DEEP BREATHS...KEEP CALM...
KEEP YOUR HEAD ON STRAIGHT...YOU <u>CAN</u> DO THIS!

If you can do these calculations, you will know more than most students in the country! Is it possible College Board will throw something weird at you? Sure...but if you can do <u>most</u> of the acid base problems, you will be in <u>great</u> shape! We are climbing "Mount Hard Stuff" as another teacher nicknamed this chapter. You are almost to the top, and it will be an easy trek down the mountain once we start to review old chapters for the real AP test. You have learned <u>SO</u> much, and you <u>can</u> learn this stuff too!
<u>This is when your perseverance needs to shine!</u>


CALCULATIONS

List made assuming you are titrating an acid with a base. You should be able to do the same things if you are titrating a base with an acid. I'm not going to write the entire list twice, just flip acid and base in your head :-)

REMEMBER – you may not know how to do part b of an FRQ, but you might know how to do part c, or d, or e of the same FRQ! Don't forget to skip around if needed!

1. Calculate the $[H^+]$ and pH in a solution **before a titration**.
   a. Strong acid – regular pH calculation
   b. Weak acid – ICE Table then pH calculation

2. Calculate the pH after titrating with a little bit of base.
   IN BUFFER REGION - a position before the ½ equivalence point.
   a. Stoich to see how much HA is used up, how much A^- is made
      i. Either ICE Table with common ion effect, or He-Ha

3. Calculate the moles and/or **volume of titrant needed to reach the equivalence point**,
   OR use the volume of titrant used to calculate the moles of acid and then concentration of acid originally present
   a. Dimensional Analysis, solution calculation type problem
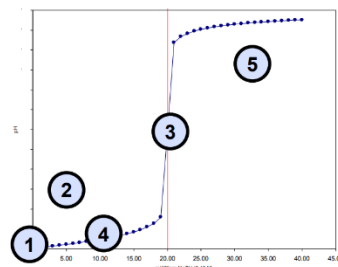
   Calculate the **pH at the equivalence point**.
   a. All HA is used up. All turned into A^-. See if A^- will hydrolyze (if titrating weak acid or base it will!)
   b. New ICE table with $A^- + H_2O \rightarrow HA + OH^-$
      i. Use the $[A^-]$ once all HA was used up
         1. If you had 0.20 M HA to start, at equivalence point $[A^-]$ = 0.20 M
   c. pH calculation using $[OH^-]$ you find in ICE Table

4. Determine the **pH at the ½ equivalence point**.
   a. pH = pKa at the ½ equivalence point – if you have the K_a then do $-\log(K_a)$
   b. If you don't have the pK_a then find volume of base added to reach equivalence point, go to half that volume, and see what the pH is at that volume
   c. If you are trying to find the pK_a from the graph, find the pH at the ½ equivalence point and that is the pK_a

<u>Examples</u>
1) A monoprotic acid (HA) has a $K_a = 2.04 \times 10^{-6}$. A 25.00 mL sample of 0.600 M acid is titrated with 0.300 M NaOH.
   a. Calculate the $[H^+]$ and the pH of the original acid solution.
   b. Calculate the pH after 15.00 mL of NaOH have been added.
   c. Determine the pH at the half-equivalence point of the titration.
   d. Find the volume of NaOH solution needed to reach the equivalence point for the titration.
   e. Calculate the pH at the equivalence point.

2) A monoprotic acid (HA) has a $K_a = 1.38 \times 10^{-5}$. A 30.00 mL sample of 0.350 M acid is titrated with 0.160 M NaOH.
   a. Calculate the $[H^+]$ and the pH of the original acid solution.
   b. Calculate the pH after 10.00 mL of NaOH have been added.
   c. Determine the pH at the half-equivalence point of the titration.
   d. Find the volume of NaOH solution needed to reach the equivalence point for the titration.
   e. Calculate the pH at the equivalence point.

CONCEPTUAL QUESTIONS

Don't forget to study these kinds of things too! You can scrounge up a lot of points even if you don't know how to do the titration calculations!

1. Know your strong and weak acids!
    a. Strong acids dissociate enough to consider them "fully" dissociated. Large K values.
    b. Weak acids do not dissociate very much. Small K values. Will dissociate more the more diluted they are.
    c. Need to identify if you are titrating strong or weak substances.

2. Sources of Lab Error
    a. You should always rinse the burette twice with your titrant.
        i. If you have leftover water in the burette it will dilute the titrant. Meaning you will need to use more to reach the equivalence point. Which makes it appear as though your titrand was a higher concentration than it actually was.
    b. Remember – the end point is not the same as the equivalence point!
        i. End point is when the color of an indicator changes.
        ii. Equivalence point is where moles H^+ = moles OH^-
        iii. The better your indicator choice, and the better your titration technique, the more accurate the end point will be.
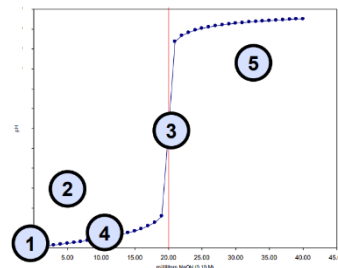
3. pH at equivalence point

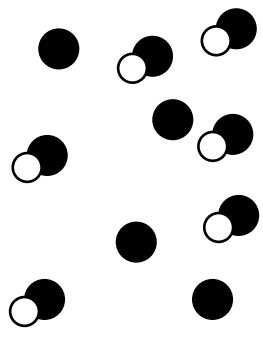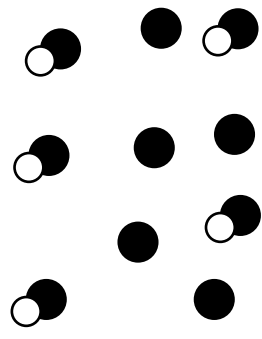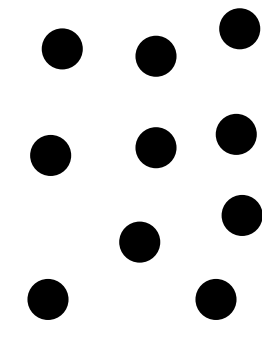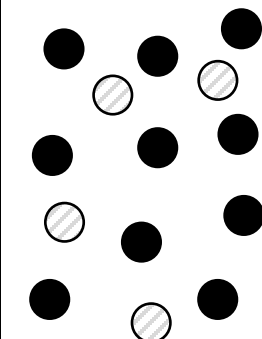| Strong Acid + Strong Base	pH = 7
Weak Acid + Strong Base	pH > 7
Weak Base + Strong	pH < 7
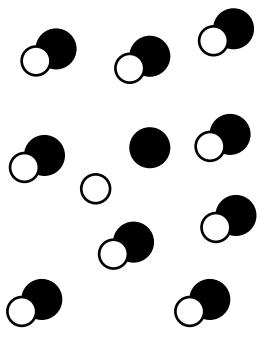
4. Which species is higher [ ] at different points in the curve
Weak Acid + Strong Base

5. Particle Diagrams
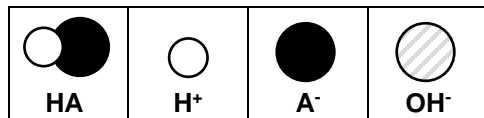
Remember – they are numbered out of order because you often need to find the volume at the equivalence point before you can find what the ½ equivalence point is!

| | HA | H⁺ | A⁻ | OH⁻ |

①	②	④	③	⑤
before titration	before ½ eq. pt.	½ equivalence pt.	equivalence pt.	past eq. pt
[HA] > [A⁻]	**[HA] > [A⁻]**	**[HA] = [A⁻]**	**[A⁻] dominant** **[HA] = 0**	**[HA] = 0**
• Weak acid, small amount of dissociation (sometimes they won't even include any particles having dissociated) • No OH⁻ added yet	• OH⁻ has reacted with some H⁺ to form water, leaving some A⁻ in sol'n • No leftover OH⁻ yet	• ½ of the HA has reacted with OH⁻, leaving ½ the partcles as A⁻ in sol'n • ½ the HA remains • No leftover OH⁻ yet	• mol OH⁻ added = original mol HA • All the HA turned into A⁻ (and now A⁻ can go on to hydrolyze!) • still no extra OH⁻ particles in solution yet	• All the HA turned into A⁻ • **And now you <u>finally</u> have extra OH⁻ in solution!**

*Sometimes they will also show the spectator ion that comes with the titrant (like Na⁺ when using NaOH. I did not include those here)