Answer on Question #50112, Chemistry, Physical Chemistry

What is the maximum limit of addition of acid and base to prevent the change of pH?

Solution:

The goal of a buffer is to keep the pH of a solution within a narrow range. While the ratio of $[A^-]/[HA]$ influences the pH of a solution, the actual concentrations of A^- and HA influence the effectiveness of a buffer.

The more A^- and HA molecules available, the less of an effect addition of a strong acid or base will have on the pH of a system. Consider the addition of a strong acid such as HCl. Initially, the HCl donates its proton to the weak base (A^-) through the reaction

$A^- + HCl \rightarrow HA + Cl^-$

This changes the pH by lowering the ratio $[A^-]/[HA]$, but as long as there is still a lot of A^- present, the change in pH will be small. But if we keep adding HCl, the weak base A^- will eventually run out. Once the A^- is gone, any additional HCl will donate its proton to water

$HCl + H_2O \rightarrow H_3O^+ + Cl^-$

This will dramatically increase the concentration $[H^+]$ and so the pH drops.

We call this "breaking the buffer solution", and we call the amount of acid a buffer can absorb before it breaks the "buffer capacity for addition of strong acid". A solution with more weak base, $[A^-]$, has a higher buffer capacity for addition of strong acid.

Similarly, a buffer will break when the amount of strong base added is so large it consumes all the weak acid, through the reaction

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

A solution with more weak acid, [HA], has a higher buffer capacity for addition of strong base.

So although the pH of a buffer is determined by only the ratio $[A^-]/[HA]$, the ability of the buffer to absorb strong acid or base is determined by the individual concentrations of $[A^-]$ and [HA].

Answer:

Maximum limit of addition of acid is till $c_{acid} \leq [A^-]$

Maximum limit of addition of base is till $c_{base} \leq [HA]$