



MANIPULATION N°3

Acid-Base Titration

Titration Colorimetric Strong Acid by Strong Base



Titration of strong acids with a strong base :

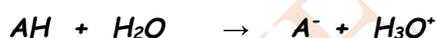
Before any manipulation, consult the pictograms and safety instructions for each chemical product and discuss them with your teacher so that you can take all the necessary protective measures.

1- Introduction :

In everyday life, we regularly use acidic or basic solutions: descaler, vinegar, lemon juice, ammonia, soda, etc.

An acid is strong if its reaction with water can be considered complete and only its conjugate base remains in solution.

The reaction of this strong acid AH is then written as follows:



2- Definitions :

2-1. Definition of an acid and a base :

- An acid is a substance that dissociates in water in the form of an H^+ ion (Arrhenius definition).
- An acid is a proton donor (Broenstedt definition): $HCl + H_2O \rightarrow H_3O^+ + Cl^-$
- A base is a substance that dissociates in water in the form of OH^- ions (Arrhenius definition).
- Une base est un accepteur de protons (Définition de Broenstedt) : $NaOH \rightarrow Na^+ + OH^-$

2-2. The strength of acids and bases :

A strong acid is an acid that dissociates completely into positive and negative ions, such as hydrochloric acid (HCl). A strong base dissociates completely into positive and negative ions, such as sodium hydroxide (NaOH).

However, most acids and bases dissociate very little in aqueous solution. Take acetic acid (CH_3COOH), for example, which has only (1.3%) of its ions dissociating in water. It is considered a weak acid. The same phenomenon occurs with ammonia (NH_3), which dissociates into two parts, NH_4^+ and OH^- . Most of its molecules do not react. Ammonia is considered a weak base.

2-3. Principle and different types of titration:

The aim of any assay is to **determine the unknown concentration** (via the quantity of substance) of a species (**titrated**) using another species (**titrant**) of known concentration. The **point of equivalence** between the **quantities of matter** present and those introduced enables the concentration of the desired species to be determined after a few calculations. There are several possible methods for determining this equivalence point: the introduction of a **coloured indicator**, the **pH** value, the **conductance** value of the solution.



a- **Calibration Titration** : Calibration titration is based on the use of solutions (called standard solutions) containing the chemical species to be determined at different known concentrations. They are prepared by dilution from a stock solution of known concentration.

The concentration of the chemical species being assayed affects a **measurable physical quantity** such as density, optical index, etc. The measured physical quantity is then compared with the concentration of the chemical species being assayed.

The physical quantity measured for the sample is then compared with those of the **standard solutions** to determine the concentration of the sample.

b- **Colorimetric Titration** : Colorimetric titration is also possible using coloured indicators such as helianthin, phenol phthalein, bromocresol green, etc., which will colour at different pH values and therefore indicate when equivalence has been attained.

c- **pH-metric Titration** : a pH-metric titration consists of following the evolution of the pH of the titrated solution during the addition of the titrant solution. The titration reaction is an acid-base reaction between a titrating couple and a titrated couple.

The pH-metric **titration curve** is the $\text{pH} = f(V_{\text{Sol. Titrant solution added}})$ curve, which shows changes in pH as a function of the volume of titrant solution added.

d- **Conductimetric titration** : Conductimetric titration is a method that consists of monitoring changes in the conductivity σ of a solution when a titrating solution is gradually added. A reaction occurs between the titrant and titrant species: ions may appear or disappear, changing the conductivity of the solution.

Before equivalence, the conductivity varies in an affine manner as a function of the volume poured, and after equivalence, the curve remains a straight line but the slope is different. The change in slope makes it possible to determine the volume at equivalence V_E .

2-4. Acid-base titration:

Dosing an aqueous solution of an acid or a base means determining its concentration by effecting an acid-base reaction.

At equivalence, the number of moles of H_3O^+ contributed by the acid must be equal to the number of moles of OH^- contributed by the base. This results in:

$$C_A \cdot V_A = C_B \cdot V_B$$

Is designated by: - C_A : the molar concentration of the acid, where V_A is the volume of acid.

- C_B : the molar concentration of the base, where V_B is the volume of the base.

Acid-base titration can be monitored by :

- **pH-metre** : the pH is measured as the reaction proceeds.
- **Colorimetry**: a coloured indicator is used.



2-5. Colour indicator:

A coloured indicator is a reagent whose colour depends on the pH. It can be used to mark the end of an assay if equivalence is attained in its colour change zone.

Acid-base indicators (also known as pH indicators) are substances that change colour with pH. They are generally weak acids that dissociate slightly in water, giving off ions. Acid-base couples are characterised by a pKa value.

The acid form and its conjugate base have different colours. The solution will take the colour of the predominant form determined by the pH of the solution:

- if $\text{pH} < \text{pKa}$ the solution takes on the colour A of the acidic form
- if $\text{pH} > \text{pKa}$ the solution takes on the colour B of the basic form
- if $\text{pH} = \text{pKa}$ then there is a mixture of the 2 colours A and B, this is the indicator's colour change zone. In general, a zone of one to two pH units is considered.

Examples of coloured indicators :

Indicator	Acidic colour	Basic colour	pH range Transition zone	pKa
Thymol blue	Red	Yellow	1,2 - 2,8	1.5
Methyl Red	Yellow	Red	4,6 - 6,0	5.1
Bromothymol Blue	Yellow	Blue	6,0 - 7,6	7.0
Phenol red	Yellow	Red	6,8 - 8,4	7.9
Phenolphthalein	Uncoloured	Pink	8,2 - 10,0	9.4

3- Experimental part :

• Colorimetric Titration of Hydrochloric Acid with Sodium Hydroxide

Materials: Burette, Erlenmeyer flask, beaker, graduated cylinder, wash bottles, NaOH solution (0.1N), HCl solution and coloured indicators.

Titration with phenolphthalein :

- 1- Rinse the equipment. Burette, Erlenmeyer flask, etc.
- 2- Fill the burette with the (NaOH) solution ($C_B=0.1N$) up to the zero graduation.
- 3- Take ($V_A=10\text{ ml}$) the solution to be dosed (HCl) and pour it into a 100 mL.
- 4- Add 2 to 3 drops of colored indicator (**phenolphthalein**).
- 5- Place the Erlenmeyer flask on a white paper under the burette.
- 6- Make a rapid titration to estimate the volume of equivalence.
- 7- Record the volume V_B of (NaOH) added.
- 8- Using a pH paper, read the pH of the solution every 2ml until coloured.





4- Results and calculations :

- 1- What is the objective of the experiment?
- 2- Write the reaction equation.
- 3- Calculate the Concentration (C_A) and Normality (N_A) of the HCl solution.
- 4- Complete (Fill) the table below:

V_B mL	0	2	4	6	8	10	12	14	16	18
pH										

- 5- Draw the graph showing the value of $pH = f(V_B)$ on millimetre paper.
- 6- Determine the volume V_E and the pH at equivalence using the graph.
- 7- What do you think a **transition zone** means?

