Types of volumetric titrations

1. Acid-base (Neutralization) titration

This type of reaction involve a reaction between acid and base. The end points of these titrations are easy to detect, either by means of an indicator or by following the change in pH using a pH meter. Example:

$NaOH + HCl \rightarrow NaCl + H_2O$

2. Precipitation titration

In this type of titration, the titrant forms a precipitate with the analyte. An example is the titration of chloride ion with silver nitrate solution to form silver chloride precipitate. Again, indicators can be used to detect the end point,...

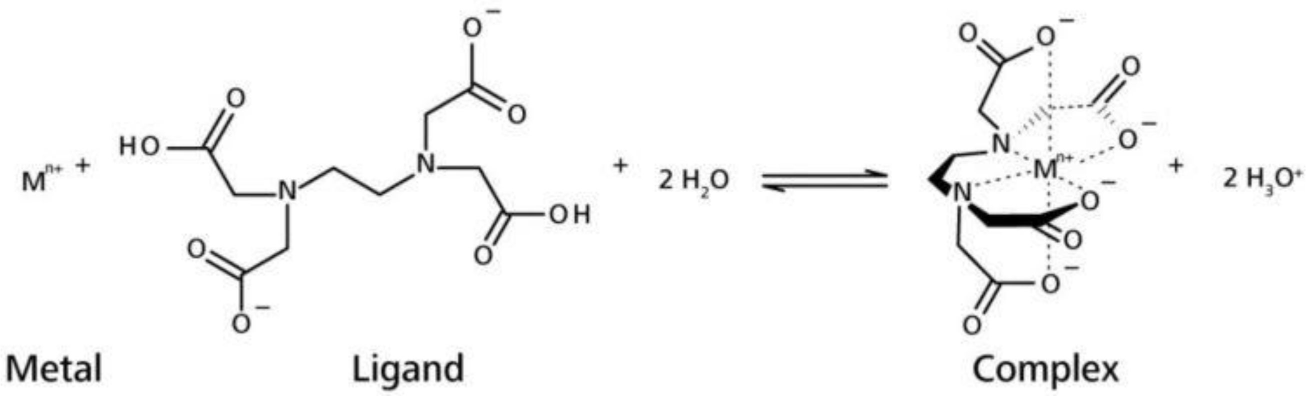
$Cl^- + Ag^+ \rightarrow AgCl(s)$ (white ppt)

$2Ag^+ + K_2CrO_4 \rightarrow Ag_2CrO_4$(brick red ppt)

3. Complexometric titration

In complexometric titrations, The titrant is often a chelating agent(Ligand) that forms a water-soluble complex with the analyte (metal ion).

Ethylenediaminetetraacetic acid (EDTA) is one of the most useful chelating agents used for titration. It will react with a large number of elements, and the reaction can be controlled by the adjustment of the pH. Indicators can be used to form a highly colored complex with the metal ion.



4. Oxidation-reduction (redox) titration

The “redox” titrations involve the titration of an oxidizing agent with a reducing agent, or vice versa. An oxidizing agent gains electrons and a reducing agent loses electrons in a reaction between them.

Potassium permanganate in the most widely used in this reaction. It is powerful oxidant. The intense color of permanganate ion is sufficient to signal the end point titrations:

$MnO^{4-} + 5\,Fe^{++} + 8\,H^{+} \longrightarrow 5\,Fe^{+++} + Mn^{++} + 4H_2O$

Calculations in titration

Because the titration involves the reaction of two substances, the amount of analyte and the amount of standard will be equal at the end point of the reaction. Then:

Suppose: A= Analyte (unknown concentration)

S= Standard (known concentration)

$$n_A = n_S$$

However: $M = n.of\ mole / V_L$ Or n. of mole = Wt / Molar mass

$$SO:\ M_A V_A = M_s V_s$$

Example 1: Calculate the concentration of 100.0 mL of NaOH solution titrated to the end point with 75.8 mL of a 0.100 M standard solution of HCl.

Sol/

HCl(aq) + NaOH(aq) → NaCl(aq) + H2O(l)

At the end point:

$$n_{NaOH} = n_{HCl}$$

(NaOH) $M_1V_1 = M_2V_2$ (HCl)

M_1 x 100 = 0.1 x 75.8

M_1= 0.0758 M

Example 2: 20 mL of H_2SO_4 (98 g/mol) was neutralized with 25mL of 0.1M sodium hydroxide solution. The equation of reaction is

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

Calculate (i) molar conc. of acid (ii) acid content of the solution in grams.

Sol/

From the equation

2 moles of NaOH is reacted with 1 mole of H_2SO_4, So,

$$\frac{n. of\ moles\ of\ NaOH}{n. of\ moles\ of\ H_2SO_4} = \frac{2}{1}$$

$$\frac{M_{NaOH} \times V_{NaOH}}{M_{H_2SO_4} \times V_{H_2SO_4}} = \frac{2}{1}$$

$$\frac{0.1 \times 25}{M_{H_2SO_4} \times 20} = \frac{2}{1}$$

$$M_{H_2SO_4} = \frac{2.5}{40} = 0.0625\ M$$

$$M = \frac{Wt}{M.wt} \times \frac{1000}{V_{mL}}$$

$$0.0625 = \frac{Wt}{98} \times \frac{1000}{20}$$

$$Wt = 0.122\ gram$$

Example 3: 50.0 mL portion of HCl solution required 29.71 mL of (0.019M) $Ba(OH)_2$ to reach an end point with bromocresol green indicator , Calculate the molarity of HCl .

Sol/

$$Ba(OH)_2 + 2HCl \rightarrow BaCl_2 + 2H_2O$$

1mole 2 mole 1mole

$$\frac{M_{Ba(OH)2} \times V_{Ba(OH)2}}{1} = \frac{M_{HCl} \times V_{HCl}}{2}$$

$$M_{HCl} = \frac{2[M_{Ba(OH)2} \times V_{Ba(OH)2}]}{V_{HCl}}$$

$$M_{HCl} = \frac{2[0.019 \times 29.71]}{50} = 0.023\ M$$

Problem 1: For titration 5 ml of H_2SO_4 are spent 10 ml 0.1N $NaOH$. Calculate mass of H_2SO_4 in 150 ml of solution.

Problem 2: For titration 15 ml of H_3PO_4 are spent 20 ml 0.01N $NaOH$. Calculate mass of H_3PO_4 in 50 ml of solution.

Problem 3: For titration 5 ml of $Ca(OH)_2$ are spent 10 ml 0.05N HCl. Calculate mass of $Ca(OH)_2$ in 250 ml of solution.