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ST Engineer

TP N°03
Acid-base dosage

Introduction

- One of the first definitions of an acid and a base was proposed in 1887 by Arrhenius and Ostwald. According to them, an acid was a compound with mobile hydrogen which released H^+ protons into water while a base was a compound which released OH^- hydroxide ions in an aqueous medium.
- In 1923, Bronsted and Lowry questioned the definition of Arrhenius and Ostwald and proposed a new definition. They defined an acid as a substance capable of giving up a proton and a base as a substance capable of capturing a proton.
- At the same time, during the same year, Lewis proposed another definition. He defined an acid as an acceptor of electron pairs and a base as a donor of electron pairs.
- An acid-base couple consists of an acid and its conjugate base (Acid/Base).
- An acid-base reaction involves two acid-base couples: the Acid1/Base1 couple and the Acid2/Base2 couple.
- An acid-base reaction is a chemical transformation between the acid of one pair and the base of another acid/base pair, via an exchange of H^+ ions. The full equation is a linear combination of the two specific half-equations of each pair.

$$\text{Acid1} = \text{Base1} + nH^+$$
$$\text{Base2} + nH^+ = \text{Acid2}$$
$$\text{Acid1} + \text{Base2} = \text{Base1} + \text{Acid2}$$ (this equation is called a «balance equation»)

Principle of a dosage

A solution contains a dissolved chemical species A. **Determining this chemical species** means determining its **quantity of matter** or its **C_A concentration** in the solution. To measure A, A is reacted with a body B contained in **a solution of known concentration C_B**. The dosage reaction must be rapid, complete, easily observable.

- An acid-base dosage can be followed by:
  - **pH-metry:** we follow the evolution of the pH during the reaction.
  - **Colorimetry:** we use a colored indicator

A colored indicator is a reagent whose color depends on the medium (or pH).
It can be used to mark the end of a dosage if equivalence is reached in its turning zone.

Examples of colored indicators:

Indicator	**Acid / tint**	**pH range (turning zone)**	**Base / tint**
Helianthin	Red	3,1 -4,4	Yellow
Methyl red	Red	4,08 -6,0	Yellow
Bromothymole blue	Yellow	6,0 -7,6	Blue
Phenol-phthalein		8,2 -10,0	
Alizarin Yellow	Yellow	10,1 -12,2	Red

Objective:
Determine the molar concentration of an acid solution, using the colorimetric dosage.

Material:
Graduated or volumetric pipettes (10 mL), Suction device, Burette (25 or 50 mL), Erlenmeyer flask (100 mL), beaker (x2).

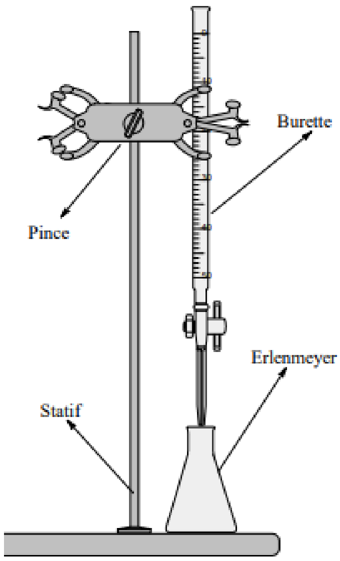
Operating mode:

1. **Dosage of a strong acid with a strong base**

The dosage of the **hydrochloric acid** will be carried out using a **sodium hydroxide** solution (NaOH) with a molar concentration **C_B = 0.1 mol/L** in the presence of phenolphthalein.
The reaction equation is:

$$HCl + NaOH \longrightarrow (Na^{+}_{aq}, Cl^{-}_{aq}) + H_2O$$

Rapid dosing (determination of a framework for the equivalent volume Ve)



□ Check that the burette stopcock is closed.

□ Rinse the graduated burette with the titrant solution (NaOH) of a precise molar concentration (C_B = 0.1 mol/L), then fill it.
□ Adjust the liquid level to the zero level of the burette by draining the excess sodium hydroxide solution into the labeled beaker.
□ Pour approximately 40 mL of solution S1 into a labeled beaker.
□ Introduce into a 100 mL Erlenmeyer flask:
□ 10 mL of hydrochloric acid solution taken using a clean volumetric pipette fitted with a suction device,
□ 1 to 3 drops of phenolphthalein,
□ Place the Erlenmeyer flask under the burette, shake manually without using the magnetic stirre
□ Add the titrant solution (mL per mL) and note the color of the solution by completing table 1:

Table 1:

V sol. titrant (ml)	1	2	3	4	5	6	7	8	…….
Color									…….

Req.: The solution changed color when you added the equivalent volume of titrant solution (Ve).
Indicate approximately this volume (by a frame); **V1 mL < Ve < V2 mL**

Precise dosage (known as "drop dosage")

Add the titrant solution until the color changes (equivalence point) while respecting the following instructions:

- quickly at the beginning, a Volume $\leq$ V1
- then drop by drop as the color change approaches (equivalence point).
- Read the equivalent volume and note the color of the solution by completing table 2.
- Repeat the operation two to three times

Table2:

	1st test	2nd test	3rd test
Ve (ml)			
Color			

- Deduce the average equivalence volume (Avg.Veq.)?
- Calculate the concentration of the hydrochloric acid solution to be titrated S2?
- Deduce the concentration of the solution S1

2. Determination of a diacid using a strong base

The dosage of sulfuric acid (H_2SO_4) will be carried out using a sodium hydroxide solution with a molar concentration C_B = 0.1 mol/L in the presence of phenolphthalein.

Rapid dosage (determination of a framework for the equivalent volume Ve)

-Check that the burette stopcock is closed.
- Rinse the graduated burette with the titrant solution (KOH or NaOH) of very precise molar concentration (C_B = 0.1 mol/L), then fill it.
-Adjust the liquid level to the zero level of the burette by draining the excess soda (potash) solution into the beaker labeled (Recovery of used products).
- Pour approximately 50 mL of the sulfuric acid solution into a labeled beaker.
- Introduce into a 100 mL Erlenmeyer flask:
-10 mL of sulfuric acid solution taken using a clean volumetric pipette fitted with a propipette,
-3 drops of phenolphthalein,
- Place the Erlenmeyer flask under the burette. Stir the solution manually without using the magnetic stirrer.
- Add the titrant solution (mL per mL) and note the color of the solution by completing

table 3.

Table 3:

V sol. titrant (ml)	1	2	3	4	5	6	7	8	**…….**
Color									**…….**

Req.: The solution changed color when you added the equivalent volume of titrant solution (Ve).
Indicate approximately this volume (by a frame); **V1 mL < Ve < V2 mL**

Precise dosage (known as "drop dosage")

Add the titrant solution until the color changes (equivalence point) while respecting the following instructions:

- quickly at the beginning, a Volume ≤ V1
- then drop by drop as the color change approaches (equivalence point).
- Read the equivalent volume and note the color of the solution by completing table 4.
- Repeat the operation two to three times

Table 4:

	1st test	**2nd test**	**3rd test**
Ve (ml)			
Color			

- Deduce the average equivalence volume (Avg.Veq.)?
- Calculate the concentration of the sulfuric acid solution to be titrated?
- What is the difference between first dosage and second dosage?

V. Questions:

1. Are there any spectator chemical species in both dosages? Which ones?
2. What are the acid/base pairs involved in each dosage?
3. Write the associated proton half-equations in the two dosages?
4. Derive the equation for the reaction of the dosage in both cases?
5. Give the definition of dosage equivalence? Deduce a relationship between the quantities of matter of oxonium ions (H_3O^+) (n_A) and hydroxide ions (OH^-) (n_B)?
6. List the chemical species present in the dosing beaker:

-for a volume poured less than $V^B{}_e$?
- for a poured volume equal to $V^B{}_e$. What should the pH be at equivalence?
-for a poured volume greater than $V^B{}_e$?