Mohamed Khider University of Biskra   Academic year 2024/2025
1 year LMD SNV
Subject: Chemistry 2

Practical Work No. 1:

pH-metric dosage (dosage of a weak acid with a strong base)

1- Reminder

- **The self-containment of water and pH**: It results in the following balance

$$2H_2O \rightleftharpoons H_3O^+ + OH^-$$

Let's apply the law of mass action: $K_c(T) = \frac{[H_3O^+][OH^-]}{[H_2O]^2}$

$[H_3O^+][OH^-] = K_c [H_2O]^2 = K_e$ / K_e The ionic product of water.
At 25°C: $[H_3O^+][OH^-] = 10^{-14} mol.l^{-1}$

- the medium is acidic: $[H_3O^+] > 10^{-7}$ mol.l^{-1}
- the medium is neutral: $[H_3O^+] = 10^{-7}$ mol.l^{-1}
- the medium is basic: $[H_3O^+] < 10^{-7}$ mol.l^{-1}

The concentration limit between an acidic medium and a basic medium is an extremely small number $[H_3O^+] = 10^{-7} = 0,0000001$ mol.l^{-1}

Generally speaking, $[H_3O^+]$ is expressed by negative powers of 10, such numbers are not convenient & handle. They should be transformed using a mathematical operation that simplifies writing. Each concentration is characterized by its negative decimal logarithm (cologarithm = 1/log).
We pose: $pH = colog [H_3O^+] = -log [H_3O^+]$
$pOH = colog [OH^-] = -log [OH^-]$
$pK = cologt K = -log K$
Example: $[H_3O^+] = 10^{-x}$ mol/l $\Rightarrow$ $log [H_3O^+] = log 10^{-x} = 10^{-pH} \Rightarrow \boxed{pH = x}$ (x > 0)

- **pH of a strong monoacid:**

A concentration C_a of strong acid, HA is introduced into the water.

The dissociation is total: $HA + H_2O \longrightarrow H^3O^+ + A^-$ $\boxed{pH = -log [H_3O^+] = log C_a}$

- **pH of a weak monoacid:**

This time the dissociation reactions are equilibria. $HA + H_2O \rightleftharpoons H_3O^+ + A$
Three equations will allow us to calculate the pH:

- **Law of mass action:** $K = \frac{[H_2O^+][A^-]}{[HA][H_2O]} \Rightarrow K_a = \frac{[H_2O^+][A^-]}{[HA]}$ ……………….(1)
- **Electrical neutrality of the solution:** In dissociation forms as many positive charges as charges negative. Neglecting the self-ionization of water, we have $[H_3O^+] = [A^-]$……...(2)
- **Conservation of A during the dissociation:** $C_a = [HA] + [A^-]$…………………………(3)

Equation (3) simplifies. In fact, the weak acid is very little dissociated. We neglect $[A^-]$ in front of [HA].
We obtain the equation: $C_a = [HA]$ ……………………………………………………………(4)
We enter into equation (1) the results (2) and (4)

$$K_a = \frac{[H_2O^+][A^-]}{C_a} \Rightarrow [H_3O^+] = (K_a C_a)^{1/2} \Rightarrow -log [H_3O^+] = ½ (-logK_a - logC_a)$$

And $pH = 1/2\ (pK_a - \log C_a)$

- **Colored indicators:** A colored indicator is an acid-base pair whose acid form and basic form have different colors

Let K_i be the mass action constant of the equilibrium between the two forms:

$$HIn + H_2O \rightleftarrows In^- + H^3O^+ \qquad K_i = \frac{[H_2O^+]\,[In^-]}{HIn}$$

- ➢ The first color is observed when: $[H_3O^+] \geq 10K_i$. either $pH \leq pK_i - 1$
- ➢ The second color is observed when: $[H_3O^+] \leq K_i/10$ either $pH \geq pK_i + 1$

Example: Helianthin ($pK_i = 3,4$)

- ➢ first color: red when $pH \leq pK_i - 1 \Rightarrow pH \leq 2,4$
- ➢ second color: yellow when $pH \geq pK_i + 1 \Rightarrow pH \geq 4,4$

2- Objectives

- How to do the calibration?
- Determination of the concentration of ethanolic acid (CH_3COOH) by pH-metric assay.

3- Materials

pH-metric + electrode, stirrer, magnetic rod, graduated cylinder (150 ml), beaker (250 ml), graduated burette, funnel, volumetric pipette (10 ml).

4- Products

Buffer solutions (pH = 7, pH = 4 or pH = 10), Ethanol acid solution (CH_3COOH), Sodium hydroxide solution (NaOH) 0.1 mol/l. colored indicator and distilled water.

5- Operating Mode:

- Prepare the pH meter (calibration) using the buffer solutions.
- Refill the burette with the basic solution (NaOH)
- Using a pipette, take 10ml of CH_3COOH then add it to the graduated cylinder.
- Make up with distilled water to 150ml.
- Pour this volume into a beaker (250ml)
- Immerse the electrode and the magnetic bar in the acid solution then start stirring.
- Note the pH_0 value (initial pH)
- Add 2 to 3 drops of the colored indicator
- Add 1ml each time and note the pH
  - ✓ **Note:** In the toning area (pour the basic solution drop by drop).
  - ✓ **Data:** Table of some colored indicators,

Indicator	turning area	First color (color in acidic environment) (HA)	Second color (color in the basic environment) (A^-)
Helianthin (Methyl's orange)	2,4 – 4,4	Red	Yellow
Methyl red	4,1 – 6,1	Red	Yellow
Bromothymol blue	6,6 – 7,6	Yellow	Red
Phenolphthalein	8,2 – 10,2	colorless	Red