Question

8. The concentration of $H_3O^+(aq)$ should be much smaller than the concentration of $CH_3COOH(aq)$. Therefore, you should conclude that ethanoic acid is a weak acid.