Tutorial #1

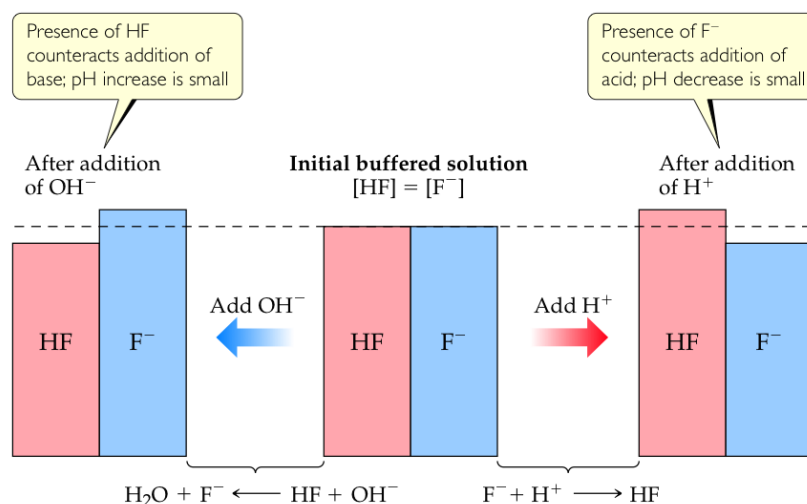**What is a buffer and why are they important?**

How does a buffer work?

Sample problem #1: Identifying buffer solutions: Identify buffer solutions from the following list:
  (a) 0.13 M sodium hydroxide and 0.27 sodium bromide

  (b) 0.13 M nitrous acid and 0.14 sodium nitrite

  (c) 0.24 M nitric acid and 0.17 M sodium nitrate

  (d) 0.31 M calcium chloride and 0.25 M calcium bromide

  (e) 0.34 M ammonia and 0.38 M ammonium bromide

Buffer pH

The common ion effect:

Presence of HF counteracts addition of base; pH increase is small

Presence of F^- counteracts addition of acid; pH decrease is small

After addition of OH^-

Initial buffered solution $[HF] = [F^-]$

After addition of H^+

Add OH^-

HF F^-

Add H^+

HF F^-

HF F^-

$$H_2O + F^- \longleftarrow HF + OH^- \qquad F^- + H^+ \longrightarrow HF$$

▲ Figure 17.2 **Buffer action.** The pH of an HF/F^- buffered solution changes by only a small amount in response to addition of an acid or base.

Sample Exercise #2: Calculating the pH of a weak acid/conjugate base buffer solution What is the pH of 125 mL of a 0.15 M solution of acetic acid before and after the addition of 0.015 mol of sodium acetate.
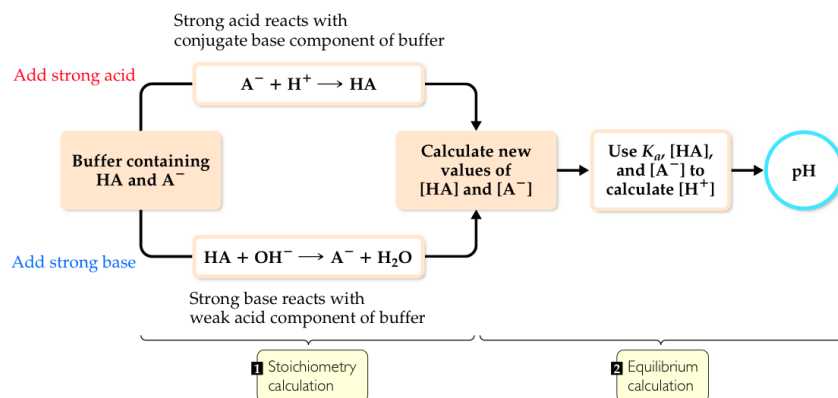
Sample Exercise #3: Calculate the pH of a weak base/conjugate acid buffer solution.
A 0.30 M aqueous solution of NH_3 has a pH of 11.37. Calculate the pH of a buffer solution that is 0.30 M in NH_3 and 0.23 M in ammonium bromide.

Henderson Hasselbach equation

When [weak acid] = [weak base], pH = pKa + log(1) = pKa + 0 = pKa

Definition of buffer capacity and how a buffer reacts after the addition of a strong base or strong acid.

Strong acid reacts with
conjugate base component of buffer

Add strong acid

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

Buffer containing
HA and A⁻

Calculate new
values of
[HA] and [A⁻]

Use K_a, [HA],
and [A⁻] to
calculate [H⁺]

pH

Add strong base

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

Strong base reacts with
weak acid component of buffer

1 Stoichiometry
calculation

2 Equilibrium
calculation

▲ Figure 17.3 Calculating the pH of a buffer after addition of a strong acid or strong base.

Sample Exercise #4: Use the Henderson Hasselbach equation to calculate pH of a buffer solution that is 0.18 M in H_2PO^- and 0.21 M in HPO_4^{2-}

Sample Exercise #5: Calculate buffer pH after adding strong acid or strong :
Determine the pH change when 0.020 mol HCl is added to 1.00 L of a buffer solution that is 0.10 M in CH_3CO_2H and 0.25 M $CH_3CO_2^-$.

Making a Buffer Solution with a Desired pH

Step 1:

Step 2:

Sample Exercise #6: Prepare a Buffer by direct addition:
Describe how to prepare 500 mL of a buffer solution with a pH = 9.85 using one of the weak acid/conjugate base systems shown here.

Weak Acid	Conjugate Base	K_a	pK_a
CH_3CO_2H	$CH_3CO_2^-$	1.8×10^{-5}	4.74
$H_2PO_4^-$	HPO_4^{2-}	6.2×10^{-8}	7.21
HCO_3^-	CO_3^{2-}	4.8×10^{-11}	10.32

Sample Exercise #7: Prepare a Buffer by acid base reactions:
Describe how to prepare a buffer solution with pH = 5.25 (using one of the weak acid/conjugate base systems shown below) by combining a 0.50 M solution of weak acid with any necessary amount of 1.00 M NaOH.

Weak Acid	Conjugate Base	K_a	pK_a
CH_3CO_2H	$CH_3CO_2^-$	1.8×10^{-5}	4.74
$H_2PO_4^-$	HPO_4^{2-}	6.2×10^{-8}	7.21
HCO_3^-	CO_3^{2-}	4.8×10^{-11}	10.32