Chapter 14 Part 6

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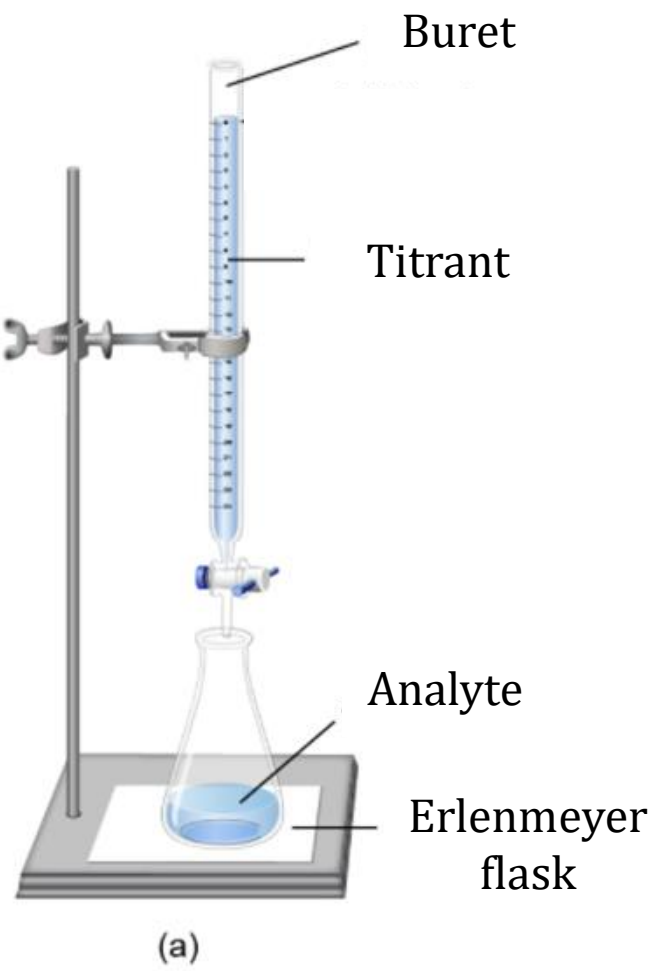
Titrations

- In a titration, a solution of known concentration, called the titrant, is added to solution of unknown concentration called the analyte.
- The volume at which enough moles of titrant has been added to fully react with all the analyte is called the equivalence point



Finding Equivalence Points

A student uses 0.200 M HNO_3 to titrate 25.00 mL of 0.300 M $Sr(OH)_2$. How many mL of HNO_3 must be added to reach the equivalence point?

Finding Equivalence Points

A student uses 0.100 M NaOH to titrate 25.00 mL of 0.100 M $HC_2H_3O_2$.
How many mL of NaOH must be added to reach the equivalence point?

Strong Base Titrating a Weak Acid

What is the pH at each of the following points in the titration of 25.00 mL of 0.100 M $HC_2H_3O_2$ with 0.100 M NaOH?
For $HC_2H_3O_2$, $K_a = 1.8 \times 10^{-5}$

A. Before the addition of any NaOH (initial pH)
B. After the addition of 10.00 mL of 0.100 M NaOH (before equiv point)
C. After the addition of 12.50 mL of 0.100 M NaOH (midpoint)
D. After the addition of 25.00 mL of 0.100 M NaOH (at equiv point)
E. After the addition of 26.00 mL of 0.100 M NaOH (beyond equiv point)

Midpoints

- The midpoint of the titration occurs at the volume halfway to the equivalence point
- At the midpoint of the titration of an acid $[HA] = [A^-]$
- At the midpoint,

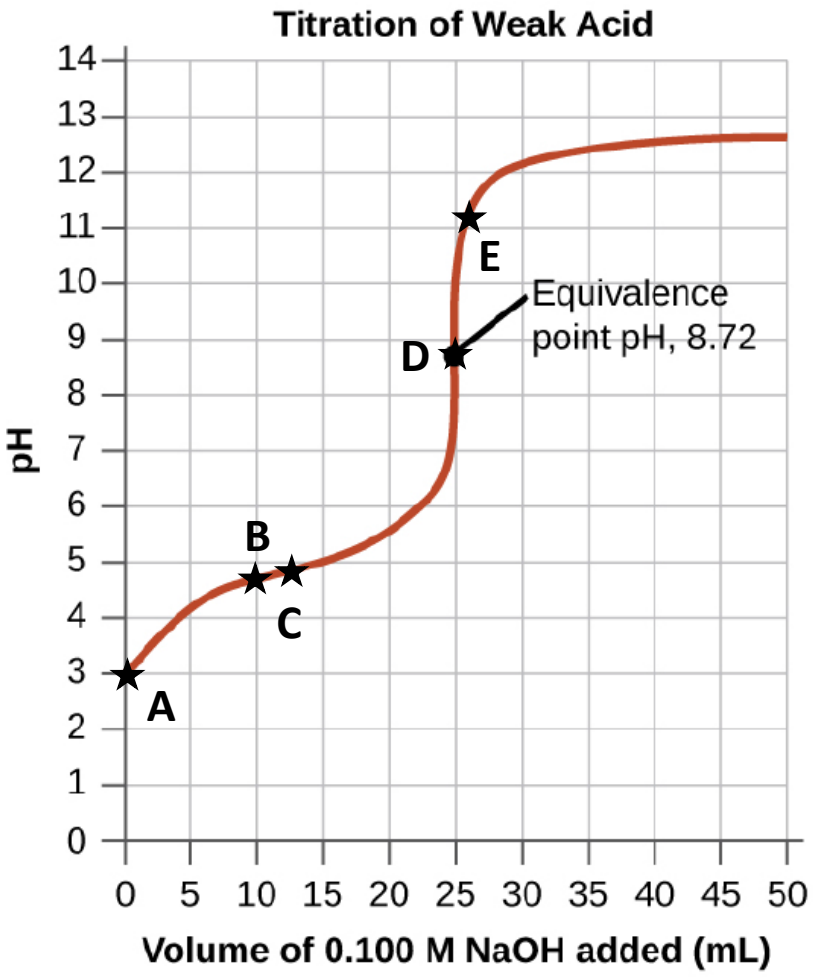
$$pH = pK_a + \log\frac{[A^-]}{[HA]}$$

$$pH = pK_a + \log(1)$$

$\log(1) \rightarrow 0$

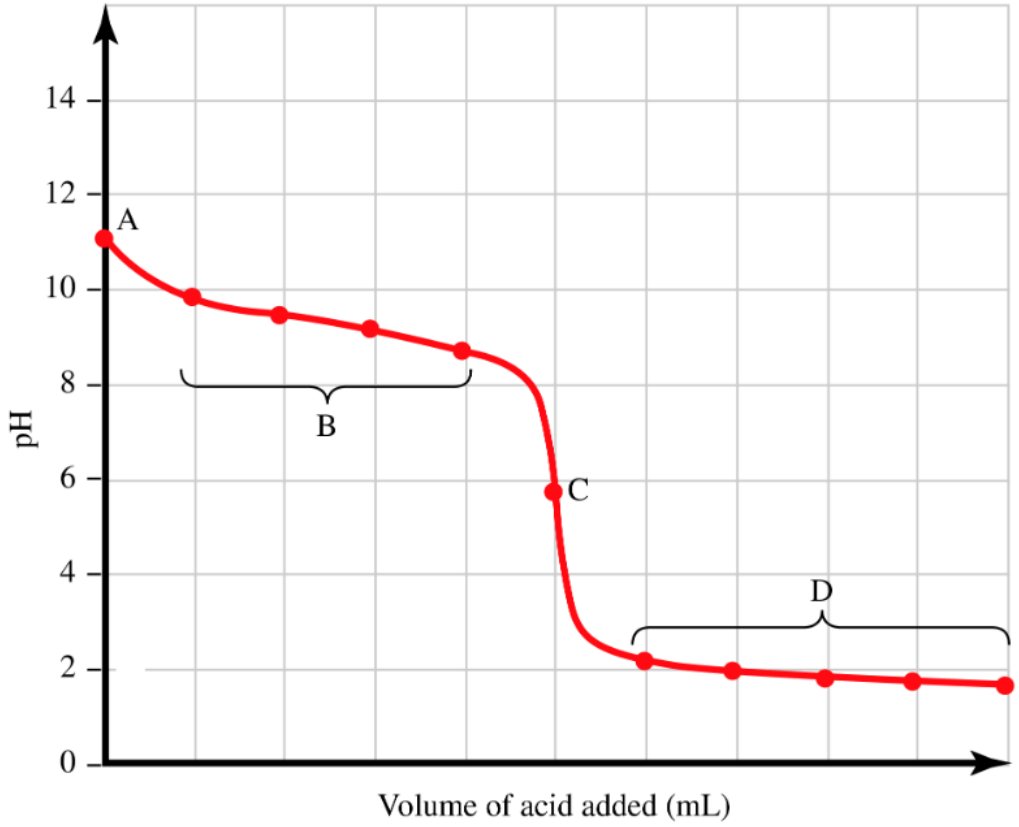
$$pH = pK_a$$

Strong Base Titrating a Weak Acid



Titration curves

Identify the region on the titration curve where pH is determined only by initial weak base concentration.



Titration curves

The pH at the equivalence point of a weak base–strong acid titration is ____.

A. equal to pK_a
B. equal to pK_b
C. less than 7.0
D. equal to 7.0
E. greater than 7.0

Titration curves

The pH at the half-equivalence point (midpoint) of a weak base–strong acid titration is ____.

A. equal to pK_a
B. equal to pK_b
C. less than 7.0
D. equal to 7.0
E. greater than 7.0

Acid-base indicators

- Acid-base indicators are substances that change color in solution when the pH reaches a particular value.
- Acid-base indicators are either weak organic acids or weak organic bases
- The volume at which enough titrant has been added for the indicator to change color is called the end point.

Acid-base indicators and pK_{in}

$$HIn(aq) + H_2O(l) \leftrightharpoons H_3O^+(aq) + In^-(aq)$$

$$K_{in} = \frac{[H_3O^+][In^-]}{[HIn]}$$

$$pH = pK_{in} + \log\left(\frac{In^-}{HIn}\right)^0$$

Choosing indicators

- It is best to choose indicators that have a sharp color change at the equivalence point.
- This can be achieved by picking indicators with pK_{in} values close to the pH at the equivalence point of the titration.

Common indicators

Indicator	pK_{in}	Color change
Alizarin yellow R	11.0	yellow to red
Thymolphthalein	9.9	colorless to blue
Phenolphthalein	9.5	colorless to pink
Thymol blue	9.2	yellow to blue
Phenol red	7.4	yellow to red
Bromothymol blue	7.3	yellow to blue
Bromocresol purple	6.4	yellow to purple
Ethyl red	5.4	colorless to red
Resorcin blue	5.3	red to blue
Resazurin	5.1	orange to violet
Methyl red	5.0	red to yellow
Bromophenol blue	4.1	yellow to blue
Thymol blue	1.7	red to yellow
Malachite green	1.3	yellow to turquoise
Methyl violet	0.8	yellow to blue