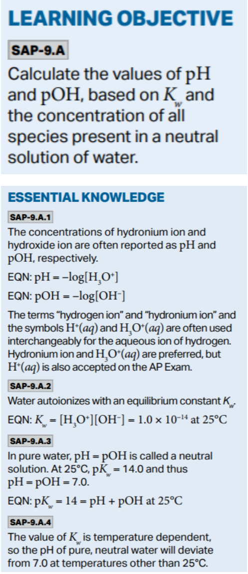
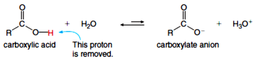
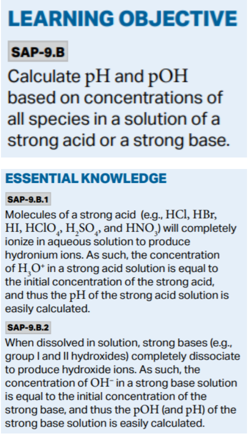
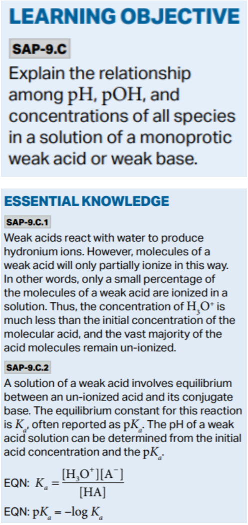
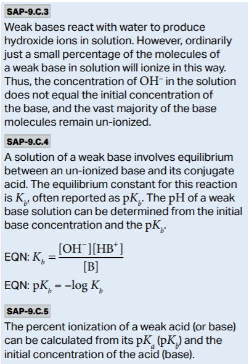
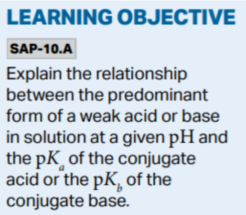
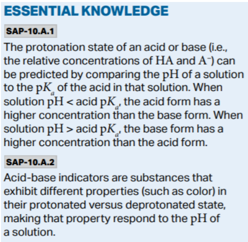
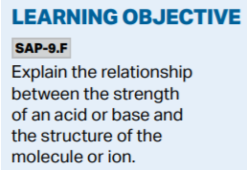
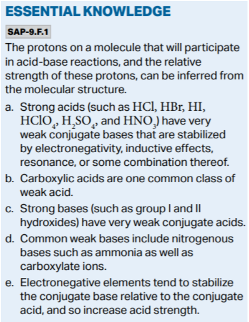
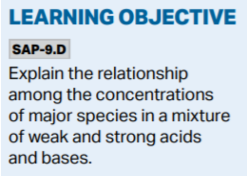
Acids/Bases (K_a & K_b) - Part A

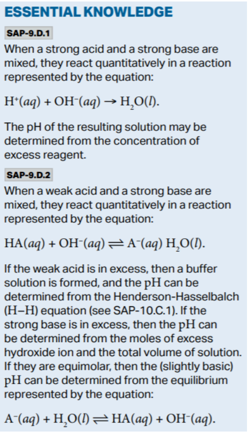
1. Go through the videos, notes, and online homeworks in the table below. Acid/Base Equilibrium tends to be a large focus on most AP exams. FYI, I organized the topics in the table below by how I prefer to cover them, not by the order the AP arranged them. That explains why you will see some of the learning objectives "out of order".

Acids/Bases	
Topics Covered	**Assignments to Complete**
Introduction to Acids and Bases  **LEARNING OBJECTIVE** **SAP-9.A** Calculate the values of pH and pOH, based on K_w and the concentration of all species present in a neutral solution of water. **ESSENTIAL KNOWLEDGE** **SAP-9.A.1** The concentrations of hydronium ion and hydroxide ion are often reported as pH and pOH, respectively. EQN: $pH = -\log[H_3O^+]$ EQN: $pOH = -\log[OH^-]$ The terms "hydrogen ion" and "hydronium ion" and the symbols $H^+(aq)$ and $H_3O^+(aq)$ are often used interchangeably for the aqueous ion of hydrogen. Hydronium ion and $H_3O^+(aq)$ are preferred, but $H^+(aq)$ is also accepted on the AP Exam. **SAP-9.A.2** Water autoionizes with an equilibrium constant K_w. EQN: $K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14}$ at 25°C **SAP-9.A.3** In pure water, pH = pOH is called a neutral solution. At 25°C, $pK_w = 14.0$ and thus pH = pOH = 7.0. EQN: $pK_w = 14 = pH + pOH$ at 25°C **SAP-9.A.4** The value of K_w is temperature dependent, so the pH of pure, neutral water will deviate from 7.0 at temperatures other than 25°C.	☐ Watch video 16.1 Acid/Base Equilibria ☐ Watch video 16.2 Bronsted-Lowry Acids & Bases ☐ Watch video 16.2.2 Conjugate Acid/Base Pairs ☐ Watch video 16.2.3 Relative Strengths of Acids ☐ Watch video 16.2.4 Relative Acid Strength Example ☐ If you want more info, skim through slides #1-13 on the Acid/Base – "Really Good Probs" Powerpoint -We will focus on the Bronsted-Lowry definition of acids/bases -Substances that are amphiprotic (can act as either an acid or base)…….. Examples: *H_2O, HCO_3^-, or HSO_4^-* ☐ Read these notes: Since this is the Acid-Base Unit, you need to be able to identify an acid and a base. Up to this point in the year we have considered an acid to have a "H" and a base to have an "OH"; however it is more complicated than that. An acid donates a proton and a base accepts a proton. You should NOW understand this better after watching the videos. ☐ In order to help you identify an acid and a base, complete 10-20 or even MORE problems from the following CSU online homework site until you have completely mastered it: CSU Practice Predicting Acid/Base Reactions Online Hwk. You do NOT need to submit this online homework. (I would HIGHLY suggest working on these with a partner. PLEASE do yourself a favor now and master the ability to identify an acid/base and write the acid/base reaction) ****Before attempting the online homework, read through the notes below:** Identifying ACIDS on the Online Hwk (If the answer is YES, then it is an acid) -Does it start with H? *(Example: HCl, H_3O^+, HCN, or HNO_3)* -Does it have a positive charge? *(Example: H_3O^+, $(CH_3)_2NH_2^+$, or $CH_3NH_3^+$)* -Is it a carboxylic acid ending in CO_2H or sometimes COOH? *(Example: $CH_2Cl\mathbf{CO_2H}$ or $C_6H_5\mathbf{CO_2H}$) - these smell putrid…….COOH smells like POOH*

	 Identifying BASES on the Online Hwk (If the answer is YES, then it is a base) -Does it end with OH? *(Example: NaOH, OH^-)* -Does it have a negative charge? *(Example: OH^-, $CH_3CO_2^-$, NO_2^-, or $CH_2ClCO_2^-$)* -Does it contain an amine group (in other words N bonded to H) but WITHOUT a charge? *(Example: NH_3, $C_6H_5NH_2$ or $(CH_3)_2NH$)* -these typically smell fishy
pH and pOH of Strong Acids and Bases  **LEARNING OBJECTIVE** **SAP-9.B** Calculate pH and pOH based on concentrations of all species in a solution of a strong acid or a strong base. **ESSENTIAL KNOWLEDGE** **SAP-9.B.1** Molecules of a strong acid (e.g., HCl, HBr, HI, $HClO_4$, H_2SO_4, and HNO_3) will completely ionize in aqueous solution to produce hydronium ions. As such, the concentration of H_3O^+ in a strong acid solution is equal to the initial concentration of the strong acid, and thus the pH of the strong acid solution is easily calculated. **SAP-9.B.2** When dissolved in solution, strong bases (e.g., group I and II hydroxides) completely dissociate to produce hydroxide ions. As such, the concentration of OH^- in a strong base solution is equal to the initial concentration of the strong base, and thus the pOH (and pH) of the strong base solution is easily calculated.	☐ PHET - pH Scale (**only** do this if we are in class at school) ☐ Watch video 16.3 The Autoionization of Water ☐ Watch video 16.4 The pH Scale ☐ Watch video 16.5 pH of Strong Acids ☐ If you want more info, skim through slides #14-31 on the Acid/Base – “Really Good Probs” Powerpoint *(This covers Strong Acids, Strong Bases, the pH Scale, and the pOH scale)* ☐ Complete 5 problems from the pH, pOH, $[H^+]$, & $[OH^-]$ Online Hwk **OR** Complete 5 problems from the Basic pH relationships Online Hwk *(Depending on your math level this will be easy or difficult, so it would be best to work on it with a partner who understands logarithms quite well)* **Once you finish the 5 problems (on paper), ****UPLOAD Your Work HERE**** *(Before uploading, make sure your work has your name, period number on it, and your camera lens is clean. Thank you!)*
Weak Acid and Base Equilibria  **LEARNING OBJECTIVE** **SAP-9.C** Explain the relationship among pH, pOH, and concentrations of all species in a solution of a monoprotic weak acid or weak base. **ESSENTIAL KNOWLEDGE** **SAP-9.C.1** Weak acids react with water to produce hydronium ions. However, molecules of a weak acid will only partially ionize in this way. In other words, only a small percentage of the molecules of a weak acid are ionized in a solution. Thus, the concentration of H_3O^+ is much less than the initial concentration of the molecular acid, and the vast majority of the acid molecules remain un-ionized. **SAP-9.C.2** A solution of a weak acid involves equilibrium between an un-ionized acid and its conjugate base. The equilibrium constant for this reaction is K_a, often reported as pK_a. The pH of a weak acid solution can be determined from the initial acid concentration and the pK_a. EQN: $K_a = \frac{[H_3O^+][A^-]}{[HA]}$ EQN: $pK_a = -\log K_a$	☐ PHET - Acid-Base Solutions (**only** do this if we are in class at school) ☐ Watch video 16.6 pH of Weak Acids Example #1 ☐ Watch video 16.6.2 Weak Acids Example #2 ☐ Watch video 16.6.3 Polyprotic Acids ☐ Watch video 16.6.4 Percent Ionization ☐ If you want more info, skim through slides #32-58 on the Acid/Base – “Really Good Probs” Powerpoint *(This covers Weak Acids & K_a, Weak Bases & K_b, calculating K_a from pH (Exercise 16.10 on p682), and % ionization (Exercise 16.11 on p684) which refer to p682 in your Brown LeMay textbook)* ☐ Complete 5 problems from the pH of Solutions of Weak Acids Online Hwk#73 (You will need this table of K_a values).........**Listen carefully, ONLY choose the problem if the K value is 1x10^{-5} or smaller so that you can ignore “x” in the RICE Table** **Once you finish the 5 problems (on paper), ****UPLOAD Your Work HERE**** *(Before uploading, make sure your work has your name, period number on it, and your camera lens is clean. Thank you!)* -There is Video HELP *(on problem #1 in the video I tell you to take the square root, but then I accidentally forgot to do it in the problem)*

 **SAP-9.C.3** Weak bases react with water to produce hydroxide ions in solution. However, ordinarily just a small percentage of the molecules of a weak base in solution will ionize in this way. Thus, the concentration of OH^- in the solution does not equal the initial concentration of the base, and the vast majority of the base molecules remain un-ionized. **SAP-9.C.4** A solution of a weak base involves equilibrium between an un-ionized base and its conjugate acid. The equilibrium constant for this reaction is K_b, often reported as pK_b. The pH of a weak base solution can be determined from the initial base concentration and the pK_b. EQN: $K_b = \frac{[OH^-][HB^+]}{[B]}$ EQN: $pK_b = -\log K_b$ **SAP-9.C.5** The percent ionization of a weak acid (or base) can be calculated from its pK_a (pK_b) and the initial concentration of the acid (base).	-Remember to ONLY choose the problem if the K value is $1x10^{-5}$ or smaller so that you can ignore “x” in the RICE Table (You do NOT have to use the quadratic equation) ☐ Watch video 16.7 Weak Bases ☐ Complete 5 problems from the pOH of Solutions of Weak Bases Online Hwk#81 (You will need this table of K_b values).........**Listen carefully, ONLY choose the problem if the K value is $1x10^{-5}$ or smaller so that you can ignore “x” in the RICE Table** **Once you finish the 5 problems (on paper), **UPLOAD Your Work HERE** *(Before uploading, make sure your work has your name, period number on it, and your camera lens is clean. Thank you!)* -There is Video HELP *(on problem #1 in the video I tell you to take the square root, but then I accidentally forgot to do it in the problem)* ☐ Complete a few problems from the CSU Online Hwk#74 (Click here for Video HELP with this Online Hwk) -These problems are more difficult as they cover pH, pOH, [ ], and % ionization. You do NOT need to submit this online homework. I would HIGHLY suggest working on these with a partner. -Make sure to use this table of K values and **ONLY choose the problem if the K value is $1x10^{-5}$ or smaller so that you can ignore “x” in the RICE Table.** ☐ If you want more info, skim through slides #59-82 on the Acid/Base – “Really Good Probs” Powerpoint *(This covers 2 really really really good problems which refer to p682 in your Brown LeMay textbook)*
pH and pKa  **LEARNING OBJECTIVE** **SAP-10.A** Explain the relationship between the predominant form of a weak acid or base in solution at a given pH and the pK_a of the conjugate acid or the pK_b of the conjugate base.  **ESSENTIAL KNOWLEDGE** **SAP-10.A.1** The protonation state of an acid or base (i.e., the relative concentrations of HA and A^-) can be predicted by comparing the pH of a solution to the pK_a of the acid in that solution. When solution pH < acid pK_a, the acid form has a higher concentration than the base form. When solution pH > acid pK_a, the base form has a higher concentration than the acid form. **SAP-10.A.2** Acid-base indicators are substances that exhibit different properties (such as color) in their protonated versus deprotonated state, making that property respond to the pH of a solution.	☐ Watch video 16.8 Relationship between Ka & Kb ☐ Watch video 16.9 Acid/Base Properties of Salt Solutions ☐ Watch video 16.9.2 Acid/Base Properties of Salts ☐ Watch video 16.9.3 pH of Salt Solution Example Problem ☐ If you want more info, skim through slides #83-109 on the Acid/Base – “Really Good Probs” Powerpoint *(This covers the relationship of K_a & K_b, K_w, pK_a, pK_b, and pK_w AND problems dealing dealing w/ Salts)* *-Note: The K_w is $1x10^{-14}$ at 25°C, but is $4x10^{-14}$ at 45°C....this means the pH is LOWER at higher temps due to a greater $[H_3O^+]$* ☐ Read these notes: Since this is the Acid-Base Unit, you need to be able to identify an acid and a base AND a salt. Why a salt? BECAUSE salts can either be acidic, basic, or neutral. In order to help you identify a salt, complete 30-40 or even MORE problems from the following CSU online homework site until you have completely mastered it: CSU Predicting Salts Online Hwk Last year was the FIRST time I ever had a class do this online homework and the students who mastered it were able to climb the hill MUCH faster than those who didn’t master it……..so I saw the importance of this online homework as well. PLEASE do yourself a favor now and master the ability to identify a salt.

	**The conjugates of a strong acid (Ex. HCl) and a strong base (Ex. NaOH) will always be a NEUTRAL salt *(Ex. NaCl)......this is because…….. the conjugate base of HCl (a strong acid) is Cl$^-$ while the conjugate acid of NaOH (a strong base) is Na$^+$ (both of these conjugates when combined to form NaCl have no effect on the pH)* **The conjugates of a weak acid (Ex. HF) and strong base (Ex. NaOH) will be a BASIC salt (Ex. NaF) **The conjugates of a strong acid (Ex. HCl) and weak base (Ex. AgOH) will be an ACIDIC salt (Ex. AgCl) **The conjugates of a weak acid and weak base will be ???? (it depends on the K_a & K_b values - this would be a very tricky problem and won't be assessed in the AP curriculum)
Molecular Structure of Acids and Bases  **LEARNING OBJECTIVE** **SAP-9.F** Explain the relationship between the strength of an acid or base and the structure of the molecule or ion.  **ESSENTIAL KNOWLEDGE** **SAP-9.F.1** The protons on a molecule that will participate in acid-base reactions, and the relative strength of these protons, can be inferred from the molecular structure. a. Strong acids (such as HCl, HBr, HI, $HClO_4$, H_2SO_4, and HNO_3) have very weak conjugate bases that are stabilized by electronegativity, inductive effects, resonance, or some combination thereof. b. Carboxylic acids are one common class of weak acid. c. Strong bases (such as group I and II hydroxides) have very weak conjugate acids. d. Common weak bases include nitrogenous bases such as ammonia as well as carboxylate ions. e. Electronegative elements tend to stabilize the conjugate base relative to the conjugate acid, and so increase acid strength.	☐ Watch video 16.10 Acid/Base Behavior ☐ Watch video 16.10.2 Oxyacids ☐ Watch video 16.10.3 Carboxylic Acids
Acid-Base Reactions and Buffers  **LEARNING OBJECTIVE** **SAP-9.D** Explain the relationship among the concentrations of major species in a mixture of weak and strong acids and bases.	☐ Read these notes: A buffer is a solution made up of a weak acid and its conjugate base (or a weak base and its conjugate acid). Example of a Buffer Solution: -A solution containing both acetic acid ($HC_2H_3O_2$ - a weak acid) AND sodium acetate ($NaC_2H_3O_2$ - the conjugate base).......technically sodium acetate is a salt in which the sodium ion (Na$^+$) is a Group 1 ANA that dissociates completely and acts as a spectator ion, while



ESSENTIAL KNOWLEDGE

SAP-9.D.1

When a strong acid and a strong base are mixed, they react quantitatively in a reaction represented by the equation:

$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$.

The pH of the resulting solution may be determined from the concentration of excess reagent.

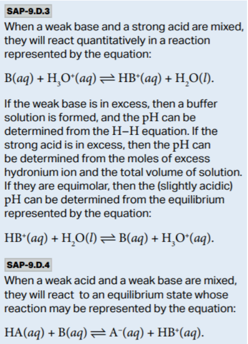
SAP-9.D.2

When a weak acid and a strong base are mixed, they react quantitatively in a reaction represented by the equation:

$HA(aq) + OH^-(aq) \rightleftharpoons A^-(aq)\ H_2O(l)$.

If the weak acid is in excess, then a buffer solution is formed, and the pH can be determined from the Henderson-Hasselbalch (H–H) equation (see SAP-10.C.1). If the strong base is in excess, then the pH can be determined from the moles of excess hydroxide ion and the total volume of solution. If they are equimolar, then the (slightly basic) pH can be determined from the equilibrium represented by the equation:

$A^-(aq) + H_2O(l) \rightleftharpoons HA(aq) + OH^-(aq)$.



SAP-9.D.3

When a weak base and a strong acid are mixed, they will react quantitatively in a reaction represented by the equation:

$B(aq) + H_3O^+(aq) \rightleftharpoons HB^+(aq) + H_2O(l)$.

If the weak base is in excess, then a buffer solution is formed, and the pH can be determined from the H–H equation. If the strong acid is in excess, then the pH can be determined from the moles of excess hydronium ion and the total volume of solution. If they are equimolar, then the (slightly acidic) pH can be determined from the equilibrium represented by the equation:

$HB^+(aq) + H_2O(l) \rightleftharpoons B(aq) + H_3O^+(aq)$.

SAP-9.D.4

When a weak acid and a weak base are mixed, they will react to an equilibrium state whose reaction may be represented by the equation:

$HA(aq) + B(aq) \rightleftharpoons A^-(aq) + HB^+(aq)$.

the acetate ion ($C_2H_3O_2^-$) is the conjugate base and DOES participate in the reaction).

-Most students struggle with writing the correct equation for buffers because they always want to react the weak acid with its conjugate base (or the weak base with its conjugate acid). This is ALWAYS INCORRECT. Instead, react the weak acid with water, which in turn makes the conjugate base (or react the weak base with water, which in turn makes the conjugate acid).

Incorrect Equation:

$HC_2H_3O_2$ + $C_2H_3O_2^-$ <-> NO REACTION OCCURS
(Weak Acid) (Conjugate)

Correct Equation:

$HC_2H_3O_2$ + H_2O <-> $C_2H_3O_2^-$ + H_3O^+
(Weak Acid) (Water) (Conjugate)

**This is just a K_a problem. If you did a RICE Table, you could then find the pH by using the $[H_3O^+]$ at equilibrium!

- ☐ Watch video 17.2 Buffer Solutions
- ☐ Watch video 17.2.2 How Buffers Work
- ☐ Watch video 17.2.3 Calculating pH of Buffer Solutions
- ☐ Watch video 17.2.4 Buffer Example Problem
- ☐ Watch video 17.2.5 Choosing the Proper Buffer Solution
- ☐ Watch video 17.2.6 Buffer Example Problem
- ☐ Complete 5 problems from Composition of Buffers Online Homework #77 *(Complete at least 5 of the problems on paper, making sure to write the buffer equation correctly (see notes above on how to set up the equation correctly).* You will need this K values table and **ONLY choose the problem if the K value is 1x10^{-5} or smaller so that you can ignore "x" in the RICE Table.**

-"Easier" problems from online hwk #85 look like……………..

A buffer solution contains acetic acid and acetate ion with concentrations of 0.83**M** and 4.0**M**, respectively. What is the pH of the buffer?

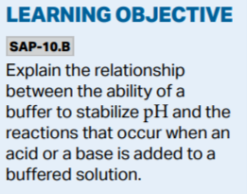
-"Medium" problems from online hwk #85 look like.................

A buffer has a pH of 4.96 and an acetic acid concentration of 0.32**M**. What is the acetate ion concentration?

-"Harder" problems...................

What is the base/acid ratio in a buffer containing acetic acid and acetate ion, if the buffer has a pH of 5.35?

Properties of Buffers

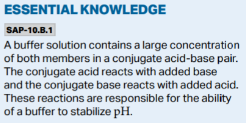


LEARNING OBJECTIVE

SAP-10.B

Explain the relationship between the ability of a buffer to stabilize pH and the reactions that occur when an acid or a base is added to a buffered solution.

- ☐ Once you understand and get good at buffer online homework #77, it is time to move on to online homework#78. These are very good problems that build off yesterday's online homework. Once you determine the pH of the buffer, then you will add either an acid or a base to the buffer. If you add an acid, obviously the pH will decrease (drop 5, 4, 3……). If you add a base, obviously the pH will increase (rise 5, 6, 7………). Complete 5 problems from Properties of Buffers Online Homework #78. Once again, you will need this K values table and **ONLY choose the**



ESSENTIAL KNOWLEDGE

SAP-10.B.1

A buffer solution contains a large concentration of both members in a conjugate acid-base pair. The conjugate acid reacts with added base and the conjugate base reacts with added acid. These reactions are responsible for the ability of a buffer to stabilize pH.

problem if the K value is $1\text{x}10^{-5}$ or smaller so that you can ignore “x” in the RICE Table. See sample problem below…….

Example problem:

A acetic acid buffer solution has the following concentrations:
$[CH_3COOH]$=0.85**M**
$[CH_3COO^-]$=3.0**M**
If 60 mL of 0.3**M** HCl is added to 494 mL of the buffer, what is the resultant pH?

Steps to solve the problem:

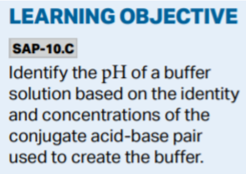
1. Determine the pH of the buffer solution (just like you did in online homework #85). Write the buffer equation correctly. (React the weak with WATER. Do NOT react the weak with its conjugate) Set up your RICE Table, ignore “x”, and solve for the pH.

   *****For the sample problem above, the pH is 5.29.***

2. You are now adding “60 mL of 0.3**M** HCl” to the buffer. Since HCl is an acid, the pH will decrease (drop 5, 4, 3……).

   *****For the sample problem above, the original pH was 5.29. The new pH will be slightly lower…….so just type in 5.28. That is all you have to do. Why doesn’t the pH change more drastically? Well if it is a good buffer, then the pH shouldn’t change much. (The point of a buffer is to resist changes in pH). Can’t you surpass the buffering capacity. Sure, but you’d have to neutralize all of the acid (or base) to do so.***

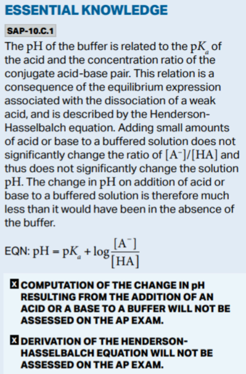
Henderson-Hasselbalch Equation



LEARNING OBJECTIVE

SAP-10.C

Identify the pH of a buffer solution based on the identity and concentrations of the conjugate acid-base pair used to create the buffer.



ESSENTIAL KNOWLEDGE

SAP-10.C.1

The pH of the buffer is related to the pK_a of the acid and the concentration ratio of the conjugate acid-base pair. This relation is a consequence of the equilibrium expression associated with the dissociation of a weak acid, and is described by the Henderson-Hasselbalch equation. Adding small amounts of acid or base to a buffered solution does not significantly change the ratio of $[A^-]/[HA]$ and thus does not significantly change the solution pH. The change in pH on addition of acid or base to a buffered solution is therefore much less than it would have been in the absence of the buffer.

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

☒ **COMPUTATION OF THE CHANGE IN pH RESULTING FROM THE ADDITION OF AN ACID OR A BASE TO A BUFFER WILL NOT BE ASSESSED ON THE AP EXAM.**

☒ **DERIVATION OF THE HENDERSON-HASSELBALCH EQUATION WILL NOT BE ASSESSED ON THE AP EXAM.**

☐ Just simply read these notes:

-The pH of the buffer is related to the pK_a of the acid and the concentration ratio of the conjugate acid-base pair. This relation is a consequence of the equilibrium expression associated with the dissociation of a weak acid, and is described by the Henderson-Hasselbalch equation. Adding small amounts of acid or base to a buffered solution does not significantly change the ratio of [A−]/[HA] and thus does not significantly change the solution pH. The change in pH on addition of acid or base to a buffered solution is therefore much less than it would have been in the absence of the buffer.

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

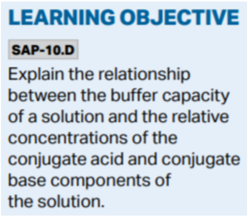
-The Henderson-Hasselbalch equation is a shortcut that can be used in lieu of a RICE Table with Buffer problems. I prefer to use a RICE Table as it demonstrates a greater understanding than simply using the Henderson-Hasselbalch equation as a plug and chug method.

Buffer Capacity

☐ Just simply read these notes:

-Increasing the concentration of the buffer components (while keeping the ratio of these concentrations constant) keeps the pH of the buffer the same but increases the capacity of the buffer to neutralize added acid or base.

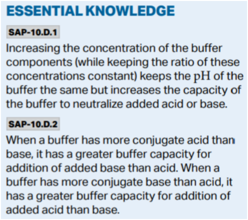
For instance, if you have an acetic acid buffer solution that has the following concentrations:



LEARNING OBJECTIVE

SAP-10.D

Explain the relationship between the buffer capacity of a solution and the relative concentrations of the conjugate acid and conjugate base components of the solution.



ESSENTIAL KNOWLEDGE

SAP-10.D.1

Increasing the concentration of the buffer components (while keeping the ratio of these concentrations constant) keeps the pH of the buffer the same but increases the capacity of the buffer to neutralize added acid or base.

SAP-10.D.2

When a buffer has more conjugate acid than base, it has a greater buffer capacity for addition of added base than acid. When a buffer has more conjugate base than acid, it has a greater buffer capacity for addition of added acid than base.

$[CH_3COOH]$ = 0.85M (weak acid)
$[CH_3COO^-]$ = 3.0M (conjugate base)

The pH will remain the same if you double the concentration of each:

$[CH_3COOH]$ = **1.70M** (weak acid)
$[CH_3COO^-]$= **6.0M** (conjugate base)

However, the buffering capacity will increase meaning you can neutralize more added acid or base.

-When a buffer has more conjugate acid than base, it has a greater buffer capacity for addition of added base than acid. When a buffer has more conjugate base than acid, it has a greater buffer capacity for addition of added acid than base.

For instance, if you have an acetic acid buffer solution that has the following concentrations:

$[CH_3COOH]$ = 0.85M (weak acid)
$[CH_3COO^-]$ = 3.0M (conjugate base)

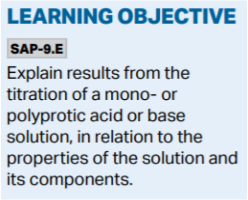
The buffer will be more equipped to neutralize an added acid (because you have 3.0M of the conjugate base as compared to ONLY 0.85M of the weak acid)

If, however, you have an acetic acid buffer solution that has the following concentrations:

$[CH_3COOH]$ = 2.0M (weak acid)
$[CH_3COO^-]$ = 1.0M (conjugate base)

The buffer will be more equipped to neutralize an added base (because you have 2.0M of the weak acid as compared to ONLY 1.0M of the conjugate base)

Acid-Base Titrations



LEARNING OBJECTIVE

SAP-9.E

Explain results from the titration of a mono- or polyprotic acid or base solution, in relation to the properties of the solution and its components.

Strong Acid - Strong Base Titrations

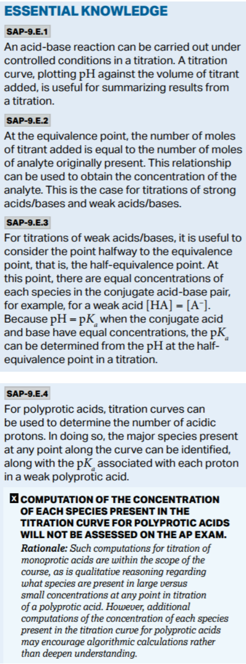
- ☐ Watch video 17.3 Strong Acid - Strong Base Titrations
- ☐ Read through the Strong Acid-Strong Base Titration Ppt
- ☐ Complete the Strong Acid - Strong Base Titration Quick Review Problems (Click here for KEY)

  UPLOAD Your Work HERE *(Before uploading, make sure your work has your name, period number on it, and your camera lens is clean. Thank you!)*

Weak Acid - Strong Base Titrations (or Weak Base - Strong Acid)

- ☐ Read these notes:

  In most of the following videos, milli moles (mmol) are used in the RICE table instead of molarity (M). I would suggest always using Molarity (M) in a RICE table as you will most likely have to convert to Molarity anyway. So, you might as well convert to Molarity right away at the beginning of the problem so you don't forget to convert to



ESSENTIAL KNOWLEDGE

SAP-9.E.1

An acid-base reaction can be carried out under controlled conditions in a titration. A titration curve, plotting pH against the volume of titrant added, is useful for summarizing results from a titration.

SAP-9.E.2

At the equivalence point, the number of moles of titrant added is equal to the number of moles of analyte originally present. This relationship can be used to obtain the concentration of the analyte. This is the case for titrations of strong acids/bases and weak acids/bases.

SAP-9.E.3

For titrations of weak acids/bases, it is useful to consider the point halfway to the equivalence point, that is, the half-equivalence point. At this point, there are equal concentrations of each species in the conjugate acid-base pair, for example, for a weak acid $[HA] = [A^-]$. Because $pH = pK_a$ when the conjugate acid and base have equal concentrations, the pK_a can be determined from the pH at the half-equivalence point in a titration.

SAP-9.E.4

For polyprotic acids, titration curves can be used to determine the number of acidic protons. In doing so, the major species present at any point along the curve can be identified, along with the pK_a associated with each proton in a weak polyprotic acid.

☒ **COMPUTATION OF THE CONCENTRATION OF EACH SPECIES PRESENT IN THE TITRATION CURVE FOR POLYPROTIC ACIDS WILL NOT BE ASSESSED ON THE AP EXAM.**

Rationale: *Such computations for titration of monoprotic acids are within the scope of the course, as is qualitative reasoning regarding what species are present in large versus small concentrations at any point in titration of a polyprotic acid. However, additional computations of the concentration of each species present in the titration curve for polyprotic acids may encourage algorithmic calculations rather than deepen understanding.*

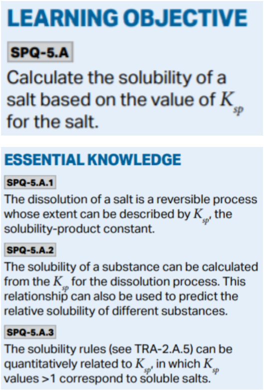
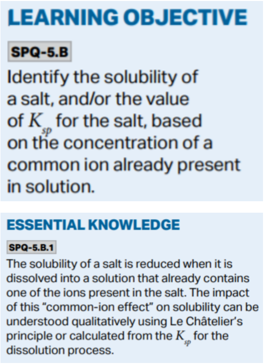
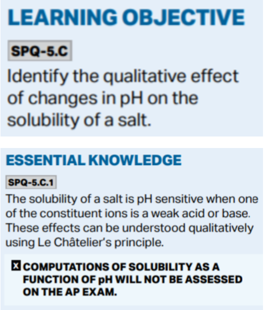
Molarity at the end of the problem.

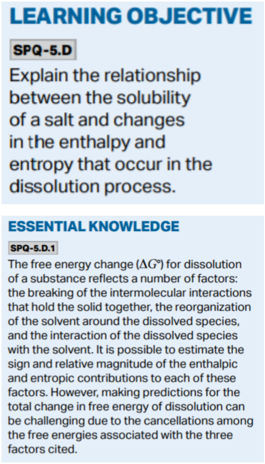
- ☐ Watch video 17.3.2 Weak Acid - Strong Base Titration #1
  -This covers "before" the titration even begins
- ☐ Watch video 17.3.3 Weak Acid - Strong Base Titration #2
  -This covers the "buffer region" (before the equivalence point of the titration)
- ☐ Watch video 17.3.4 Weak Acid - Strong Base Titration #3
  -This covers a special point in the "buffer region" known as the "Half-way Point" (After watching the video you should know why it is called the Half-way Point)
- ☐ Watch video 17.3.5 Weak Acid - Strong Base Titration #4
  -This covers at the "equivalence point"
- ☐ Watch video 17.3.6 Weak Acid - Strong Base Titration #5
  -This covers "after" the equivalence point
  ***After the equivalence point, you have both OH$^-$ and the conjugate base A$^-$. However, it is like a group project - usually only one person does the work…..only OH$^-$ really contributes to the pH and the A$^-$ just puts its name on the paper. (Aka…..“Social Loafers”)*
- ☐ Watch video 17.3.7 Weak Acid - Strong Base Titration #6
  -This covers what the overall titration looks like
- ☐ Read through the Weak Acid-Strong Base Titration Ppt
  ***After the equivalence point, you have both OH$^-$ and the conjugate base A$^-$. However, it is like a group project - usually only one person does the work…..only OH$^-$ really contributes to the pH and the A$^-$ just puts its name on the paper. (Aka…..“Social Loafers”)*
- ☐ Complete the Weak Acid - Strong Base Titration Quick Review Problems (Click here for KEY)
  ****UPLOAD Your Work HERE**** *(Before uploading, make sure your work has your name, period number on it, and your camera lens is clean. Thank you!)*

Salts (K_{sp}) - Part B

1. Go through the videos, notes, and online homeworks in the table below.

Salts	
Topics Covered	**Assignments**

Intro to Solubility Equilibria  **LEARNING OBJECTIVE** **SPQ-5.A** Calculate the solubility of a salt based on the value of K_{sp} for the salt. **ESSENTIAL KNOWLEDGE** **SPQ-5.A.1** The dissolution of a salt is a reversible process whose extent can be described by K_{sp}, the solubility-product constant. **SPQ-5.A.2** The solubility of a substance can be calculated from the K_{sp} for the dissolution process. This relationship can also be used to predict the relative solubility of different substances. **SPQ-5.A.3** The solubility rules (see TRA-2.A.5) can be quantitatively related to K_{sp}, in which K_{sp} values >1 correspond to soluble salts.	☐ Watch Video 17.4 ☐ Watch Video 17.4.2 ☐ Watch Video 17.4.3 ☐ Read these notes: -The dissolution of a salt is a reversible process whose extent can be described by K_{sp}, the solubility-product constant. -The solubility of a substance can be calculated from the K_{sp} for the dissolution process. This relationship can also be used to predict the relative solubility of different substances -The solubility rules can be quantitatively related to K_{sp}, in which K_{sp} values greater than one ($K_{sp} > 1$) correspond to soluble salts (Group 1 ANA). ☐ Watch Mr. Kiffe's Online Hwk#37 (aka#90) Video Help ☐ Complete 5 problems from Slightly Soluble Salts Online Homework #90 (*Make sure K_{sp} values have 3 sig figs for this online hwk*)
Common Ion Effect  **LEARNING OBJECTIVE** **SPQ-5.B** Identify the solubility of a salt, and/or the value of K_{sp} for the salt, based on the concentration of a common ion already present in solution. **ESSENTIAL KNOWLEDGE** **SPQ-5.B.1** The solubility of a salt is reduced when it is dissolved into a solution that already contains one of the ions present in the salt. The impact of this "common-ion effect" on solubility can be understood qualitatively using Le Châtelier's principle or calculated from the K_{sp} for the dissolution process.	☐ Watch Video 17.1 ☐ Read these notes: -The solubility of a salt is reduced when it is dissolved into a solution that already contains one of the ions present in the salt. The impact of this "common-ion effect" on solubility can be understood qualitatively using Le Châtelier's principle or calculated from the K_{sp} for the dissolution process. ☐ Complete 5 problems from Solubility & The Common Ion Effect Online Hwk #92 (*For the first couple problems, just click the "Show Answer" button to see how to solve these type of problems)* ☐ Complete 5 problems from Predicting Precipitation Online Hwk #91 (*For the first couple problems, just click "Yes" or "No" to see how to solve these type of problems)*
pH & Solubility  **LEARNING OBJECTIVE** **SPQ-5.C** Identify the qualitative effect of changes in pH on the solubility of a salt. **ESSENTIAL KNOWLEDGE** **SPQ-5.C.1** The solubility of a salt is pH sensitive when one of the constituent ions is a weak acid or base. These effects can be understood qualitatively using Le Châtelier's principle. ☒ **COMPUTATIONS OF SOLUBILITY AS A FUNCTION OF pH WILL NOT BE ASSESSED ON THE AP EXAM.**	☐ Watch Video 17.5.2 ☐ Read these notes: -The solubility of a salt is pH sensitive when one of the constituent ions is a weak acid or base. These effects can be understood qualitatively using Le Châtelier's principle.
Free Energy of Dissolution	☐ Read these notes: -The free energy change (ΔG°) for dissolution of a substance reflects a number of factors: the breaking of the intermolecular interactions that hold the solid together, the reorganization of the solvent around the dissolved species, and the interaction of the dissolved species with the solvent. It is possible to estimate the sign and relative magnitude of the enthalpic and entropic contributions to each of

 **LEARNING OBJECTIVE** SPQ-5.D Explain the relationship between the solubility of a salt and changes in the enthalpy and entropy that occur in the dissolution process. **ESSENTIAL KNOWLEDGE** SPQ-5.D.1 The free energy change ($\Delta G°$) for dissolution of a substance reflects a number of factors: the breaking of the intermolecular interactions that hold the solid together, the reorganization of the solvent around the dissolved species, and the interaction of the dissolved species with the solvent. It is possible to estimate the sign and relative magnitude of the enthalpic and entropic contributions to each of these factors. However, making predictions for the total change in free energy of dissolution can be challenging due to the cancellations among the free energies associated with the three factors cited.	these factors. However, making predictions for the total change in free energy of dissolution can be challenging due to the cancellations among the free energies associated with the three factors cited.

2. If you have extra time this week, then……
    a. Complete the 2019 AP Chemistry FRQ. (Once finished, check your answers using the KEY.)