# 8.3 Weak Acid and Base Equilibria

Name: _____ Class: _____ Date: _____ **Total: 11 marks**

**KEY WORDS** acid • weak acid • ph pH • base • strong acid

## 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 Key knowledge and 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 $HA \rightleftharpoons H^+ + A^-$:

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

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

**■ The ICE + approximation**

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

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

**■ 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 $pH = -\log(1.34 \times 10^{-3}) = 2.87$.

**■ Bases use Kb**

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

## 2 Practice

Now apply the methods above.

**2.1** Write the $K_a$ expression for $HF \rightleftharpoons H^+ + F^-$. [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 $[H^+]$. [2]

## 3 Exam-style questions

**3.1** For a weak acid, $[H^+] \approx$ [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 $[H^+]$ 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]

## Solutions

Each answer shows the steps, then the **result**.

**2.1**

- $K_a = \dfrac{[\mathrm{H}^+][\mathrm{F}^-]}{[\mathrm{HF}]}$

**2.2**

- Weak

**2.3**

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

**3.1 B**

- $[\mathrm{H}^+] \approx \sqrt{K_a C}$

**3.2**

(a)

- $[\mathrm{H}^+] = \sqrt{(1.0 \times 10^{-5})(0.20)} = \sqrt{2.0 \times 10^{-6}} = 1.41 \times 10^{-3}$ M

(b)

- $\mathrm{pH} = -\log(1.41 \times 10^{-3}) = 2.85$

**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