Titration!

What is titration?

Simply put, a titration is a very controlled neutralization reaction to determine the concentration of an unknown acid or base.

How Titrations are done

In order to perform titration, you will have an acid/*base with* ***unknown*** *concentration* and *an acid/base with* ***known*** *concentration (called Standard solution).*

A set amount of the unknown solution is placed in the Erlenmeyer flask with couple drops of the pH indicator (ex. Phenolphthalein).

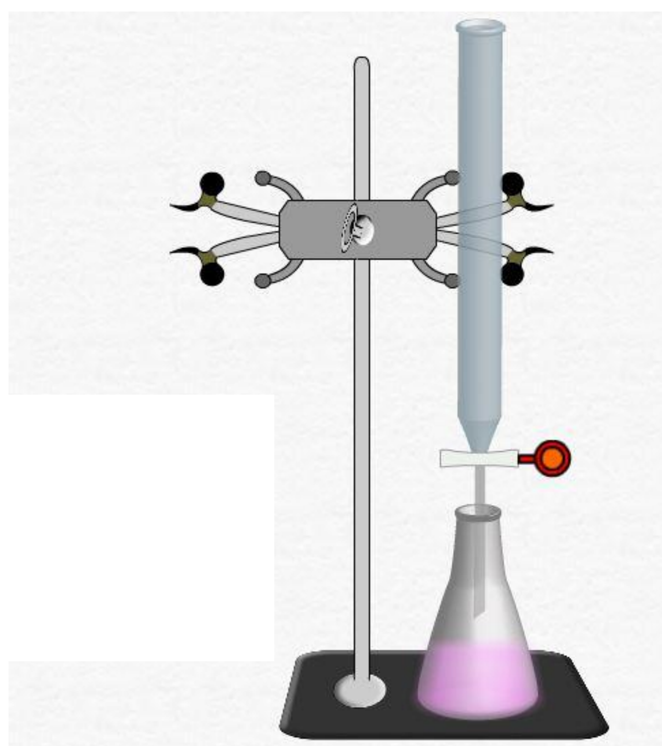
The Standard solution is then placed in the Buret and carefully dispensed into the Erlenmeyer flask.

The titration is “completed” when the solution changes colour due to the pH indicator.

The amount of the Standard Solution (known concentration) is then recorded for calculation.

Titration Setup:

- Stand
- Buret Clamp
- Buret
- Funnel
- Erlenmeyer Flask
- Acid / Base Indicator
- Sometimes a white piece of paper at the bottom of the Erlenmeyer flask for visibility



The Theory Behind Titrations

When the solution of unknown concentration is mixed with the standard solution (known concentration), the reaction is essentially a neutralization reaction. Therefore, when there is an equal number of [H+] and [OH-], this is the neutralization point or the *equivalence point*.

The reason we use a pH indicator is to visually see when the *equivalence point* has occurred since a pH indicator changes colour at a specific pH range. Once the pH indicator has changed its colours, it has reached its ***end point*** and no further colour change will occur. It is important to choose a pH indicator that changes colour at the ***equivalence point*** of the acid / base. (see below).

Once we have determined the amount of solution is required to reach the end point, we can use the volume used and determine the number of moles used.

With the number of moles of the known calculated, we can use stoichiometry to calculate the amount of the unknown in the solution.

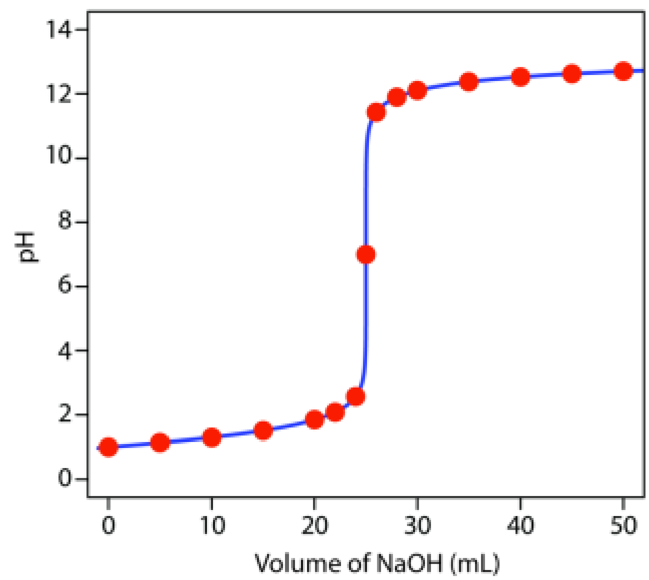
Titration Curves:

When we collect the data of the amount of Standard has been dispensed to the pH change, we get a titration curve. An example of a titration curve of HCl and NaOH is depicted on the diagram on the right.

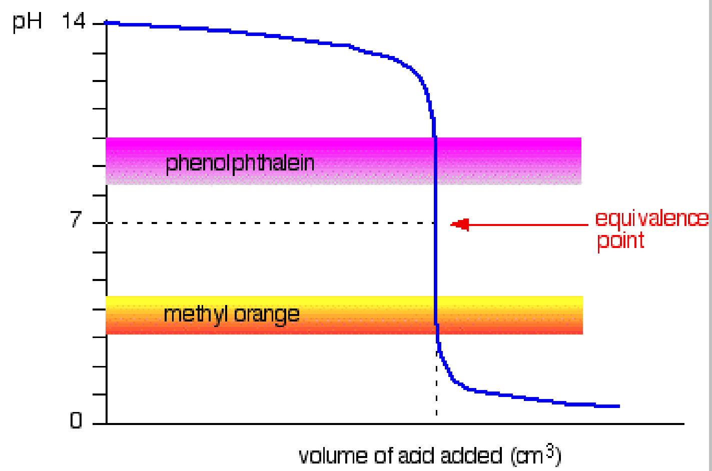
The titration curve on the right is generated by dispensing a standard solution of base with an unknown concentration of an acid.

In the middle of the curve at about pH of 7 and 25ml of NaOH, the equivalence point of this particular titration was achieved. Since HCl and NaOH is a strong acid / strong base neutralization reaction, the equivalence point is at pH of 7.

However, if the reaction is between a strong acid and a weak base or a strong base and a weak acid, the equivalence point will not be at a pH of 7 and another indicator instead of phenolphthalein will need to be used.



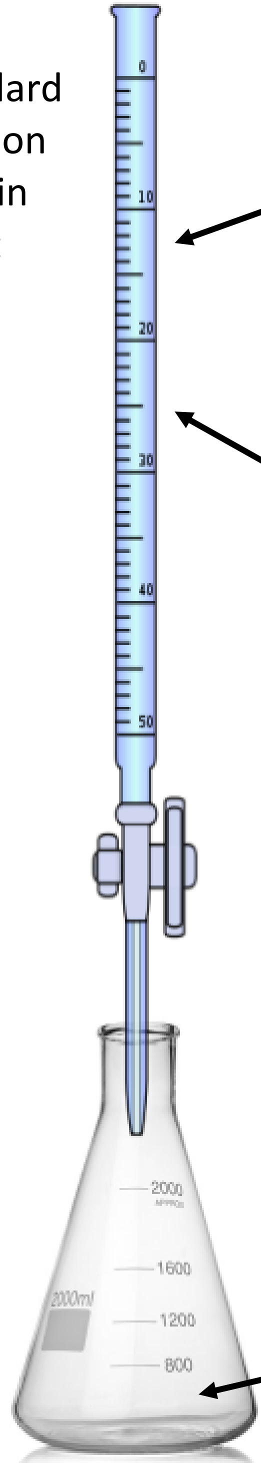
Titration between a strong acid and strong base

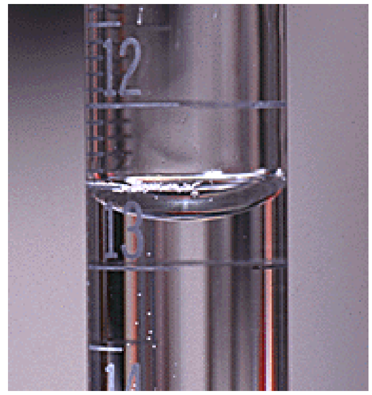


pH indicator phenolphthalein is used because it changes colours near the equivalence point

Titration setup:

Standard solution goes in buret





Initial Reading of buret: ~12.6ml

Final Reading of buret: ~24.2ml

Amount of standard solution used

24.2 – 12.6 **= 11.6ml**

Unknown solution with a known volume in here with pH indicator

Example question:

You are to determine an unknown concentration of HCl (strong acid) by using NaOH as the standard solution for your titration. Here are the results collected from your titration:

	Unknown Acid (HCl)	Standard solution (0.1 M NaOH)
Initial Reading of Buret		0.62ml
Final Reading of Buret		14.45ml
Volume	11.44ml Used (in Erlenmeyer flask)	13.84ml (subtract)

1. Calculate the volume used:

   14.45ml – 0.62ml = 13.84ml of 0.1M NaOH (standard solution) was used.

2. Calculate the moles of standard solution used:

13.84ml → 0.01384L (we need L for molarity calculation)

Therefore, the number of moles is M = mol/L

Mol = M * L

Mol = 0.1M (Known concentration) * 0.01384L

Mol of NaOH used = 0.001384moles

3. Use stoichiometry to calculate the number of moles of acid:

   NaOH + HCl → NaCl + H_2O

   Since it is a 1:1 ratio, there number of moles of HCl is 0.001384moles

   Note: NOT ALL TITRATION REACTIONS ARE 1:1

4. We can determine the concentration by dividing the moles of acid by the volume:

   M = mol / L

   M = 0.001384mol / 0.01144L

   M = 0.121mol/L of HCl was in the solution

Example 2:

A sample of acetic acid (weak acid) is titrated with a 0.990 mol/L sodium hydroxide solution to determine the concentration of acetic acid. The following data was collected from the titration:

	Base Buret			Acid Buret		
	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
Final Reading (ml)	11.87	18.33	27.97			
Initial Reading (ml)	0.24	11.88	18.35			
Actual volume used (ml)				13.86	7.86	11.49

a. Calculate the concentration of the acetic acid solution for each trial.

b. Calculate the average concentration of acetic acid