

8.3 Weak Acid and Base Equilibria

Name: _____ Class: _____ Date: _____

Total: 11 marks

Objective

Build the skills to answer exam questions on **weak acid and base equilibria** (K_a and K_b).

You must be able to:

- write the K_a (or K_b) expression
- use an ICE table with the small- x approximation
- find the pH of a weak acid

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ The acid-dissociation constant

For $\text{HA} \rightleftharpoons \text{H}^+ + \text{A}^-$:

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

A **small** K_a means a weak acid (little ionization).

■ The ICE + approximation

Start $[\text{HA}] = C$, $[\text{H}^+] = [\text{A}^-] = 0$; change $-x, +x, +x$. With x small, $C - x \approx C$, so

$$K_a \approx \frac{x^2}{C} \Rightarrow x = \sqrt{K_a C} = [\text{H}^+].$$

■ A worked pH

0.10 M acid, $K_a = 1.8 \times 10^{-5}$: $x = \sqrt{(1.8 \times 10^{-5})(0.10)} = \sqrt{1.8 \times 10^{-6}} = 1.34 \times 10^{-3}$, so $\text{pH} = -\log(1.34 \times 10^{-3}) = 2.87$.

■ Bases use K_b

For a weak base, $K_b = \frac{[\text{BH}^+][\text{OH}^-]}{[\text{B}]}$, and the same method gives $[\text{OH}^-]$, then pOH and pH.

2 Practice

Now apply the methods above.

2.1 Write the K_a expression for $\text{HF} \rightleftharpoons \text{H}^+ + \text{F}^-$. [1]

2.2 Does a small K_a mean a strong or weak acid? [1]

2.3 For 0.10 M acid with $K_a = 4 \times 10^{-7}$, use $x = \sqrt{K_a C}$ to find $[\text{H}^+]$. [2]

3 Exam-style questions

3.1 For a weak acid, $[\text{H}^+] \approx$ [1]

- A K_a
 - B $\sqrt{K_a C}$
 - C C
 - D $K_a C$
-

3.2 A 0.20 M solution of a weak acid has $K_a = 1.0 \times 10^{-5}$.

(a) Find $[\text{H}^+]$ using the approximation. [2]

(b) Find the pH. [2]

3.3 Explain why the small- x approximation is valid for a weak acid but not for a strong

acid.

[2]

4 Go further

You are now ready for the real exam questions on this subtopic:

- work through the **8.3 Weak Acid and Base Equilibria** lesson on the **Learn** page;
- read the **Weak Acid and Base Equilibria** section of the AP Chemistry handout on the **Know** page.

Solutions

2.1 $K_a = \frac{[\text{H}^+][\text{F}^-]}{[\text{HF}]}$.

2.2 Weak.

2.3 $x = \sqrt{(4 \times 10^{-7})(0.10)} = \sqrt{4 \times 10^{-8}} = 2 \times 10^{-4} \text{ M}$.

3.1 B $-\text{[H}^+] \approx \sqrt{K_a C}$.

3.2 (a) $[\text{H}^+] = \sqrt{(1.0 \times 10^{-5})(0.20)} = \sqrt{2.0 \times 10^{-6}} = 1.41 \times 10^{-3} \text{ M}$. (b) $\text{pH} = -\log(1.41 \times 10^{-3}) = 2.85$.

3.3 A weak acid ionizes only slightly, so x is tiny compared to C and $C - x \approx C$; a strong acid ionizes fully, so $x \approx C$ and the approximation fails.