

pH Calculation Methods

pH calculations depend on the type of solution—strong acids, weak acids, strong bases, weak bases, and buffer solutions. Below are methods for each:

1. pH of a Strong Acid Solution

For a strong acid (e.g., HCl, HNO₃), the acid fully dissociates in water:



So, the concentration of H^+ ions is equal to the concentration of the acid.

Example:

Calculate the pH of **0.01 M HCl**.

Solution:

$$\begin{aligned}\text{pH} &= -\log[\text{H}^+] \\ &= -\log(0.01) \\ &= 2\end{aligned}$$

2. pH of a Weak Acid Solution

For weak acids (e.g., CH₃COOH), use the acid dissociation constant K_a and the equilibrium expression:



The pH is found using:

$$\text{pH} = -\log\left(\sqrt{K_a C}\right)$$

where C is the initial concentration.

Example:

Calculate the pH of **0.1 M acetic acid** ($K_a = 1.8 \times 10^{-5}$).

Solution:

$$\text{pH} = -\log\left(\sqrt{(1.8 \times 10^{-5})(0.1)}\right)$$

Let's compute the value.

The pH of the **0.1 M acetic acid** solution is **2.87**.

3. pH of a Strong Base Solution

For strong bases (e.g., NaOH, KOH), the base fully dissociates in water:



The concentration of OH^- is equal to the base concentration.

To find pH:

$$\text{pOH} = -\log[\text{OH}^-]$$

$$\text{pH} = 14 - \text{pOH}$$

Example:

Find the pH of **0.02 M NaOH**.

Let's calculate it.

The pH of the **0.02 M NaOH** solution is **12.30**.

4. pH of a Weak Base Solution

For weak bases (e.g., NH_3), we use the base dissociation constant K_b :



$$\text{pOH} = -\log\left(\sqrt{K_b C}\right)$$

$$\text{pH} = 14 - \text{pOH}$$

Example:

Calculate the pH of **0.05 M ammonia** ($K_b = 1.8 \times 10^{-5}$).

Let's compute.

The pH of the **0.05 M ammonia** solution is **10.98**.

5. pH of a Buffer Solution (Using Henderson-Hasselbalch Equation)

For buffer solutions:

- **Acidic buffer:**

$$\text{pH} = \text{pK}_a + \log \frac{[\text{Salt}]}{[\text{Acid}]}$$

- **Basic buffer:**

$$\text{pOH} = \text{pK}_b + \log \frac{[\text{Salt}]}{[\text{Base}]}$$

Example:

Find the pH of a buffer solution containing **0.1 M CH₃COOH** and **0.05 M CH₃COONa** ($pK_a = 4.76$).

Let's compute.

The pH of the **buffer solution** containing **0.1 M acetic acid** and **0.05 M sodium acetate** is **4.46**.

Summary of pH Calculations

Type of Solution	Formula Used	Example Calculation	Result
Strong Acid	$\text{pH} = -\log[H^+]$	0.01M HCl	pH = 2.00
Weak Acid	$\text{pH} = -\log \sqrt{K_a C}$	0.1M CH ₃ COOH ($K_a = 1.8 \times 10^{-5}$)	pH = 2.87
Strong Base	$\text{pH} = 14 - \text{pOH}$	0.02M NaOH	pH = 12.30
Weak Base	$\text{pH} = 14 - \log \sqrt{K_b C}$	0.05M NH ₃ ($K_b = 1.8 \times 10^{-5}$)	pH = 10.98
Buffer Solution	$\text{pH} = pK_a + \log \frac{[\text{Salt}]}{[\text{Acid}]}$	0.1M CH ₃ COOH + 0.05M CH ₃ COONa	pH = 4.46