

practical work N°2 :

**ENTHALPY OF ACID-BASE NEUTRALISATION**

**1-INTRODUCTION:**

The transformations that matter undergoes are accompanied by the release or absorption of energy. A reaction that releases heat is called an **Exothermic** reaction, and one that absorbs heat is called an **Endothermic** reaction.

**2-OBJECTIVES**

- 1- Determine the specific capacity of the calorimeter.
- 2- Measure the heat quantity of  $Q_{\text{NaOH}}$  and  $Q_{\text{HCl}}$ .
- 3- Observation of endothermic and exothermic reactions.
- 4- Determination of the heat of neutralisation

**3- THEORETICAL SECTION:**

**3-1-Enthalpy:**

According to the first principle of thermodynamics, the elementary variation in the internal energy  $dU$  of a system is equal to the sum of the quantities of heat and work that this system has exchanged with the external environment. We can therefore write  $dU = dW + dQ$ .

In the particular case of a fluid at uniform pressure  $P$ , the elementary work  $dW$  is expressed by the relation:  $dW = -PdV$ . So we can write:  $dU = -PdV + dQ$ .

-If the transformation takes place at constant volume (isochoric transformation), then  $dV= 0$  and therefore  $dU = dQ$ .

- If the transformation takes place at constant pressure (isobaric transformation), then  $dP= 0$ . In this case, we introduce the quantity  $H$ , which is the enthalpy of the system.

Enthalpy is a state function used in the first principle of thermodynamics.

It is defined by the expression:  $H=U+PV$ . The expression of enthalpy is also frequently used in its differential form:  $dH = dU + PdV + VdP$ .

This then becomes:  $dH = dQ + VdP$ .

Therefore, if we change the volume of the system while imposing a constant pressure on it (isobaric transformation,  $dP = 0$ ), the difference in enthalpy between the final state of the system and the initial state is equal to the heat exchanged, i.e.  $\Delta H = Q$ .

This principle gives a precise definition of heat. When a hot body is brought into contact with a colder one, the temperatures of each body equalize.

- For an isolated system (as in a calorimeter) we have the following relationship:

$$\sum Q_i = 0.$$

We have:  $Q = m \cdot c (T_f - T_i)$

Knowing that:

**m** : the mass of the body in **kg**,

**c** : the specific heat of the body in **J/g.K. or J/g.c°**.

**(T<sub>f</sub>-T<sub>i</sub>)** : temperature difference between the initial and final states.

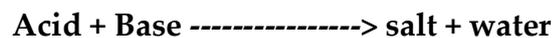
Where:  $Q = k (T_f - T_i)$

**k**: the heat capacity of the body in **kJ/K**.

### 3-2- Neutralization

The neutralization of an acid by a base is a reaction in which all the molecules of the acid have been neutralized by the base.

The neutralization of a base by an acid is a reaction in which all the molecules of the base have been neutralized by the acid.



**Example:**



### 3-3 -Neutralization enthalpy :

The neutralization reaction leads to an increase in temperature. Heat is released by the combination of  $\text{H}_3\text{O}^+$  and  $\text{OH}^-$  ions.

By mixing the acid and base solutions in a calorimeter, we can determine the amount of heat released during the neutralization reaction “**Q<sub>neutralization</sub>**” by applying the principle of heat conservation in an adiabatic system:  $\Sigma Q_i = 0$ .

$$Q_{cal} + Q_{acide} + Q_{base} + Q_{neut} = 0 \quad \Rightarrow \quad Q_{neut} = -Q_{systeme}$$

So ;  $\Delta H_{neut} = Q_{neut} / n$

#### 4-MATERIALS :

- Balance
- calorimeter
- 100 mL flasks
- Graduated test tubes.
- Graduated pipette
- Distilled water flasks.

#### 5- SOLUTIONS USED :

-HCl(0.5M) ; H<sub>2</sub>O ; NaOH(0.5M)

#### 6-EXPERIMENTAL SECTION:

##### -Manipulation N 1:

- a) Introduce a mass of water  $m_1 = 100g$  into the calorimeter and note the temperature  $T_1$  (Water + Calorimeter).
- b) Add a mass  $m_2 = 100g$  of warm water to the calorimeter ( $60^\circ C < T_2 < 70^\circ C$ ), and note  $T_2$ .
- c) Then measure the new temperature  $T_{eq}$  (System equilibrium temperature).  
(**System 1:** Cold water + hot water + calorimeter).

##### -QUESTIONS:

- Give  $C_{cal} = f ( m_{H_2O}, C_{H_2O}, T_{eq} )$ ?
- Measure ( $C_{cal}$ ) and  $K_{cal}$ ? knowing that  $m_{cal} = 2630g$ .
- Determine ( $Q_{cal}$ ) in calories and joule?

**-Manipulation N 2:**

- a) Introduce  $m_1 = 100\text{g}$  of HCl solution (0.5M) into the calorimeter.
- b) Using a thermometer, record temperature  $T_1$  ( $T_1 = T_{\text{HCl}} = T_{\text{NaOH}}$ ).
- c) Add a mass  $m_2 = 100\text{g}$  of NaOH solution (0.5M) to the calorimeter.
- d) Note the mixing temperature  $T_{\text{eq}}$  (**System2:** acid + base + calorimeter).

**-QUESTIONS :**

- Write down the chemical equation for neutralization?
- Give the heat quantities exchanged within the system?
- Determine  $Q_{\text{neut}} = f(T_{\text{eq}})$ ?
- Measure the number of moles of HCl?
- Measure the number of moles of NaOH?
- Calculate the molar heat of neutralization,  $\Delta H_{\text{neut}}$ ?
- Calculate the molar heat of ionization of water?