

Weak Acids and Ka

Answer key with worked solutions

A. Understanding

1. Ka expression.

$K_a = \frac{[\text{H}_3\text{O}^+][\text{A}^-]}{[\text{HA}]}$. A large K_a means the acid ionizes to a greater extent: it is a stronger acid.

2. Ranking and pKa of HF.

Strongest to weakest: **HF > acetic acid > HCN** (largest to smallest K_a). $\text{pKa}(\text{HF}) = -\log(6.8 \times 10^{-4}) = 3.17$

B. pH of weak acids

3. 0.20 M acetic acid.

$[\text{H}_3\text{O}^+] \approx \sqrt{1.8 \times 10^{-5} \times 0.20} = 1.9 \times 10^{-3} \text{ M}$ (about 0.9% of 0.20, so the shortcut is valid).
 $\text{pH} = 2.72$; percent ionization $\approx 0.9\%$

4. 0.25 M HCN.

$[\text{H}_3\text{O}^+] \approx \sqrt{4.9 \times 10^{-10} \times 0.25} = 1.1 \times 10^{-5} \text{ M}$. $\text{pH} = 4.96$

C. Ka from a measured pH

5. 0.050 M acid, pH 3.20.

$[\text{H}_3\text{O}^+] = [\text{A}^-] = 10^{-3.20} = 6.3 \times 10^{-4} \text{ M}$; $[\text{HA}] = 0.050 - 0.00063 = 0.0494 \text{ M}$. $K_a = (6.3 \times 10^{-4})^2 \div 0.0494 = 8.1 \times 10^{-6}$; percent ionization = 1.3%

D. Weak bases

6. 0.20 M ammonia.

$$[\text{OH}^-] \approx \sqrt{1.8 \times 10^{-5} \times 0.20} = 1.9 \times 10^{-3} \text{ M}; \text{pOH} = 2.72; \text{pH} = \mathbf{11.28}$$

7. K_b of acetate.

$$K_b = K_w / K_a = 1.0 \times 10^{-14} \div 1.8 \times 10^{-5} = \mathbf{5.6 \times 10^{-10}}$$

E. Challenge

8. Why the pH values differ.

HCl is a **strong** acid: it ionizes completely, so $[\text{H}_3\text{O}^+] = 0.20 \text{ M}$ and $\text{pH} = 0.70$. Acetic acid is **weak**: less than 1% ionizes, so $[\text{H}_3\text{O}^+]$ is only $1.9 \times 10^{-3} \text{ M}$ and $\text{pH} = 2.72$.