# Totally Epic AP Chem Review: Acids and Bases in a Day!

| Various Ways to Describe Acid Strength | | |
|---|---|---|
| **Property** | **Strong Acid** | **Weak Acid** |
| Ionization constant ($K_a$) value | $K_a$ is large | $K_a$ is small |
| Percent Ionization | % Ionization = 100% | % Ionization << 100% |
| Position of the dissociation (ionization) equilibrium | Far to the right (product-favored) | Far to the left (reactant-favored) |
| Equilibrium concentration of $H^+$ when compared to original [HA] | $[H^+] \approx [HA]_0$ | RICE! $[H^+] << [HA]_0$ |

**Generic Acid:** $HA + H_2O \rightarrow H_3O^+ + A^-$

$$K_a = \frac{[x][x]}{[HA]_i - x} \approx \frac{[x][x]}{[HA]_i} \text{ where } [H_3O^+] = x << [HA]_i$$

**Conjugate Base (of Generic Acid):** $A^- + H_2O \rightarrow HA + OH^-$

$$K_b = \frac{[x][x]}{[A^-]_i - x} \approx \frac{[x][x]}{[A^-]_i} \text{ where } [OH^-] = x << [A^-]_i$$

Self-Ionization of Water: About 2 out of 1 billion water molecules self-ionize!

$$H_2O(l) + H_2O(l) \rightarrow H_3O^+(aq) + OH^-(aq)$$

$$K_w = [H_3O^+][OH^-] = K_a \times K_b = 1.0 \times 10^{-14} \quad \text{(at 25°C)}$$

## 1) Strong Acids/ Strong Bases

You MUST memorize:

**Strong Acids:** HBr, HI, HCl, $H_2SO_4$, $HNO_3$, $HClO_4$

*Hint:* BriCl-SO-NO-ClO ("Brickle-So-No-Clo")

**Strong Bases:** Groups IA and IIA metal hydroxides

**100% Dissociation!** Easy life:

$$pH = -\log[H^+] = -\log[HA]_o$$

$$pOH = -\log[OH^-] = -\log[B]_o$$

$$pH + pOH = 14$$

## 2) Weak Acids/ Weak Bases

If it's not strong, it's weak!

< 1% Dissociation → Equilibrium!

**Time saver:**

- Since acids ionize 1 $H^+$ at a time, $[H_3O^+] = [A^-]$, and $[OH^-] = [BH^+]$.
- For weak acids and bases, make the assumption $[HA]_o - x \approx [HA]_o$ and $[B]_o - x \approx [B]_o$.

Weak Acids:

$$K_a = \frac{[x][x]}{[HA]_i - x} \approx \frac{[x][x]}{[HA]_i} \text{ where } [H_3O^+] = x << [HA]_i$$

Weak Bases:

$$K_b = \frac{[x][x]}{[B]_i - x} \approx \frac{[x][x]}{[B]_i} \text{ where } [OH^-] = x << [B]_i$$

## Percent Ionization

**Percent Ionization:** percentage of acid molecules that dissociate (ionize) when dissolved in water

$$\%\ \textbf{Ionization} = \frac{molarity\ of\ ionized\ acid}{initial\ molarity\ of\ acid} \times 100 = \frac{[H_3O^+]_{equil}}{[HA]_0} \times 100$$

## Important Notes

- The **favored direction of the reaction** is the one in which the Weaker acid/base are produced.
- The **stronger** an acid is, the weaker its conjugate base (and vice versa).
- Diluting an acid (↓ concentration) will ↑ pH and ↑ percent ionization.

**Practice, practice, practice!**

HCl = Strong acid!

1. Calculate the pH of a 0.020 M solution of hydrochloric acid.

$$pH = -\log[H^+] = -\log[HCl] = -\log(\underbrace{0.020}_{2\text{ s.f.}}) = \boxed{1.\underbrace{70}_{}}$$

2 s.f. after decimal in pH!

$HC_2H_3O_2$ = Weak acid!

2. Calculate the pH and percent ionization of a 0.020 M solution of acetic acid ($K_a$ = 1.8 x $10^{-5}$).

$$K_a = \frac{[H_3O^+][C_2H_3O_2^-]}{[HC_2H_3O_2]} = \frac{x^2}{[HC_2H_3O_2]} = \frac{x^2}{\underbrace{0.020-x}_{\text{Assume } x \ll 0.020}} \approx \frac{x^2}{0.020} = 1.8E-5$$

$$x = \sqrt{(1.8E-5)(0.020)} = 6.0E-4\ M = [H_3O^+]$$

$$pH = -\log(6.0E-4) = \boxed{3.22}$$

$$\%\ Ion. = \frac{[H_3O^+]}{[HC_2H_3O_2]_i} \times 100 = \frac{6.0E-4}{0.020} \times 100 = \boxed{3.0\%}$$

3. Calculate the pH for a 1.7 x $10^{-2}$ M solution of KOH.

Strong base!

$$pOH = -\log[OH^-]$$

$$= -\log[KOH] = -\log(1.7E-2) = 1.77$$

$$pH = 14 - pOH = 14 - 1.77 = \boxed{12.23}$$

Weak base!

4. Calculate the pH and percent ionization for a 1.7 x $10^{-2}$ M solution of $NH_3$ ($K_b$ = 1.8 x $10^{-5}$).

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]} = \frac{x^2}{[NH_3]} = \frac{x^2}{\underbrace{(1.7E-2)-x}_{\text{assume } x \ll 1.7E-2}} \approx \frac{x^2}{1.7E-2} = 1.8E-5$$

$$x = \sqrt{(1.8E-5)(1.7E-2)} = 5.5E-4\ M = [OH^-]$$

$$pOH = -\log(5.5E-4) = 3.26$$

$$pH = 14 - pOH = 14 - 3.26 = \boxed{10.74}$$

$$\%\ Ion = \frac{[OH^-]}{[NH_3]_i} \times 100 = \frac{5.5E-4}{1.7E-2} \times 100 = \boxed{3.3\%}$$