Hydrolysis of Ions and Titration

Titration is a procedure used to determine the concentration of an acid or base. This is accomplished by reacting a known volume of a solution of unknown concentration with a known volume of a solution of known concentration. When the number of acid equivalents equals the number of base equivalents added, or vice-versa, the equivalence point is reached.

The equivalence point of a titration between a strong acid and a strong base is at a pH of 7.00 at 25 ^{O}C, because no hydrolysis of salt ions occurs.

The equivalence point in a titration is estimated in two common ways: either by using a graphical method, plotting the pH of the solution as a function of added titrant by using a pH meter, or by watching for a colour change of an indicator. (The point at which the indicator actually changes colour is not the equivalence point but is called the end point.)

The equivalence point of a titration between a weak acid and a strong base will tend to be greater than pH of 7.00 because of hydrolysis of the anion of the salt produces OH^{-1} in solution and the resulting solution is basic in pH.

See pp Diagram:
Sketch this into your notes and be able to reproduce for a test or exam.

The equivalence point of a titration between a strong acid and a weak base will tend to be less than pH of 7.00 because of hydrolysis of the cation of the salt produces H_3O^{+1} ions in solution and the resulting solution is acidic in pH.

See pp Diagram:
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Acid – Base Titration: Problems

I **<u>The reaction of a Strong Acid with a Strong Base: Neutralization reactions</u>**

The equivalence point of a titration between a strong acid and a strong base is at a pH of 7.00 because no hydrolysis of salt ions occurs.

Examples of pH at the Equivalence Point of a Strong Acid with a Strong Base Titration:

1. In a titration experiment, 28.50 mL of 0.50 mol dm^{-3} $H_2SO_{4(aq)}$ were required to neutralize 25.00 mL of $NaOH_{(aq)}$. What was the concentration of the $NaOH_{(aq)}$?

2. Calculate the concentration of nitric acid, $HNO_{3(aq)}$, if 20.00 mL of the acid is completely neutralized by 15.50 mL of 0.100 mol L^{-1} barium hydroxide.

3. If 5.25 g of barium hydroxide, $Ba(OH)_{2(aq)}$, is to be neutralized with 0.200 molL^{-1} perchloric acid, $HClO_{4(aq)}$, what volume of acid would be required for complete reaction?

4. If 40.8 cm^3 of 0.106 mol dm^{-3} H_2SO_4 neutralizes 50.0 cm^3 LiOH solution, determine the concentration of the base.

II The reaction of a Weak Acid with a Strong Base: Basic solution

In general, mixing equal molar amounts of a weak acid with a strong base will produce a salt wherein the anion is the conjugate base of the weak acid, and it will undergo hydrolysis to produce OH^{-1} ions in solution. The solution will be basic, the pH depending on the K_b of the anion.

Examples of pH at the Equivalence Point of a Strong Base with a Weak Base Titration

1. In a titration experiment, 50.0 cm^3 of 0.10 mol dm^{-3} NaOH are reacted with 50.0 cm^3 of 0.10 mol dm^{-3} formic acid, HCOOH, $K_a = 1.80 \times 10^{-4}$, what is the pH of the resulting solution.

2. What volume of 0.100 mol dm^{-3} NaOH are required to react completely with 0.976 g of the weak, monoprotic acid benzoic acid, C_6H_5COOH? What is the pH of the solution after reaction? (K_b of the benzoate ion, $C_6H_5COO^{-1} = 1.61 \times 10^{-10}$).

3. In a titration experiment, 40.0 cm^3 of 0.15 mol dm^{-3} NaOH was added to 60.0 cm^3 of 0.20 mol dm^{-3} propionic acid, CH_3CH_2COOH, $K_a = 1.40 \times 10^{-4}$ mol dm^{-3}. Calculate the pH of this mixture.

4. Phenol, C_6H_5OH, is a weak organic acid. Assume you dissolve 0.500 g of phenol in 1.0×10^2 cm^3 of water and titrate it with 0.100 mol dm^{-3} NaOH. What is the pH at the equivalence pointe? (K_a Phenol, $C_6H_5OH = 1.30 \times 10^{-10}$).

III The reaction of a Strong Acid with a Weak Base: Acidic Solution

In general, a strong acid and a weak base will give an acidic solution when equal molar quantities are mixed because hydrolysis of the cation of the salt produces H_3O^{+1} ions in solution.

Examples of pH at the Equivalence Point of a Strong Acid with a Weak Base Titration

1. Suppose you titrate 1.00×10^2 cm^3 of 0.10 mol dm^{-3} HCl with 50.0 cm^3 of 0.20 mol dm^{-3} NH_3. What is the pH of the solution at the equivalence point? (K_a $NH_4^{+1} = 5.6 \times 10^{-10}$)

2. Aniline, $C_6H_5NH_2$, is a weak organic base. If you mix 50.0 cm^3 of 0.20 mol dm^{-3} HCl with 0.93 g of aniline, are the acid and the base completely consumed? What is the pH of the resulting solution? (K_a $C_6H_5NH_3^{+1} = 2.4 \times 10^{-5}$).

3. Pyridine, C_5H_5N, is a weak base, (K_a for the pyridinium ion, $C_5H_5NH^{+1} = 6.7 \times 10^{-6}$), suppose you mixed 20.0 cm^3 of 0.50 mol dm^{-3} HNO_3 with 30.0 cm^3 of 0.20 mol dm^{-3} of pyridine, is the solution acidic or basic at the equivalence point? Calculate the pH of the resulting solution.

IV Weak Acid and Weak Base: pH depends on relative K_a and K_b values