

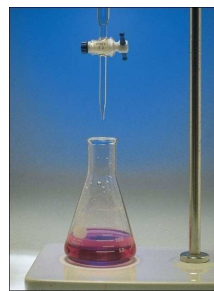
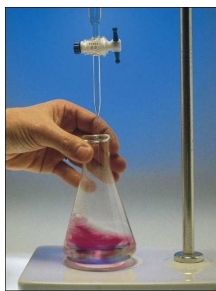
Titrations and Titration Curves

Plot of pH of solution vs. volume of titrant (acid or base) added. Shape of acid-base titration curve gives information on what is titrated.

Equivalence Point:

End Point:

Indicator:

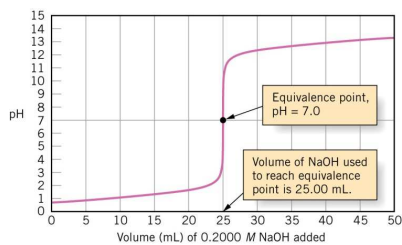


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Titration of Strong Acid with Strong Base

Example: 25.00 mL 0.2000 M HCl titrated with 0.2000 M NaOH.

Neutralization reaction:



Four Stages on curve:

Stage I (prior to addition of base):

Stage II (prior to equivalence point):

Stage III (at equivalence point):

Stage IV (after equivalence point):

In titration of strong acid by strong base, what type of salt is present at the equivalence point?

Strong Acid-Strong Base Example

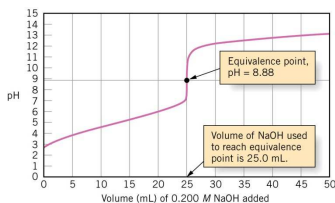
A 25 mL volume of 0.50 M HNO_3 is titrated with 0.25 M KOH. What volume of base is needed to reach the equivalence point? Calculate the pH of the solution after addition of the following volumes of base:

- a. 0.0 mL b. 25 mL c. 50 mL d. 60. mL

Titration of a Weak Acid with a Strong Base

Example: 25.0 mL 0.200 M $\text{HC}_2\text{H}_3\text{O}_2$ ($K_A = 1.8 \times 10^{-5}$) titrated with 0.200 M NaOH.

Neutralization reaction:



Four Stages on curve:

Stage I (prior to addition of base):

Stage II (prior to equivalence point):

Stage III (at equivalence point):

Stage IV (after equivalence point):

*In titration of weak acid by strong base, what type of salt is present at the equivalence point?
What is the pH half-way to the equivalence point in a titration of weak acid by strong base?*

Weak Acid-Strong Base Example

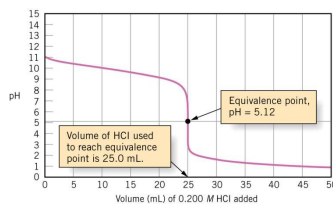
Consider the titration of 10. mL of 0.10 M HF ($K_A = 6.8 \times 10^{-4}$) with 0.20 M KOH. What volume of base is needed to reach the equivalence point? Calculate the pH of the solution after addition of the following volumes of base:

- a. 0.0 mL b. 2.5 mL c. 5.0 mL d. 6.0 mL

Titration of a Weak Base with a Strong Acid

Example: 25.0 mL 0.200 M NH_3 ($K_B = 1.8 \times 10^{-5}$) titrated with 0.200 M HCl.

Neutralization reaction:



Four Stages on curve:

Stage I (prior to addition of acid):

Stage II (prior to equivalence point):

Stage III (at equivalence point):

Stage IV (after equivalence point):

In titration of weak base by strong acid, what type of salt is present at the equivalence point?

What is the pH half-way to the equivalence point in a titration of weak base by strong acid?

Weak Base-Strong Acid Example

Consider the titration of 20. mL of 0.10 M NH_3 ($K_B = 1.8 \times 10^{-5}$) with 0.20 M HCl. What volume of acid is needed to reach the equivalence point? Calculate the pH of the solution after addition of the following volumes of acid:

- a. 0.0 mL b. 5.0 mL c. 10. mL d. 15.0 mL

Indicators

A substance used in titrations to indicate the equivalence point of a reaction.

- Q The equivalence point in a titration of acetic acid with NaOH occurs at pH=8.4. Could an indicator that changes color at pH of 3.2 or 12.5 be used in this titration? Why or why not?

Indicators.....

1.

2.

3.

4.

- Q The indicator Alizarin Yellow has $K_{A, \text{In}} = 8.9 \times 10^{-12}$ and changes color from yellow to orange red. What is the end point pH of the Alizarin Yellow indicator? What is the color of this indicator in solutions with pH of 7, 11, and 13, respectively?

Indicator Examples

1. For phenolphthalein ($K_{A,In} = 7.9 \times 10^{-10}$). Around what pH will phenolphthalein change color? Could phenolphthalein be used as an indicator during the titration of a strong acid with a strong base? weak acid with strong base? weak base with strong acid?

2. Three titrations were to be carried out with the acids and bases indicated below. Choose the best indicator for each titration from the following: phenolphthalein ($K_{A,In} = 7.9 \times 10^{-10}$), methyl orange ($K_{A,In} = 1.6 \times 10^{-4}$), and bromothymol blue ($K_{A,In} = 1.6 \times 10^{-7}$)
 - a. HNO_3 with NH_3
 - b. HNO_3 with KOH
 - c. HClO_2 with NaOH