TP N°V: Titration by the Oxidation-Reduction Method

Case: Manganimetry

I. Generalities:

Oxidation-reduction reactions are electron exchange reactions involving electron acceptors and donors. Oxidants have the ability to capture electrons, while reducers can donate electrons. In the human body, oxidation-reduction reactions provide energy for its natural activities. These reactions require either O_2 or H_2. If the substances in the body react with or bind to O_2, oxidation occurs, or if they react with or bind to H_2, reduction occurs (or releases O_2).

Oxidants and reducers are used in disinfecting tissues contaminated with blood (hospitals) or dyes, treating infections, wounds such as Dakin, hydrogen peroxide, bleach. The reaction defining the relationship between a reducer and an oxidant is:

$$\underset{\text{donor}}{\text{Reducer}} \underset{\textbf{(Reduction)}}{\overset{\textbf{(oxidation)}}{\rightleftharpoons}} \underset{\text{acceptor}}{\text{Oxidant}} + n\,e^-$$

In these reactions, the reducer oxidizes by gaining electrons, while the oxidant reduces by losing electrons. **Examples:**

- The transition of iron "Fe" into a solution corresponds to an oxidation.

$$Fe \longrightarrow Fe^{2+} + 2\,e^-$$

- The deposition of copper "Cu" from a solution of Cu^{2+} ions corresponds to a reduction.

$$Cu^{2+} + 2\,e^- \longrightarrow Cu$$

Below are the oxidation-reduction couples and their classification in ascending order.:

Major oxidizing agents :	Li^+	Zn^{2+}	Fe^{2+}	H^+	I_2	Fe^{3+}	O_2	MnO_4^-	F_2
Corresponding reduced forms:	Li	Zn	Fe	H	I^-	Fe^{2+}	H_2O	Mn^{2+}	F^-

II. Main objective of the first experiment (Manganometry):

Determine the normality of a solution of $FeSO_4$.

1. **Principle:** The normality of $FeSO_4$ is determined using the oxidation reaction with potassium permanganate $KMnO_4$ in an acidic medium. However, it is essential to first determine the normality of $KMnO_4$ (since it is unstable, and as it has been prepared a week ago, it is preferable to determine its normality).

2. **$KMnO_4$ titration:** Determination of the normality of the $KMnO_4$ solution in an acidic medium in the presence of oxalic acid ($H_2C_2O_4$, 2 H_2O). It is an oxidation-reduction reaction, and its balanced equation is:

Oxidation: $C_2O_4^{--} \longrightarrow 2\,CO_2 + 2\,e^-$ **(X 5)**

Reduction: $MnO_4^- + 5\,e^- + 8\,H^+ \longrightarrow Mn^{2+} + 4\,H_2O$ **(X 2)**

$$2\,MnO_4^- + 16\,H^+ + 5\,C_2O_4^{--} \longrightarrow 2\,Mn^{2+} + 8\,H_2O + 10\,CO_2$$

3. Procedure:

a) Place potassium permanganate ($KMnO_4$, oxidizing agent) in the burette. Place 10 ml of oxalic acid ($H_2C_2O_4$, N1= 0.1N) and 20 ml of sulfuric acid H_2SO_4 (10%) in the Erlenmeyer flask. Heat the mixture to around 60 °C as the reaction is slow, and heat catalyzes the reaction (the color disappears rapidly).

b) Allow a few drops of $KMnO_4$ to flow, shake, and wait until they are decolorized. Continue adding a few drops until an excess drop produces a persistent pale pink color (does not disappear).

4- Manganometric titration of FeSO4:

Procedure:

a) Acidify (add an acid) 10 ml of FeSO4 with 20 ml of H_2SO_4 solution.

b) Proceed to the titration, which, unlike the titrations of oxalic acid, should be done cold.

c) Add the $KMnO_4$ solution (concentration determined in 3) until a pale pink color is obtained due to the addition of a single excess drop of $KMnO_4$. Repeat the experiment twice.