

# **N37 – Acid Base**

## **Weak Problems**

# **N37 – Acid Base**

**Yay, ICE Tables are back!**

# A Weak Acid Equilibrium Problem

What is the pH of a 0.50 M solution of acetic acid,  $\text{HC}_2\text{H}_3\text{O}_2$ ,  $K_a = 1.8 \times 10^{-5}$  ?

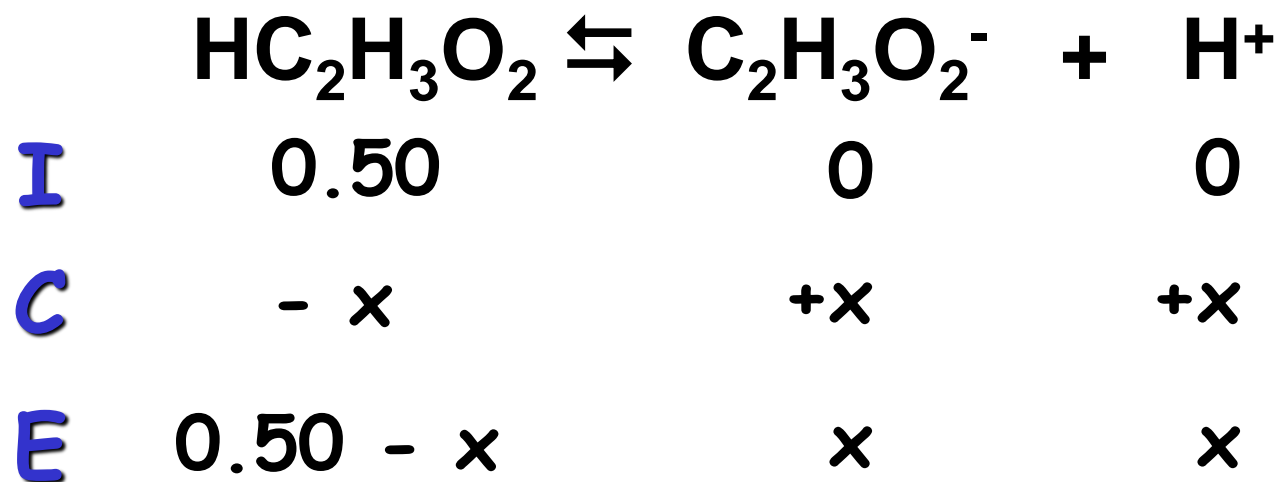
**Step #1:** Write the dissociation equation



# A Weak Acid Equilibrium Problem

What is the pH of a 0.50 M solution of acetic acid,  $\text{HC}_2\text{H}_3\text{O}_2$ ,  $K_a = 1.8 \times 10^{-5}$  ?

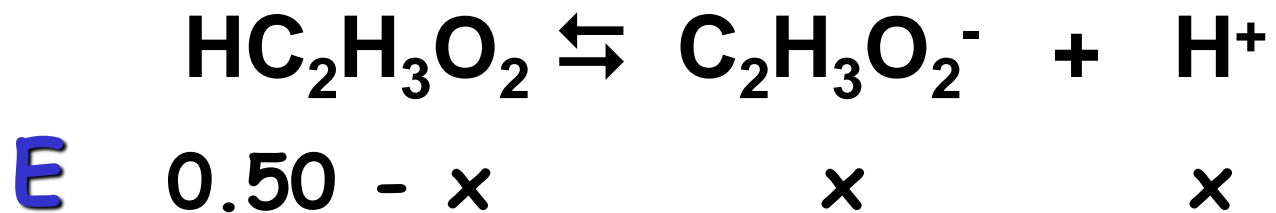
Step #2: ICE it!



# A Weak Acid Equilibrium Problem

What is the pH of a 0.50 M solution of acetic acid,  $\text{HC}_2\text{H}_3\text{O}_2$ ,  $K_a = 1.8 \times 10^{-5}$  ?

**Step #3:** Set up the law of mass action



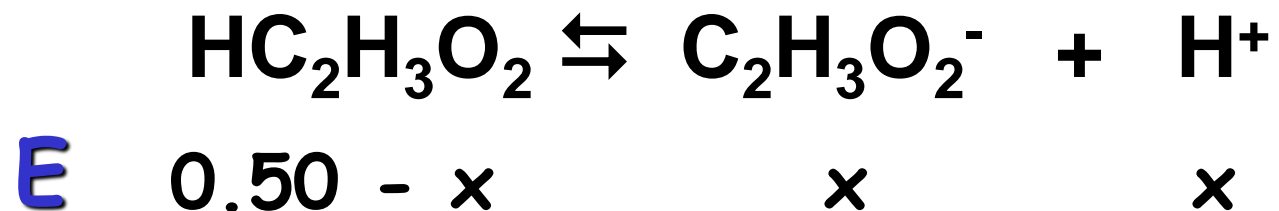
$$1.8 \times 10^{-5} = \frac{(x)(x)}{(0.50 - x)} \approx \frac{x^2}{(0.50)}$$

*Can use the 5% rule because  $K < 1$  and  $K$  at least 1000 times smaller than [initial]*

# A Weak Acid Equilibrium Problem

What is the pH of a 0.50 M solution of acetic acid,  $\text{HC}_2\text{H}_3\text{O}_2$ ,  $K_a = 1.8 \times 10^{-5}$  ?

**Step #4:** Solve for  $x$ , which is also  $[\text{H}^+]$

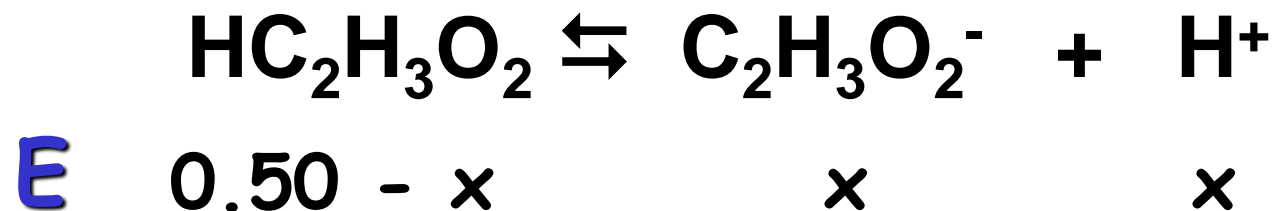


$$1.8 \times 10^{-5} = \frac{x^2}{(0.50)} \quad [\text{H}^+] = 3.0 \times 10^{-3} \text{ M}$$

# A Weak Acid Equilibrium Problem

What is the pH of a 0.50 M solution of acetic acid,  $\text{HC}_2\text{H}_3\text{O}_2$ ,  $K_a = 1.8 \times 10^{-5}$  ?

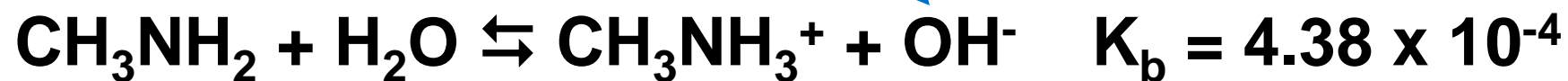
**Step #5:** Convert  $[\text{H}^+]$  to pH



$$\text{pH} = -\log(3.0 \times 10^{-3}) = 4.52$$

# Reaction of Weak Bases with Water

The base reacts with water, producing its conjugate acid and hydroxide ion:



$$K_b = 4.38 \times 10^{-4} = \frac{[\text{CH}_3\text{NH}_3^+][\text{OH}^-]}{[\text{CH}_3\text{NH}_2]}$$



# $K_b$ for Some Common Weak Bases

Many students struggle with identifying weak bases and their conjugate acids. What patterns do you see that may help you?

Base	Formula	Conjugate Acid	$K_b$
Ammonia	$\text{NH}_3$	$\text{NH}_4^+$	$1.8 \times 10^{-5}$
Methylamine	$\text{CH}_3\text{NH}_2$	$\text{CH}_3\text{NH}_3^+$	$4.38 \times 10^{-4}$
Ethylamine	$\text{C}_2\text{H}_5\text{NH}_2$	$\text{C}_2\text{H}_5\text{NH}_3^+$	$5.6 \times 10^{-4}$
Diethylamine	$(\text{C}_2\text{H}_5)_2\text{NH}$	$(\text{C}_2\text{H}_5)_2\text{NH}_2^+$	$1.3 \times 10^{-3}$
Triethylamine	$(\text{C}_2\text{H}_5)_3\text{N}$	$(\text{C}_2\text{H}_5)_3\text{NH}^+$	$4.0 \times 10^{-4}$
Hydroxylamine	$\text{HONH}_2$	$\text{HONH}_3^+$	$1.1 \times 10^{-8}$
Hydrazine	$\text{H}_2\text{NNH}_2$	$\text{H}_2\text{NNH}_3^+$	$3.0 \times 10^{-6}$
Aniline	$\text{C}_6\text{H}_5\text{NH}_2$	$\text{C}_6\text{H}_5\text{NH}_3^+$	$3.8 \times 10^{-10}$
Pyridine	$\text{C}_5\text{H}_5\text{N}$	$\text{C}_5\text{H}_5\text{NH}^+$	$1.7 \times 10^{-9}$

# Reaction of Weak Bases with Water

The generic reaction for a base reacting with water, producing its conjugate acid and hydroxide ion:



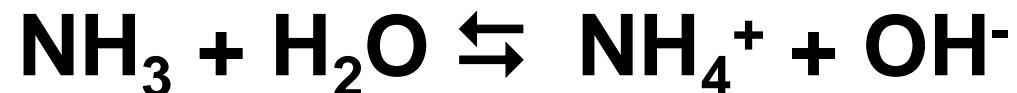
$$K_b = \frac{[BH^+][OH^-]}{[B]}$$

(Yes, all weak bases do this – DO NOT make this more complicated than it needs to be.)

# A Weak Base Equilibrium Problem

What is the pH of a 0.50 M solution of ammonia,  $\text{NH}_3$ ,  
 $K_b = 1.8 \times 10^{-5}$  ?

**Step #1:** Write the equation for the reaction



# A Weak Base Equilibrium Problem

What is the pH of a 0.50 M solution of ammonia,  $\text{NH}_3$ ,  
 $K_b = 1.8 \times 10^{-5}$  ?

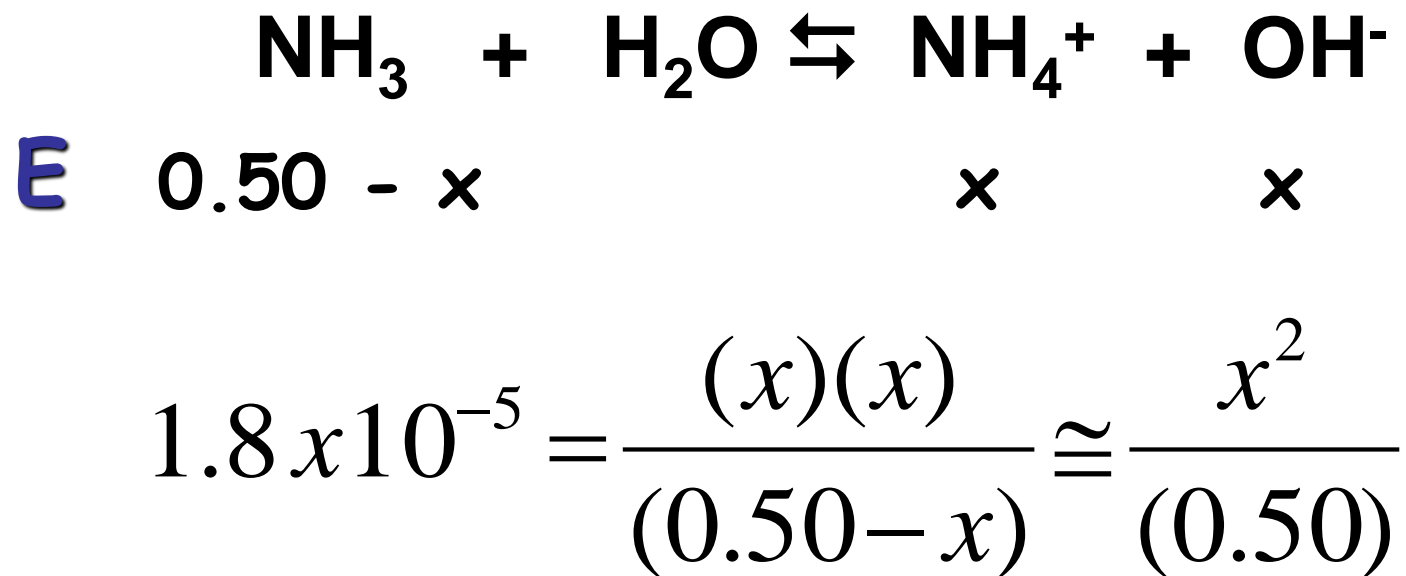
Step #2: ICE it!

	$\text{NH}_3$	+	$\text{H}_2\text{O}$	$\rightleftharpoons$	$\text{NH}_4^+$	+	$\text{OH}^-$
<b>I</b>	0.50				0		0
<b>C</b>	- x				+x		+x
<b>E</b>	0.50 - x				x		x

# A Weak Base Equilibrium Problem

What is the pH of a 0.50 M solution of ammonia,  $\text{NH}_3$ ,  
 $K_b = 1.8 \times 10^{-5}$  ?

**Step #3:** Set up the law of mass action

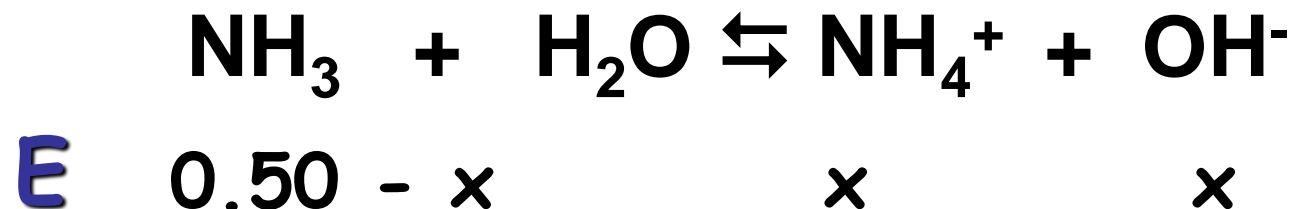


*Can use the 5% rule because  $K < 1$  and  $K$  at least 1000 times smaller than [initial]*

# A Weak Base Equilibrium Problem

What is the pH of a 0.50 M solution of ammonia,  $\text{NH}_3$ ,  $K_b = 1.8 \times 10^{-5}$  ?

**Step #4:** Solve for x, which is also  $[\text{OH}^-]$

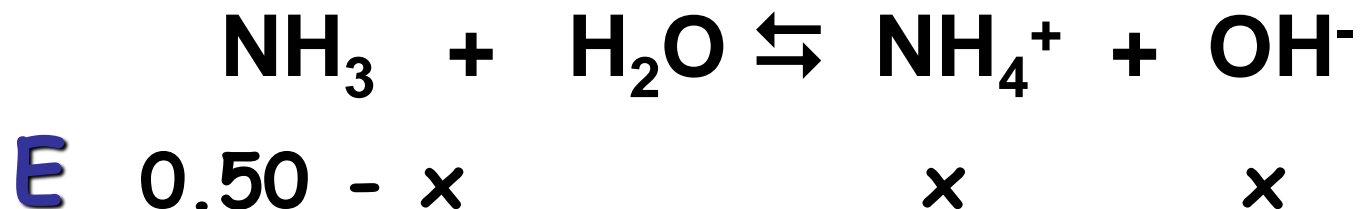


$$1.8 \times 10^{-5} = \frac{x^2}{(0.50)} \quad [\text{OH}^-] = 3.0 \times 10^{-3} \text{ M}$$

# A Weak Base Equilibrium Problem

What is the pH of a 0.50 M solution of ammonia,  $\text{NH}_3$ ,  
 $K_b = 1.8 \times 10^{-5}$  ?

**Step #5:** Convert  $[\text{OH}^-]$  to pH



$$pOH = -\log(3.0 \times 10^{-3}) = 4.52$$

$$pH = 14.00 - pOH = 9.48$$

# Remember...

You can convert back and forth from  $K_a$  to  $K_b$  and vice versa. If you are given  $K_a$  for an acid but are doing problems with the acid's conjugate base you can use that  $K_a$  to find the  $K_b$  that you need.

$$K_a \times K_b = K_w$$

$$K_a \times K_b = (1 \times 10^{-14})$$