Buffers

Titration of a Weak Acid

- When a strong acid is titrated with a strong base, the pH at any point is determined by the concentration of un-titrated acid or excess base.
- When a weak acid is titrated with a strong base, the weak acid dissociates to yield a small amount of H^+.

Titration of a Weak Acid Continue

- $HA \rightleftharpoons H^+ + A^-$

When OH^- ions are added

- $H^+ + OH^- \rightarrow H_2O$

The equilibrium between the weak acid and its ions is disrupted. Thus, more HA ionizes and the newly produced H^+ ions neutralized by more OH^- ions until all of the H^+ originally present is neutralized.

- $HA + OH^- \rightleftharpoons H_2O + A^-$

Titration of a Weak Acid Continue

- Example: Calculate the appropriate values and draw the curve for the titration of 500ml of 0.1M weak acid HA with 0.1M KOH, $K_a = 10^{-5}$, p $K_a = 5$?
- **A) at the start point:** before any addition of any base

$pH = ½ (pK_a + p [HA])$

$pH = ½ (5 + 1)$

$pH = 3$

- **B) at any point during the titration:** after the addition of 100ml KOH

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

Titration of a Weak Acid Continue

Since KOH + HA ⟺ KA + H_2O

No. of moles of KOH added = M * V = 0.1 * 0.1

= 0.01 mole

No. of moles of original HA= M * V = 0.1 * 0.5

= 0.05mole

1 mole of OH^- will react with 1 mole of HA to produces 1 mole of salt. Thus, the no. of moles of salt produced = 0.01 mole.

No. of moles of remaining HA added=moles of HA originally present – moles of HA titrated to salt.

= 0.05 – 0.01

= 0.04 mole

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

Titration of a Weak Acid Continue

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

pH = 5 + log (0.01 / 0.04)

pH = 4.4

C) at any point during the titration: after the addition of 250ml KOH

No. of moles of KOH added = M * V = 0.1 * 0.25

= 0.025 mole

No. of moles of original HA= M * V = 0.1 * 0.5

= 0.05mole

1 mole of OH^- will react with 1 mole of HA to produces 1 mole of salt. Thus, the no. of moles of salt produced = 0.025 mole.

No. of moles of remaining HA added= moles of HA originally present – moles of HA titrated to salt.

= 0.05 – 0.025

= 0.025 mole

Titration of a Weak Acid Continue

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

pH = 5 + log (0.025 / 0.025)

pH = 5

Here the $[A^-] = [HA]$ thus, $pH = pK_a$

D) at any point during the titration: after the addition of 375ml KOH

No. of moles of KOH added = M * V = 0.1 * 0.375

= 0.0375 mole

No. of moles of original HA= M * V = 0.1 * 0.5

= 0.05mole

1 mole of OH^- will react with 1 mole of HA to produces 1 mole of salt. Thus, the no. of moles of salt produced = 0.0375 mole.

No. of moles of remaining HA added= moles of HA originally present – moles of HA titrated to salt.

= 0.05 – 0.0375

= 0.0125 mole

Titration of a Weak Acid Continue

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

pH = 5 + log (0.0375/ 0.0125)

pH = 5.48

E) at the end point of the titration: after the addition of 500ml KOH

No. of moles of KOH added = M * V = 0.1 * 0.5

= 0.05 mole

No. of moles of original HA= M * V = 0.1 * 0.5

= 0.05mole

1 mole of OH^- will react with 1 mole of HA to produces 1 mole of salt. Thus, the no. of moles of salt produced = 0.05 mole.

The final volume of the solution = 500+500 = 1000ml

Titration of a Weak Acid Continue

$[A^-]$ = 0.05/1

= 0.05 M

p $[A^-]$ = -log 0.05

= 1.3

pOH = ½ (pK_b + p $[A^-]$)

= ½ (9 + 1.3)

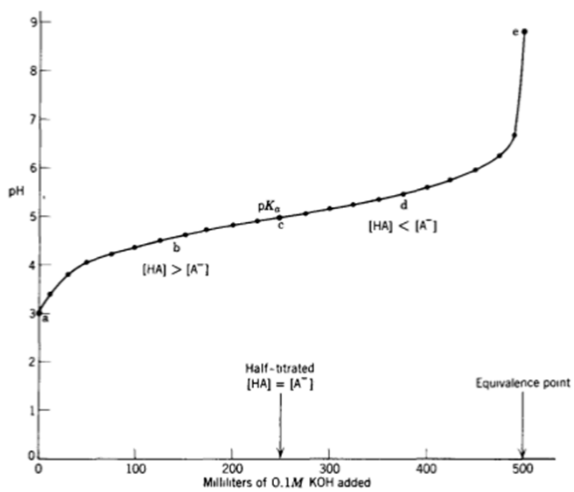
= 5.15

pH= pKw – pOH

= 14- 5.15

=8.85

Titration of a Weak Acid Continue



Buffers

- Buffer is a solution which resist large changes in the pH by partially absorbing addition of the H^+ or OH^- ions to the system.
- Acidic buffer: mixture of weak acid and its salt of strong base.
- Basic buffers: mixture of weak base and its salt of strong acid.
- Buffers resist changes in pH upon the addition of limited amounts H^+ of or OH^-.
- Buffer pH do changes upon the addition of H^+ of or OH^- but the change is much less than that would occur in case of buffer absence.

Mechanism of Action of Buffers

- Example of buffer CH3COOH / $CH3COO^-$
- When H^+ is added to the buffer:

$CH3COO^- + H^+ \rightleftarrows CH3COOH$

- When OH^- is added to the buffer:

$CH3COOH + OH^- \rightleftarrows CH3COO^- + H_2O$

- The buffer absorb the effect of H^+ or OH^- as possible as it can.

Buffer Capacity

- The ability of a buffer to resist changes in the pH is referred to as a buffer capacity.
- The no. of moles of H^+ that must be added to one liter of the buffer in order to decrease the pH by one unit.
- The no. of moles of OH^- that must be added to one liter of the buffer in order to increase the pH by one unit.

Buffer Capacity Continue

- $\beta = \frac{2.3 Ka [H^+][C]}{(Ka + [HA])^2}$
- $\beta max = 0.575\,[C]$
- In the equation:
- β = buffer capacity
- $[H^+]$ = hydrogen ion concentration of the buffer
- [C]= total concentration of buffer components = $[HA] + [A^-]$.
- https://www.youtube.com/watch?v=g_ZK2ABUjvA