

18 • Acid-Base Reactions

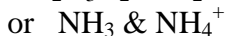
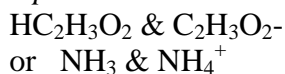
BLUFFER'S GUIDE

1. Buffers:

A solution that resists a change in pH when small amounts of acid or base are added.

Buffers are a mixture of
a weak acid & its conjugate base or
a weak base & its conjugate acid.

Examples:



Your blood is a buffer.

The equilibrium is the acid equilibrium:



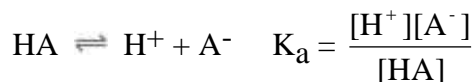
in which both the acid and its conjugate base are available to counteract the stress of adding acid or base (Le Châtelier's). The equilibrium shifts, but is almost completely counteracted by the proton donor or acceptor.

Similarly, for bases with conjugate acids:



The best buffer contains large, equal amounts of the proton donor and the proton acceptor.
[HA] = [A⁻] (Note: they cancel out of K_a)

Consider:



The best buffer, K_a = [H⁺]; pH = pK_a.
The pH of a buffer can be adjusted by changing the ratio of acid and base.

$$[\text{H}^+] = K_a \frac{[\text{HA}]}{[\text{A}^-]}$$

$$\text{pH} = \text{p}K_a - \log \frac{[\text{HA}]}{[\text{A}^-]}$$

Similarly, for bases with conjugate acids:

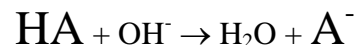


$$K_b = \frac{[\text{OH}^-][\text{HB}^+]}{[\text{B}]}$$

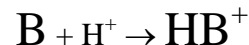
$$[\text{OH}^-] = K_b \frac{[\text{B}]}{[\text{HB}^+]}$$

$$\text{pOH} = \text{p}K_b - \log \frac{[\text{B}]}{[\text{HB}^+]}$$

Buffers can also be formed by changing a weak acid **into** its conjugate base by neutralizing **some** of the acid..



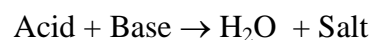
The same can be done with a weak base:



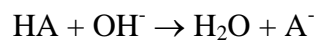
So, a weak acid and some strong base can form a buffer. A weak base and some strong acid can also form a buffer.

2. Titration:

A carefully measured neutralization.



Since volumes are measured, this is a "volumetric analysis."



The salt is the conjugate base of the weak acid or the conjugate acid of the weak base. A "half-titration" (neutralizing half the weak acid or weak base) forms a buffer. In that case the pH = pK_a of the acid. (pOH = pK_b)

3. Equivalence Point:

The point in a titration when stoichiometric amounts of acid and base have reacted.

Note that the salt solution that is formed may have a pH >, <, or = 7. (Remember hydrolysis.)

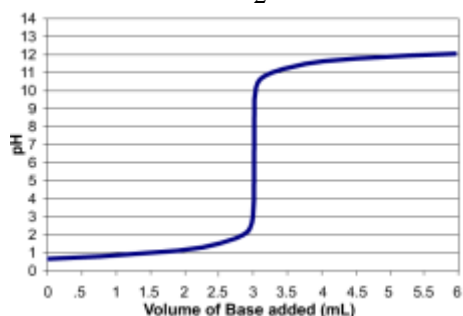
Indicators for a titration are selected based on the pH at the equivalence point.

acid	base	pH at eq. pt.
STRONG	STRONG	pH = 7
STRONG	weak	pH < 7
weak	STRONG	pH > 7
weak	weak	it depends

4. Titration Curves:

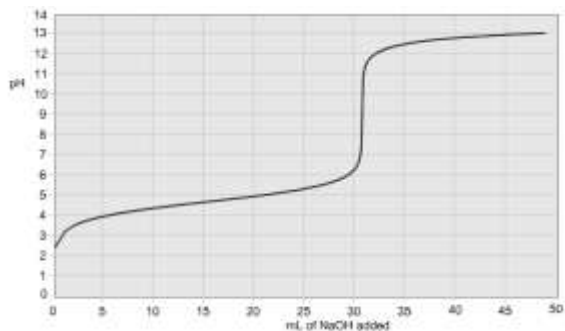
This graph shows how the pH changes as a titration occurs.

(A) Strong acid/Strong Base



NOTE: Graph should have “pH” as the vertical axis and “added base” as the horizontal axis. The graph should be in an “S” shape. The middle of the “S” is the equivalence point (pH = 7). The top part of the “S” levels off at the pH of the base solution.

(B) Weak acid/Strong Base



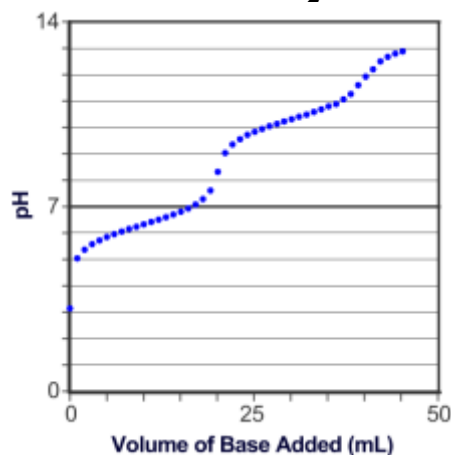
NOTE: The middle of the lower part of the “S” indicates the point of maximum buffering where $[\text{HA}]/[\text{A}^-] = 1$. The middle of the “S” is the equivalence point (above pH = 7) and $[\text{HA}] = 0$. The top part of the “S” levels off at the pH of the base solution.

(C) Weak base/Strong acid



NOTE: Graph should have “pH” as the vertical axis and “added acid” as the horizontal axis. The graph should be in a “backwards S” shape. The middle of the upper part of the “backwards S” indicates the point of maximum buffering where $[\text{B}]/[\text{HB}^+] = 1$. The middle of the “backwards S” is the equivalence point (below pH = 7) and $[\text{B}] = 0$. The bottom part of the “backwards S” levels off at the pH of the acid solution.

(D) Weak diprotic acid/Strong base



NOTE: Graph should have “pH” as the vertical axis and “added base” as the horizontal axis. The graph should be in a “double S” shape. The middle of the lower part of the “first S” indicates the point of maximum buffering of the first buffering zone where $[\text{H}_2\text{A}]/[\text{HA}^-] = 1$. The middle of the “first S” is the first equivalence point where $[\text{H}_2\text{A}] = 0$. The top part of the “first S” (i.e. the lower part of the “second S”) indicates the point of maximum buffering of the second buffering zone where $[\text{HA}^-]/[\text{A}^{2-}] = 1$. The middle of the “second S” is the second equivalence point where $[\text{HA}^-] = 0$. The top part of the “second S” levels off at the pH of the base solution.