

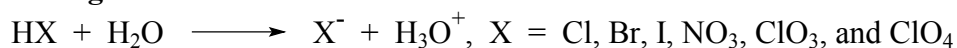
$$K_a = \frac{[\text{H}_3\text{O}^+][\text{A}^-]}{[\text{HA}]}$$

$$K_b = \frac{[\text{OH}^-][\text{HB}^+]}{[\text{B}]}$$

$$[\text{H}_3\text{O}^+] = \frac{-K_a + \sqrt{K_a^2 + 4K_a C_{\text{HA}}}}{2} \approx \sqrt{K_a C_{\text{HA}}}$$

$$[\text{OH}^-] = \frac{-K_b + \sqrt{K_b^2 + 4K_b C_{\text{B}}}}{2} \approx \sqrt{K_b C_{\text{B}}}$$

1. **Strong acid**



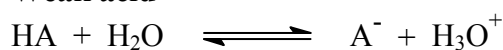
0.10 M HClO₃, K_a large

$$[\text{H}_3\text{O}^+] = [\text{HClO}_3] = 0.10 \text{ M}$$

pH = 1.00

(pH of 0.10 M H₂SO₄ ≈ **0.96**)

2. **Weak acid**



0.10 M HC₃H₃O₃, K_a = 2.8 × 10⁻³

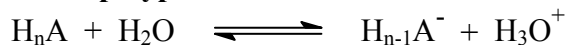
$$\text{'x small' assumption } [\text{H}_3\text{O}^+] = 1.7 \times 10^{-2} \text{ M} = \sqrt{K_a C_{\text{HC}_3\text{H}_3\text{O}_3}}$$

pH = 1.78

$$\text{quadratic solution } [\text{H}_3\text{O}^+] = 1.5 \times 10^{-2} \text{ M}$$

pH = 1.81

3. **Weak polyprotic acid**



0.10 M H₃AsO₄, K_{a1} = 5.8 × 10⁻³, K_{a2} = 1.1 × 10⁻⁷, K_{a3} = 3.2 × 10⁻¹²

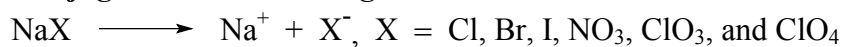
$$\text{'x small' assumption } [\text{H}_3\text{O}^+] = 2.4 \times 10^{-2} \text{ M} = \sqrt{K_{a1} C_{\text{H}_3\text{AsO}_4}}$$

pH = 1.62

$$\text{quadratic solution } [\text{H}_3\text{O}^+] = 2.1 \times 10^{-2} \text{ M}$$

pH = 1.67

4. **Conjugate base of a strong acid**

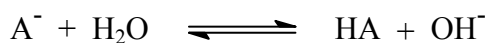
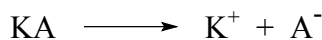


0.10 M NaNO₃, K_a (HNO₃) large, K_b very small

$$[\text{H}_3\text{O}^+] = 1.0 \times 10^{-7} \text{ M (from the water)}$$

pH = 7.00

5. **Conjugate base of a weak acid (with a nonacidic (or basic) cation)**



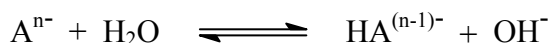
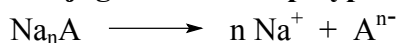
$$0.10 \text{ M KCNO}, K_a(\text{HCNO}) = 3.5 \times 10^{-4}, K_b = 2.9 \times 10^{-11}$$

$$[OH^-] = 1.7 \times 10^{-6} \text{ M} = \sqrt{K_b C_{\text{CNO}^-}}$$

$$\text{pOH} = 5.77$$

$$\text{pH} = 8.23$$

6. **Conjugate base of a polyprotic weak acid (with a nonacidic (or basic) cation)**



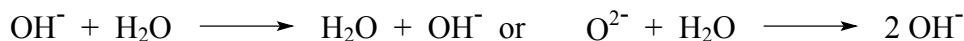
$$0.10 \text{ M Na}_2\text{CO}_3, K_{a2}(\text{HCO}_3^-) = 5.6 \times 10^{-11}, K_{b1} = 1.8 \times 10^{-4}$$

$$[OH^-] = 4.2 \times 10^{-3} \text{ M} = \sqrt{K_{b1} C_{\text{CO}_3^{2-}}}$$

$$\text{pOH} = 2.37$$

$$\text{pH} = 11.63$$

7. **Strong base**



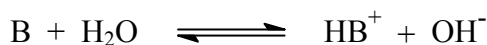
$$0.10 \text{ M K}_2\text{O}, K_b \text{ large}$$

$$[OH^-] = 2 \times [K_2O] = 0.20 \text{ M}$$

$$\text{pOH} = 0.70$$

$$\text{pH} = 13.30$$

8. **Weak base**



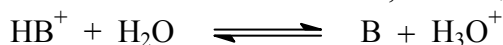
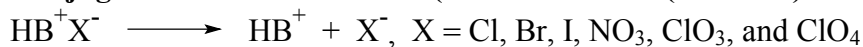
$$0.10 \text{ M C}_5\text{H}_5\text{N (pyridine)}, K_b = 1.7 \times 10^{-9}$$

$$[OH^-] = 1.3 \times 10^{-5} \text{ M} = \sqrt{K_b C_{\text{C}_5\text{H}_5\text{N}}}$$

$$\text{pOH} = 4.89$$

$$\text{pH} = 9.11$$

9. **Conjugate acid of a weak base (with a nonbasic (or acidic) anion)**



$$0.10 \text{ M (CH}_3\text{NH}_3\text{)NO}_3, K_b(\text{CH}_3\text{NH}_2, \text{methylamine}) = 4.4 \times 10^{-4}, K_a = 2.3 \times 10^{-11}$$

$$[\text{H}_3\text{O}^+] = 1.5 \times 10^{-6} \text{ M} = \sqrt{K_a C_{\text{CH}_3\text{NH}_3^+}}$$

$$\text{pH} = 5.82$$