Titrations

Acid-Base Titrations

Adding NaOH from the buret to acetic acid in the flask, a weak acid. In the beginning the pH increases very slowly.

Acid-Base Titrations

Additional NaOH is added. pH rises as equivalence point is approached.

Acid-Base Titrations

Additional NaOH is added. pH increases and then levels off as NaOH is added beyond the equivalence point.

Acid-Base Reactions

QUESTION: You titrate 100 mL of a 0.025 M solution of benzoic acid with 0.100 M NaOH to the equivalence point. What is the pH of the final solution?

Benzoic acid + NaOH

Equivalence point

pH of solution of benzoic acid, a weak acid

Acid-Base Reactions

Section 18.4

QUESTION: You titrate 100 mL of a 0.025 M solution of benzoic acid with 0.100 M NaOH to the equivalence point. What is the pH of the final solution?

\[ \text{HBz} + \text{NaOH} \rightarrow \text{Na}^+ + \text{Bz}^- + \text{H}_2\text{O} \]
Acid-Base Reactions

**Section 18.4**

The product of the titration of benzoic acid, the benzoate ion, Bz\(^-\), is the conjugate base of a weak acid.

Therefore, final solution is basic.

[Image of chemical structure: \( \text{Bz} + \text{H}_2\text{O} \rightarrow \text{Bz}^- + \text{H}_3\text{O}^+ \)]

**Equilibrium calculation**

\[
K_b = 1.6 \times 10^{-10}
\]

**Strategy** — find the conc. of the conjugate base Bz\(^-\) in the solution AFTER the titration, then calculate pH.

This is a two-step problem:

1. **Stoichiometry** of acid-base reaction
2. **Equilibrium calculation**

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**Acid-Base Reactions**

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**Stoichiometry Portion**

1. Calc. moles of NaOH req'd
   
   \( (0.100 \text{ L NaOH})(0.025 \text{ M}) = 0.0025 \text{ mol} \text{ NaOH} \)

   This requires **0.0025 mol NaOH**

2. Calc. volume of NaOH req'd

   \( 0.0025 \text{ mol} (1 \text{ L} / 0.100 \text{ mol}) = 0.025 \text{ L} \)

   **25 mL of NaOH req'd**

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**Acid-Base Reactions**

**Question:** You titrate 100. mL of a 0.025 M solution of benzoic acid with 0.100 M NaOH to the equivalence point. What is the pH of the final solution?

**Equivalence Point**

Most important species in solution is benzoate ion, Bz\(^-\), the weak conjugate base of benzoic acid, HBz.

\[
\text{Bz}^- + \text{H}_2\text{O} \rightarrow \text{Bz}^- + \text{H}_3\text{O}^+ \quad K_b = 1.6 \times 10^{-10}
\]

**Equivalence Point**

Initial concentrations:

- [Bz\(^-\)] = 0.020 M
- [HBz] = 0
- [OH\(^-\)] = 0

Change:

- \(-x\)
- \(+x\)
- \(+x\)

Equilibrium:

\[
\begin{align*}
\text{initial} & : 0.020 & 0 & 0 \\
\text{change} & : -x & +x & +x \\
\text{equilib} & : 0.020 - x & x & x
\end{align*}
\]

**Calc. volume of NaOH req'd**

\(0.0025 \text{ mol} (1 \text{ L} / 0.100 \text{ mol}) = 0.025 \text{ L} \)

\(25 \text{ mL of NaOH req'd} \)

**Calc. moles of NaOH req'd**

\( (0.100 \text{ L NaOH})(0.025 \text{ M}) = 0.0025 \text{ mol} \text{ NaOH} \)

**Calc. concentration of species**

\( x = [\text{OH}^-] = 1.8 \times 10^{-6} \)

\( \text{pOH} = 5.75 \quad \Rightarrow \quad \text{pH} = 8.25 \)
QUESTION: You titrate 100. mL of a 0.025 M solution of benzoic acid with 0.100 M NaOH to the equivalence point. What is the pH at half-way point?

Acid-Base Reactions

QUESTION: You titrate 100. mL of a 0.025 M solution of benzoic acid with 0.100 M NaOH. What is the pH at the half-way point?

\[ \text{HBz} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{Bz}^- \]

At the half-way point, \([\text{HBz}] = [\text{Bz}^-]\)

Therefore, \([\text{H}_3\text{O}^+] = K_a = 6.3 \times 10^{-5}\)

\[ \text{pH} = 4.20 \]