Weak acid by strong base titrations

**Question:** Sketch a generic titration curve for a weak acid by strong base titration.

**Answer:**

**Points on weak acid by strong base titration curve:**

1. Before strong base is added this is a weak acid problem.
2. After strong base is added and up to just before the equivalence point, this is a buffer problem. The effect of adding OH\(^-\) is to convert the weak acid into its conjugate base. Between the initial point and the equivalence point, both HA and A\(^-\) are present, hence a buffer. At halfway to equivalence just enough OH\(^-\) has been added to convert one-half of the weak acid into its conjugate base, therefore [HA] = [A\(^-\)] so pH = pK\(_a\).
3. At the equivalence point, this is a weak base calculation. Just enough strong base has been added to convert all the weak acid, HA into its conjugate base, A\(^-\). Only A\(^-\), Na\(^+\) and H\(_2\)O remain. At the equivalence point in a weak acid by strong base titration, the pH is always greater than 7.0 because a weak base is always present (the conjugate base of the original weak acid).
4. After the equivalence point, strong base is in excess. This is a strong base problem. Figure out how much OH\(^-\) is present, then calculate pH. There are two bases present at this point (A\(^-\) and OH\(^-\)) but the pH is determined by the strongest base. The contribution of OH\(^-\) by the weak base is negligible as compared to the excess strong base present.

**Things to remember when performing weak acid by strong base calculations:**

1. These types of calculations usually involve two problems in one. First a stoichiometry problem, which involves the strong base reacting
with the weak acid. Since a strong base is reacting, the reaction goes to completion, hence the stoichiometry problem. After the stoichiometry part of the calculation, see what is remaining in solution to determine the type of problem i.e. buffer, weak base or strong base problem.

2. Work with mmoles or moles instead of concentrations.
3. First calculate the volume of base necessary to reach the equivalence point. This will allow you to determine what type of problem you should have at each volume point.

**Question Chapter 15 #57**

A 25.0 mL sample of 0.100 M lactic acid (HC₃H₅O₃, pKₐ = 3.86) is titrated with 0.100 M NaOH. Calculate the pH after the addition of:

(a) 0.0 mL  
(b) 8.0 mL  
(c) 12.5 mL  
(d) 20.0 mL  
(e) 25.0 mL  
(f) 30.0 mL

**Answer:**
Weak base by strong acid titrations

**Question:** Sketch a generic titration curve for a weak base by strong acid titration.

**Answer:**

**Points on titration curve:**

1. Before any strong acid is added this is a weak base problem.
2. After strong acid is added and up to just before the equivalence point, this is a buffer problem. At halfway to the equivalence point $pH = pK_a$.
3. At the equivalence point this is a weak acid problem.
4. Past the equivalence point this is a strong acid problem.

**Question Chapter 15 # 59**

A 25.0 mL sample of 0.100 M $\text{NH}_3 \ (K_b = 1.8 \times 10^{-5})$ was titrated with 0.100 M $\text{HCl}$. Calculate the pH at the following volumes of strong acid added:

(a) 0.0 mL
(b) 12.5 mL
(c) 25.0 mL

**Answer:**
Now you should be able to look at any titration curve and label it either as strong acid by strong base, strong base by strong acid, weak acid by strong base, or weak base by strong acid.

You should be able to determine the major species present at any point in the various curves and to calculate pH at any point for any of the various types of titrations.

Extra Problems:

**Chapter 15 #130**

A 0.210 g sample of an acid (molar mass = 192 g/mol) is titrated with 30.5 mL of 0.108 M NaOH to a phenolphthalein end point. Is the acid monoprotic, diprotic or triprotic?

**Chapter 15 #132**

A student titrates an unknown weak acid, HA, to a pale pink phenolphthalein end point with 25.0 mL of 0.100 M NaOH. The student then adds 13.0 mL of 0.100 M HCl. The pH of the resulting solution is 4.7. How is the value of pKa for the unknown acid related to 4.7?