

Titration Curves

Weak Base-Strong Acid Titration Curves

- ◆ Before the addition.
- ◆ Construct an "equilibrium" reaction table ONLY!
- ◆ $K_b = \frac{[\text{OH}^-][\text{BH}^+]}{[\text{B}]}$ and obtain $[\text{OH}^-]$.
- ◆ Calculate the pOH, then the pH.

Additions before the equivalence point.

- ◆ Construct a "stoichiometry" reaction table.
- ◆ Determine MOLES of base in excess (not neutralized) and MOLES of conjugate acid formed.
- ◆ Divide MOLES by the TOTAL VOLUME to obtain $[\text{BH}^+]$ and $[\text{B}]$.
- ◆ Construct an "equilibrium" reaction table.
- ◆ $K_b = \frac{[\text{OH}^-][\text{BH}^+]}{[\text{B}]}$ and obtain $[\text{OH}^-]$.
- ◆ Calculate the pOH, then the pH.

Additions at the equivalence point

- ◆ Construct a "stoichiometry" reaction table.
- ◆ Determine MOLES of conjugate acid formed.
- ◆ Divide MOLES by the TOTAL VOLUME to obtain $[\text{BH}^+]$.
- ◆ Calculate K_a ($K_a \times K_b = K_w$).
- ◆ Construct an "equilibrium" reaction table, reacting the conjugate base with water.
- ◆ $K_a = \frac{[\text{A}^-][\text{H}_3\text{O}^+]}{[\text{HA}]}$ and obtain $[\text{H}_3\text{O}^+]$.
- ◆ Calculate the pH.

Additions beyond the equivalence point

- ◆ Construct a "stoichiometry" reaction table.
- ◆ Determine MOLES of acid in excess (not neutralized) and the MOLES of conjugate acid.
- ◆ Divide MOLES by the TOTAL VOLUME.
- ◆ Because $[\text{H}_3\text{O}^+]_{\text{excess}} \gg [\text{H}_3\text{O}^+]_{\text{conj. acid}}$, use $[\text{OH}^-]_{\text{excess}}$ to calculate the pH.

Problem

- ◆ 20.0 mL of 0.10 M triethylamine, $(\text{CH}_3\text{CH}_2)_3\text{N}$, ($K_b = 5.2 \times 10^{-4}$) are titrated with 0.100 M HCl. Calculate the pH after the additions of 0.0, 10.0, 15.0, 19.0, 19.5 mL, 19.95, 20.0, 20.05, and 25.0 mL samples of HCl.
- ◆ Then, construct a titration curve and label it properly.

0 mL $(\text{CH}_3\text{CH}_2)_3\text{N} + \text{H}_2\text{O} \rightleftharpoons (\text{CH}_3\text{CH}_2)_3\text{NH}^+ + \text{OH}^-$

0.1 M
 $K_b = \frac{[\text{Triethylamine}][\text{OH}^-]}{[\text{Triethylammonium}]}$
 $5.2 \times 10^{-4} = \frac{x^2}{0.1 - x}$
 $x = [\text{OH}^-] = 0.00228$
 $\text{pOH} = 2.64$
 $\text{pH} = 11.36$

10 mL $\frac{1}{2}$ eq point

$\text{TEA} + \text{H}^+ \rightarrow \text{TEAH}^+$
 20 mL (0.02 mol) 1 1
 $\text{pOH} = -\log(5.2 \times 10^{-4}) = 3.28$
 $\text{pH} = 10.72$

15 mL $\text{TEA} + \text{H}^+ \rightarrow \text{TEAH}^+$
 20 mL (0.02 mol) 1 1
 15 mL (0.015 mol) 0.5 mol 1.5 mol
 $\text{pOH} = -\log(5.2 \times 10^{-4}) + \log \frac{1.5}{0.5} = 3.76$
 $\text{pH} = 10.24$

19 mL $\text{TEA} + \text{H}^+ \rightarrow \text{TEAH}^+$
 20 mL (0.02 mol) 1 1
 19 mL (0.019 mol) 0.1 mol 1.9 mol
 $\text{pOH} = -\log(5.2 \times 10^{-4}) + \log \frac{1.9}{0.1} = 4.56$
 $\text{pH} = 9.44$

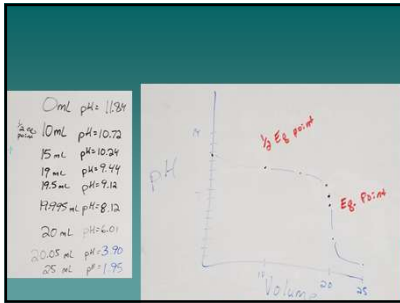
19.5 mL $\text{TEA} + \text{H}^+ \rightarrow \text{TEAH}^+$
 20 mL (0.02 mol) 1 1
 19.5 mL (0.0195 mol) 0.05 mol 1.95 mol
 $\text{pOH} = -\log(5.2 \times 10^{-4}) + \log \frac{1.95}{0.05} = 4.88$
 $\text{pH} = 9.12$

19.95 mL $\text{TEA} + \text{H}^+ \rightarrow \text{TEAH}^+$
 20 mL (0.02 mol) 1 1
 19.95 mL (0.01995 mol) 0.005 mol 1.995 mol
 $\text{pOH} = -\log(5.2 \times 10^{-4}) + \log \frac{1.995}{0.005} = 5.88$
 $\text{pH} = 8.12$

20 mL $\text{TEA} + \text{H}^+ \rightarrow \text{TEAH}^+$
 20 mL (0.02 mol) 1 1
 20 mL (0.02 mol) 0 2
 $K_a \times K_b = K_w$
 $K_a = 1.92 \times 10^{-10}$
 $\text{pH} = 4.28$

20.05 mL $\text{TEA} + \text{H}^+ \rightarrow \text{TEAH}^+$
 20 mL (0.02 mol) 1 1
 20.05 mL (0.02005 mol) 0.0005 mol 1.9995 mol
 $\text{pH} = 4.01$

25.0 mL $\text{TEA} + \text{H}^+ \rightarrow \text{TEAH}^+$
 20 mL (0.02 mol) 1 1
 25.0 mL (0.025 mol) 0 2.5
 $\text{pH} = 1.79$



Problem

- 50.0 mL of 0.10 M ammonia, NH_3 , ($K_b = 1.8 \times 10^{-5}$) are titrated with 0.10 M HNO_3 .
- Calculate the pH after the additions of 0.0, 10.0, 25.0, 49.0, 49.95, 50.0, 50.05, 51.0 and 75.0 mL samples of HNO_3 .
- Then, construct a titration curve and label it properly.

Answer

Volume	pH
0 mL	11.12
10 mL	9.85
25 mL	9.25
49 mL	7.56
49.95 mL	6.25
50 mL	5.28
50.05 mL	4.30
51 mL	3.00
75 mL	1.70

