Chemistry Lecture #97: Neutralization Reactions and Titration

An acid solution contains more H^+ than OH^-. An acid solution can be neutralized by adding a base, which contains OH^-. The added OH^- reacts with the excess H^+ to form H_2O.

$$H^+ + OH^- \longrightarrow H_2O$$

Acids and bases neutralize each other to form water and salt. Salt is a crystal composed of the negative ion of an acid and the positive ion of a base.

Here's an example of a neutralization reaction:

$$HCl + NaOH \longrightarrow H_2O + NaCl$$

In this reaction, the H^+ from HCl combines with the OH^- from NaOH to form H_2O. If the water is evaporated, the Na^+ from NaOH combines with the Cl^- from HCl to form NaCl, also known as common table salt.

Here are some more neutralization reactions that produce water and salt:

$$H_2SO_4 + 2KOH \longrightarrow 2H_2O + K_2SO_4$$

$$2HNO_3 + Ca(OH)_2 \longrightarrow 2H_2O + Ca(NO_3)_2$$

$$H_2CO_3 + 2NH_4OH \longrightarrow 2H_2O + (NH_4)_2CO_3$$

$$HC_2H_3O_2 + NaOH \longrightarrow H_2O + NaC_2H_3O_2$$

How can you tell if an acid solution has been neutralized? One way to do it is to add an indicator. This is a substance that changes color when the pH of a solution reaches a certain level.

Phenolphthalein is an indicator that changes from a clear to a pink color when a solution becomes slightly basic. This means that the indicator will not change color when $[H^+]$ exactly equals $[OH^-]$. But it does change color when the two concentrations are very close, so we use it to get a general measure of when an acid solution has been neutralized.

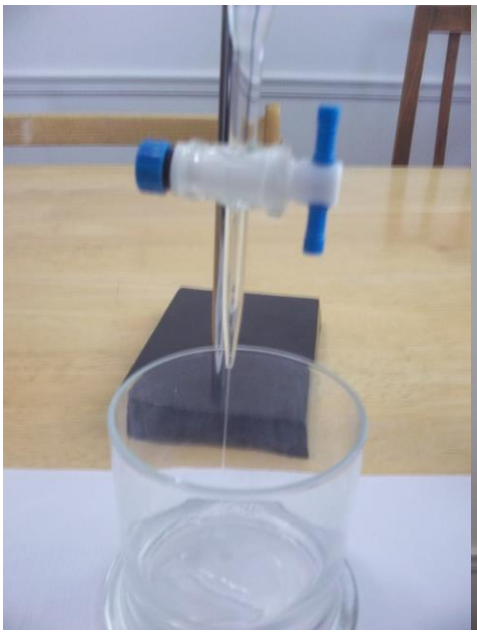
If we know the concentration of the base that neutralized an acid, we can determine the concentration of the acid. This is done through a process called titration. Acid titration is where a basic solution of known concentration is slowly added to an acid solution of unknown concentration. When the acid solution is neutralized, the volume of basic solution that was added is measured. The concentration of the acid is then determined mathematically.

Phenolphthalein indicator turns pink when an acid solution has been neutralized.

A burette is used to add the basic solution to the acid. A burette is a long measuring tube filled with the basic solution. There are numbers on the side of the burette. As the solution is dispensed, you can see how much solution is left by matching the level of the liquid to the numbers.

A burette used for titration.

The burette is filled to the zero mark.



Liquid is dispensed from the tip.

2 mL have been dispensed.

I'm going to titrate 10 mL of acetic acid solution (vinegar) with 1.0 M NaOH solution. The neutralization reaction is

$$HC_2H_3O_2 + NaOH \longrightarrow H_2O + NaC_2H_3O_2$$

If it takes 10 mL of NaOH solution to neutralize the acid, the concentration of acetic acid is probably also 1.0 M. If it takes less than 10 mL of NaOH, the concentration of acid will be less than 1.0 M. And if it takes more than 10 mL of NaOH, the concentration of acid will be greater than 1.0 M. We can use math to calculate the acid concentration with more precision, but I'll save that for the next lecture.

I'll add some phenolphthalein to the acid. When the acid is neutralized, the solution will turn pink.

The titration that I performed required 6 mL of 1.0 M NaOH to neutralize 10 mL of vinegar/acetic acid solution. The pictures below show the appearance of the solution before and after titration.

Acetic acid solution before titration. The solution contains phenolphthalein.

Acetic acid solution after being neutralized. Phenolphthalein turns pink when the solution is neutral.

The approximate concentration of the acetic acid solution is probably around 0.6 or 0.7 M. In the next lecture, I'll show you how to calculate the exact concentration using the concentration and volume of the base, and the volume of the acid.