AP CHEMISTRY • EXERCISE SHEET

8.3 Weak Acid and Base Equilibria

Name: ____________ Class: ________ Date: ________ **Total: 11 marks**

KEY WORDS acid 酸 • weak acid 弱酸 • ph pH 值 • base 碱 • strong acid 强酸

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 $HA \rightleftharpoons H^+ + A^-$:

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

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, $K_b = \frac{[BH^+][OH^-]}{[B]}$, 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

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

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** — $[H^+] \approx \sqrt{K_a C}$.

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