

**MOHAMED KHIDER UNIVERSITY OF BISKRA.**

**FACULTY OF EXACT SCIENCES AND NATURAL AND LIFE SCIENCES**

**DEPARTMENT OF BIOLOGY**

**Semester2: THERMODYNAMICS AND CHEMISTRY OF  
MINERAL SOLUTIONS**

**CHAPTER I**

**Part 2**

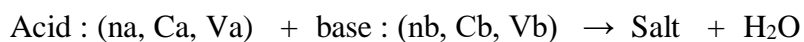
**Level: 1<sup>st</sup> year LMD**

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**Academic year: 2023/2024**

### **3. The pH of saline solutions:**

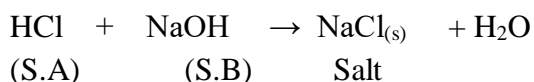
We call salt any neutral species which, in solution. They are always trained in neutralization by reaction between acid and base.



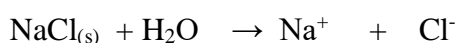
*Examples: NaCl, NH<sub>4</sub>NO<sub>3</sub>.*

#### **3.1. The pH of a solution of strong acid and strong base:**

Consider the following neutralization reaction:



In aqueous solution, there is total dissolution of the salt: NaCl(s) (Sodium chloride)



Cl<sup>-</sup>: Conjugate base (very weak) of a strong acid (HCl), Cl<sup>-</sup>: does not modify the pH of the solution: Cl<sup>-</sup>: is inactive (indifferent or spectator ion), it does not participate in any acid-equilibrium basic.

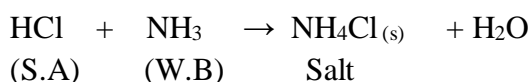
Na<sup>+</sup>: Conjugated acid (very weak) of a strong base (NaOH), Na<sup>+</sup>: does not modify the pH of the solution: Na<sup>+</sup>: is inactive (indifferent or spectator ion), it does not participate in any acid-base equilibrium.

$$\text{pH(NaCl)} = \text{pH(H}_2\text{O)} = \frac{1}{2} \text{p}K_e = 7 \quad \text{at } t=25 \text{ C}^\circ$$

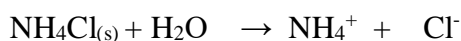
Conclusion: Salts of strong acids and strong bases dissociate in water without changing the pH, the solution remains neutral.

#### **3.2. The pH of a solution of strong acid and weak base:**

Consider the following neutralization reaction:



In aqueous solution, there is total dissolution of the salt: NH<sub>4</sub>Cl(s) (Ammonium chloride)



Cl<sup>-</sup>: Conjugate base (very weak) of a strong acid (HCl), Cl<sup>-</sup>: does not modify the pH of the solution: Cl<sup>-</sup>: is inactive (indifferent or spectator ion), it does not participate in any acid-equilibrium basic.

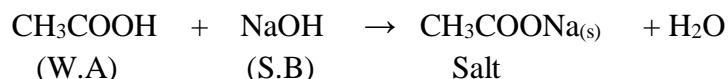
NH<sub>4</sub><sup>+</sup>: Conjugated acid (very weak) of a weak base (NH<sub>3</sub>), it participates in acid-base equilibrium.

If: [H<sub>3</sub>O<sup>+</sup>] >> [OH<sup>-</sup>] and [NH<sub>4</sub><sup>+</sup>] >> [NH<sub>3</sub>] ⇒ the acid is weakly dissociated.

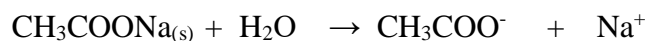
$$\text{pH(NH}_4\text{Cl)} = \text{pH(NH}_4^+) = \text{pH(Conjugate w. acid)} = \frac{1}{2} (\text{p}K_a - \log[\text{NH}_4^+]) \quad \text{at } t=25 \text{ C}^\circ$$

### 3.3. The pH of a solution of weak acid and strong base:

Consider the following neutralization reaction:



In aqueous solution, there is total dissolution of the salt:  $\text{CH}_3\text{COONa}_{(s)}$  (Sodium acetate)



$\text{CH}_3\text{COO}^-$ : Conjugate base (very weak) of a weak acid ( $\text{CH}_3\text{COOH}$ ), it participates in acid-base equilibrium.

$\text{Na}^+$ : Conjugated acid (very weak) of a strong base ( $\text{NaOH}$ ),  $\text{Na}^+$ : does not modify the pH of the solution:  $\text{Na}^+$ : is inactive (indifferent or spectator ion), it does not participate in any acid-base equilibrium.

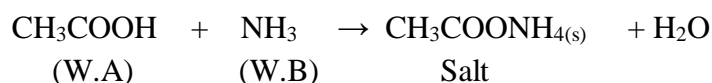
If:  $[\text{OH}^-] \gg [\text{H}_3\text{O}^+]$  and  $[\text{CH}_3\text{COO}^-] \gg [\text{CH}_3\text{COOH}] \Rightarrow$  the base is weakly protonated.

$$\text{pH}(\text{CH}_3\text{COONa}) = \text{pH}(\text{CH}_3\text{COO}^-) = \text{pH}(\text{Conjugate w. base}) = \frac{1}{2} (\text{p}K_e + \text{p}K_a + \log[\text{CH}_3\text{COO}^-])$$

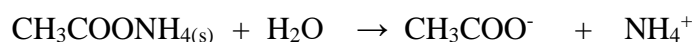
at  $t=25\text{ }^\circ\text{C}$

### 3.4. The pH of a weak acid and weak base solution:

Consider the following neutralization reaction:



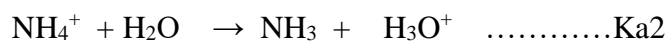
In aqueous solution, there is total dissolution of the salt:  $\text{CH}_3\text{COONH}_4_{(s)}$  (Ammonium acetate) of concentration = C



$\text{CH}_3\text{COO}^-$ : Conjugate base (very weak) of a weak acid ( $\text{CH}_3\text{COOH}$ ), it participates in acid-base equilibrium.



$\text{NH}_4^+$ : Conjugated acid (very weak) of a weak base ( $\text{NH}_3$ ), it participates in acid-base equilibrium.



However, the mixture between a w. A and a w. B gives a weakly acidic or weakly basic solution  $\Rightarrow$  pH is close to 7.

If:  $C \gg [\text{H}_3\text{O}^+]$  and  $C \gg [\text{OH}^-] \Rightarrow$  by making the product  $\text{Ka}_1$ .  $\text{Ka}_2$

$\text{pH}(\text{CH}_3\text{COONH}_4) = \frac{1}{2} (\text{p}K_{a1} + \text{p}K_{a2})$ , the pH is independent of the initial concentration C.

### **3.5. The pH of a buffer solution:**

A buffer solution is defined as a mixture of a weak acid AH and their conjugates base A<sup>-</sup> in equal or similar proportions.

The expression for the acidity constant K<sub>a</sub> of the HA/A<sup>-</sup> couple is:

$$K_a = \frac{[A^-] \cdot [H_3O^+]}{[AH]} \Rightarrow [H_3O^+] = \frac{K_a \cdot [AH]}{[A^-]}$$

$$pH = pk_a - \log \frac{[AH]}{[A^-]} \Leftrightarrow pH = pk_a - \log \frac{[Acid]}{[Base]}$$

#### **Noticed:**

A buffer solution can be obtained from:

- Weak acid AH + a weak base A.
- Weak acid HA + strong base.
- Weak base A<sup>-</sup> (NaA salt) + strong acid.

Buffer solutions have the property of minimizing pH variations caused by:

- An addition of acid or base.
- An addition of solvent (dilution).