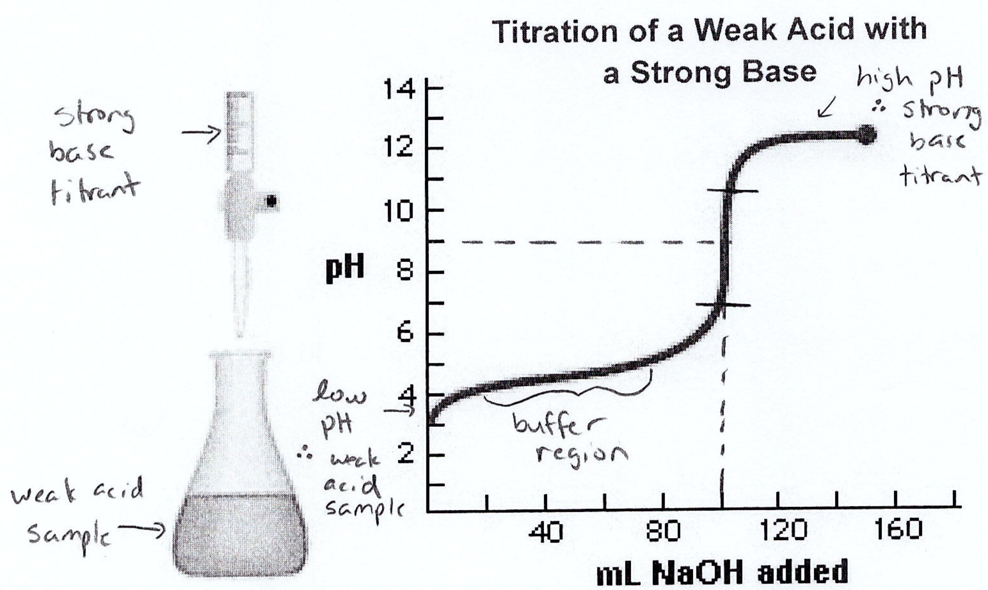
Titration or pH Curves

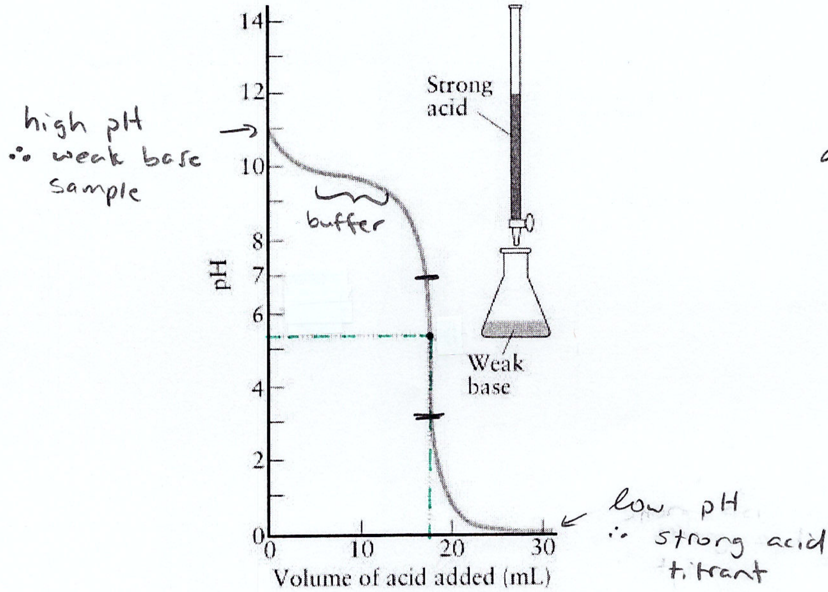
- The concentration of H_3O^+ ions or OH^- ions in a solution can be determined experimental using *titration curves* or *pH curves*
- During an acid-base titration, as a weak base sample is titrated with a strong acid titrant (or vice versa) the pH of the sample solution is constantly being measured and recorded.
  - With acid-base titrations, the titrant continues to be added even well past the **end point** (the point in which a color change in the sample can be observed)
  - A graph showing how the pH of the solution changed in relation to the amount of titrant added is then used to calculate the concentration of the of H_3O^+ ions or OH^- ions in the original sample. This graph is called a **pH curve** or **titration curve.**
- Let's analyze two different pH/titration curves



*The *equivalence point* is when the moles in the sample are equal to the moles of the titrant added.

use phenolphthalein indicator

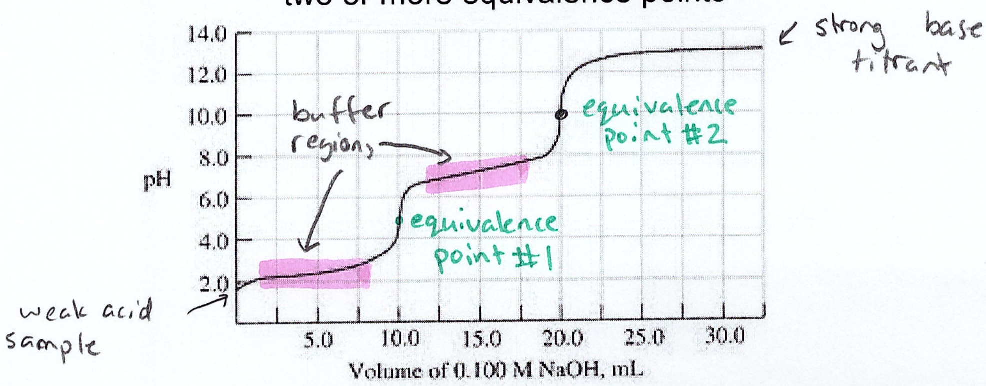
Graph Information	Location on Graph	Analysis of Example
Sample Type	Indicated by the initial pH reading because no titrant has been added yet	weak acid
Titrant Type *always strong!*	Indicated by final pH reading because the solution is just excess titrant	strong base
*Equivalence Point**	The midway point on the vertical section of the graph	occurs at pH of 9 & titrant volume of 100mL.
Buffer Region	After a small amount of strong base is added, a buffer will form and the pH of the solution will remain somewhat constant even when more strong base is added	see graph



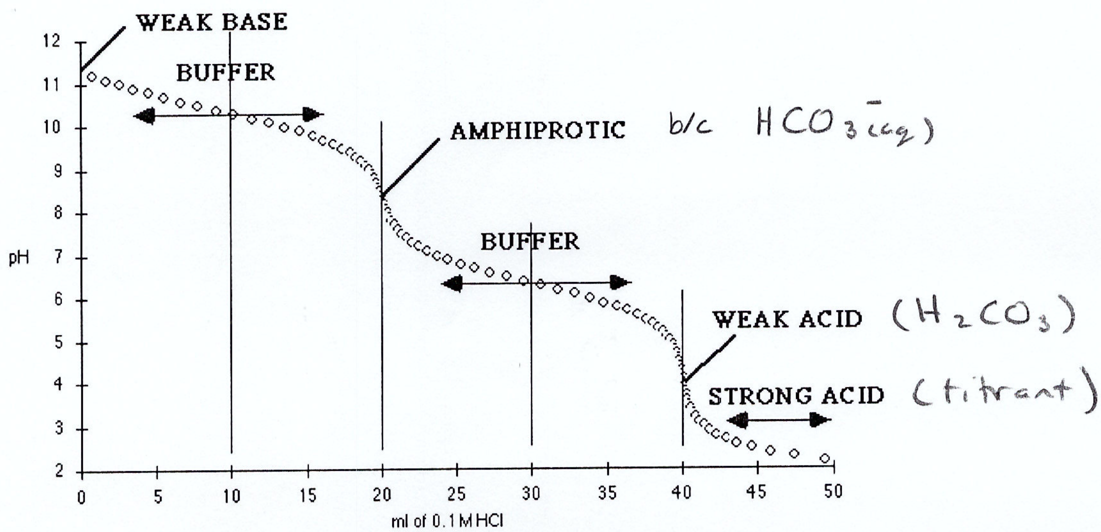
use methyl red as best indicator

Graph Information	Location on Graph	Analysis of Example
Sample Type	Indicated by the initial pH reading because no titrant has been added yet	weak base
Titrant Type	Indicated by final pH reading because the solution is just excess titrant	strong acid
Equivalence Point*	The midway point on the vertical section of the graph	pH of 5.3 ∴ titrant volume of 18 mL
Buffer Region	After a small amount of strong base is added, a buffer will form and the pH of the solution will remain somewhat constant even when more strong base is added	see graph

- Polyprotic substances can also be titrated with a strong acid/base and can produce titration/pH curves that can be analyzed in the same fashion as the previous two curves.
  - The only difference is that since a polyprotic substance can lose or gain more than one hydrogen ion (H^+), the titration/pH curve will have two or more equivalence points



TITRATION OF $CO_3^{2-}{}_{(aq)}$ WITH $HCl_{(aq)}$



- With acid-base titrations, an indicator is needed to observe the end point
  - Acid/base **indicators** are weak acids. Therefore, they will have a small acid ionization constant (K_a) and will establish equilibrium
  - The indicator/weak acid is one color and the conjugate base is another color

- EXAMPLE: Write out the Bronsted-Lowry equation for phenol red indicator. Use the equilibrium to predict which way the equilibrium will shift when a strong base is added. What observations would you see? ↳ Le Chatelier's principle!

$$\underset{\text{yellow}}{HPr_{(aq)}} + H_2O_{(l)} \rightleftharpoons \underset{\text{red}}{Pr^-_{(aq)}} + H_3O^+$$

- adding a strong base (OH^-) will decrease H_3O^+, ∴ equilibrium will shift right ∴ you will observe a more red color

- Each indicator has a specific pH range (see data book pg. 10) in which that indicator will change color. Therefore, an appropriate indicator for an acid-base titration is one that has a pH range that includes the pH at the equivalence point
  - EXAMPLE: Select appropriate indicators for the two previous titration curves that we analyzed.

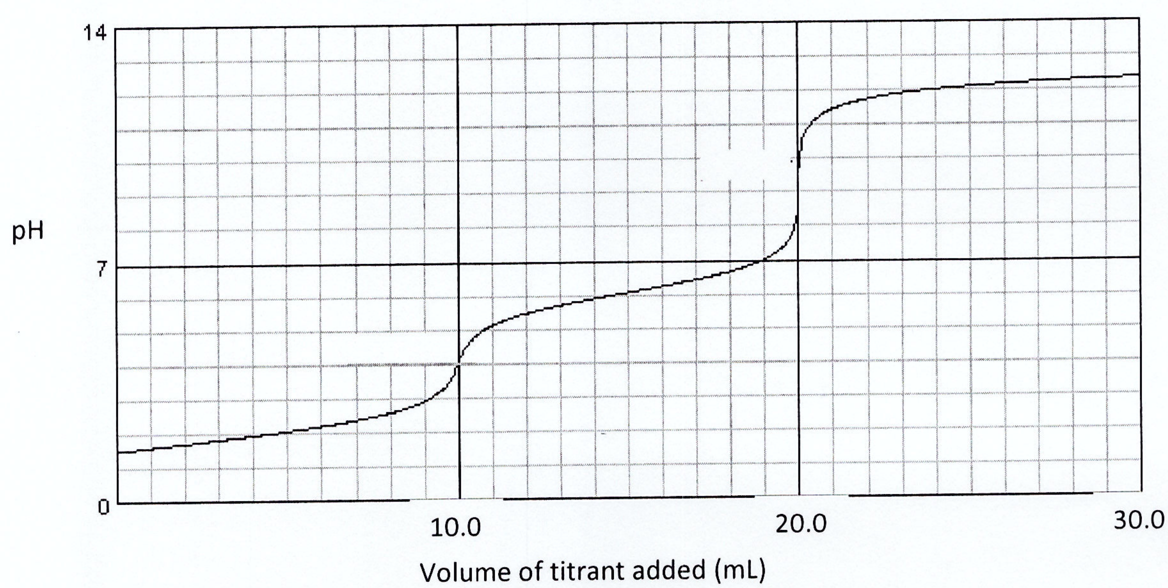
*****Now try Practice Problems*****

Practice Problems

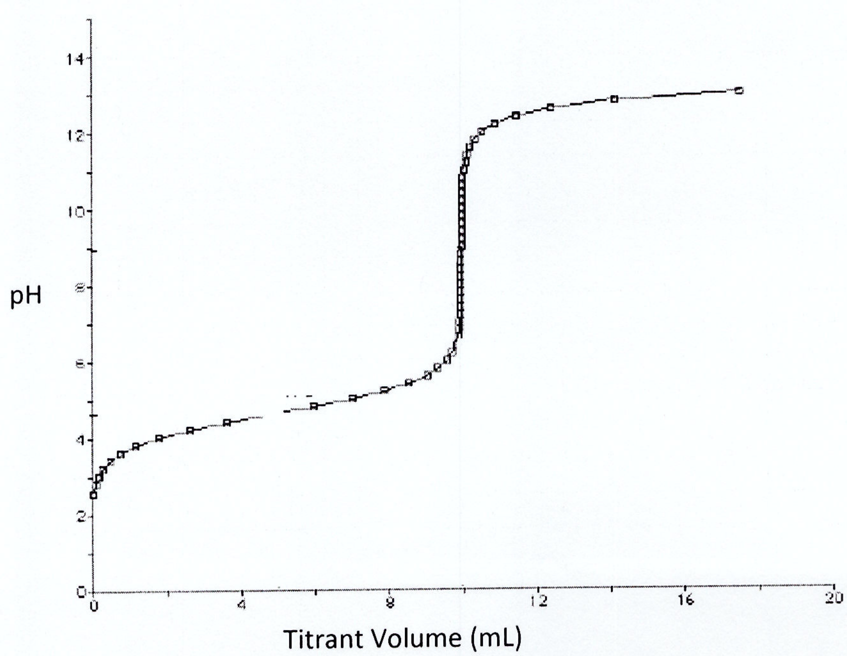
Answer the next questions for all of the different titration curves.

a) What is the type of sample that is being titrated (weak acid or weak base)?
b) What is the type titrant (strong acid or strong base)?
c) What is the pH at the equivalence point/s?
d) What is an appropriate indicator to use for this titration for each equivalent point?
e) Identify the regions on the graph where a buffer exists.

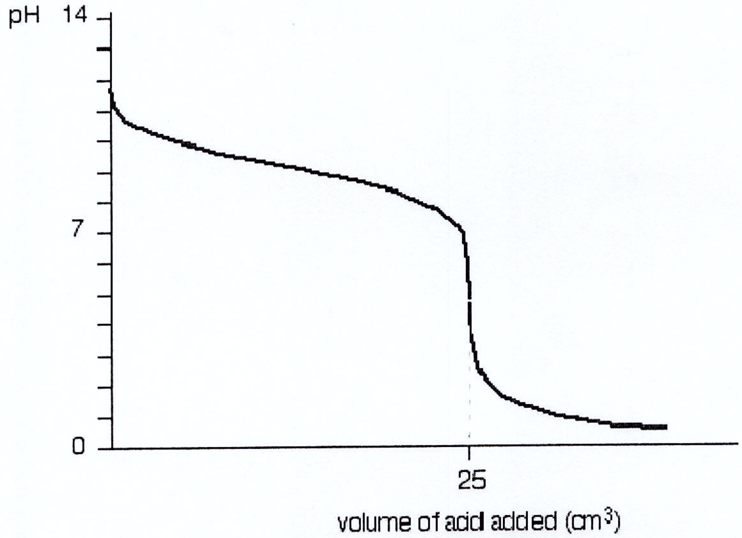
1.



2.



3.



Solutions

1.

a. Weak acid
b. Strong base
c. pH = 4 and pH = p
d. 1st Equivalence point use bromocresol green. 2nd equivalence point use phenolphthalein
e. Buffer exists when a volume of titrant added is 1-8 mL and 12-18 mL

2.

a. Weak acid
b. Strong base
c. pH = 9
d. Phenolphthalein
e. Buffer exists when a volume of titrant added is 2-8 mL

3.

a. Weak base
b. Strong acid
c. pH = 4
d. bromocresol green
e. Buffer exists when a volume of titrant added is approximately 4-20 cm^3