

N37 – Acid Base

Weak Problems

Link to YouTube Presentation: <https://youtu.be/WwZBnDhd9J0>

N37 – Acid Base

Weak Problems

Target: I can review Acid Base definitions and perform pH calculations for weak acids/bases

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, $\text{HC}_2\text{H}_3\text{O}_2$, $K_a = 1.8 \times 10^{-5}$?

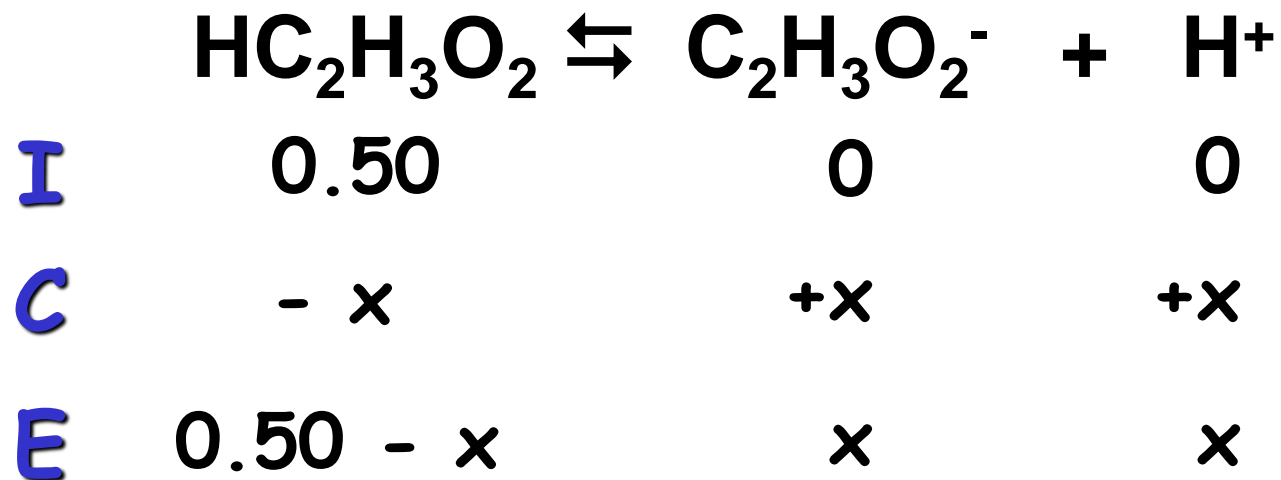
Step #1: Write the dissociation equation



A Weak Acid Equilibrium Problem

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

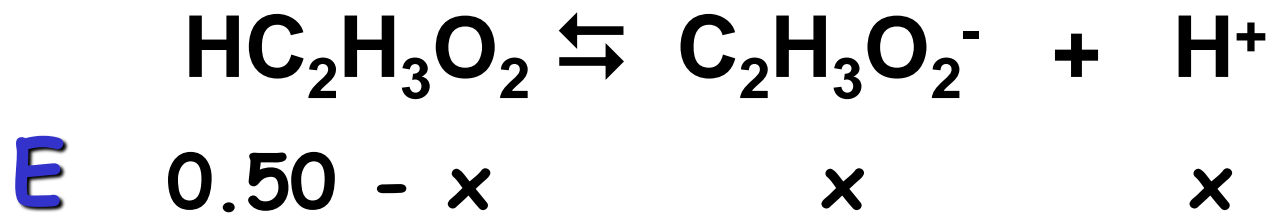
Step #2: ICE it!



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



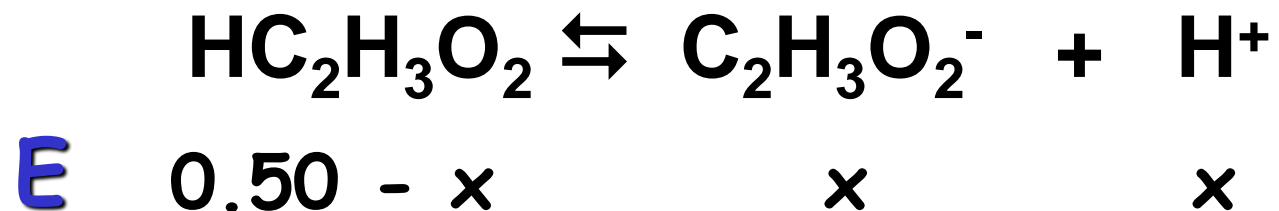
$$1.8 \times 10^{-5} = \frac{(x)(x)}{(0.50 - x)} \cong \frac{x^2}{(0.50)}$$

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 $[\text{H}^+]$

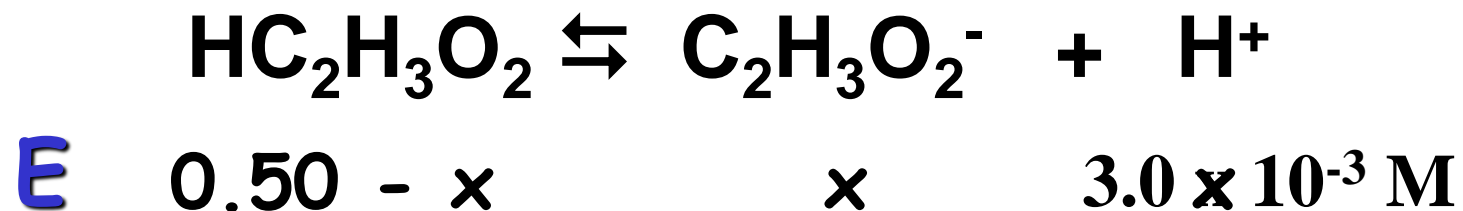


$$1.8 \times 10^{-5} = \frac{x^2}{(0.50)} \quad [\text{H}^+] = 3.0 \times 10^{-3} \text{ M}$$

A Weak Acid Equilibrium Problem

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

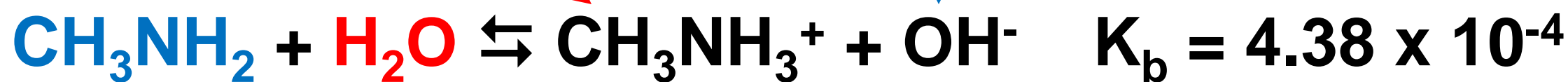
Step #5: Convert $[\text{H}^+]$ to pH



$$\text{pH} = -\log(3.0 \times 10^{-3}) = 2.52$$

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	NH_3	NH_4^+	1.8×10^{-5}
Methylamine	CH_3NH_2	CH_3NH_3^+	4.38×10^{-4}
Ethylamine	$\text{C}_2\text{H}_5\text{NH}_2$	$\text{C}_2\text{H}_5\text{NH}_3^+$	5.6×10^{-4}
Diethylamine	$(\text{C}_2\text{H}_5)_2\text{NH}$	$(\text{C}_2\text{H}_5)_2\text{NH}_2^+$	1.3×10^{-3}
Triethylamine	$(\text{C}_2\text{H}_5)_3\text{N}$	$(\text{C}_2\text{H}_5)_3\text{NH}^+$	4.0×10^{-4}
Hydroxylamine	HONH_2	HONH_3^+	1.1×10^{-8}
Hydrazine	H_2NNH_2	H_2NNH_3^+	3.0×10^{-6}
Aniline	$\text{C}_6\text{H}_5\text{NH}_2$	$\text{C}_6\text{H}_5\text{NH}_3^+$	3.8×10^{-10}
Pyridine	$\text{C}_5\text{H}_5\text{N}$	$\text{C}_5\text{H}_5\text{NH}^+$	1.7×10^{-9}

Reaction of Weak Bases with Water

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



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

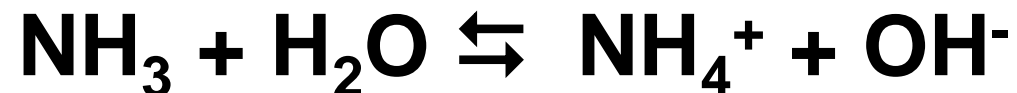
Yes, all weak bases do this –

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, 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, NH_3 , $K_b = 1.8 \times 10^{-5}$?

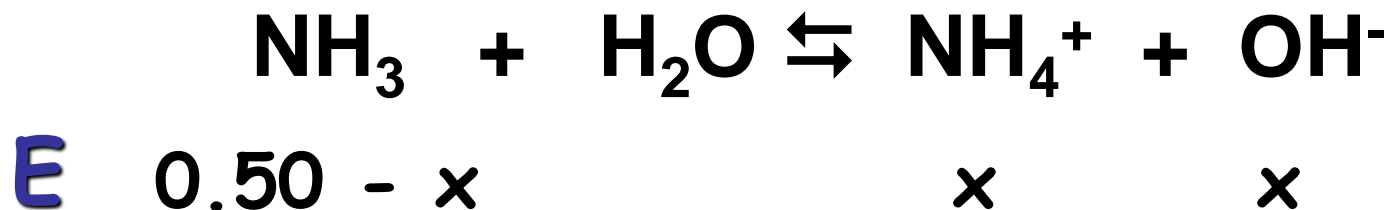
Step #2: ICE it!

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

A Weak Base Equilibrium Problem

What is the pH of a 0.50 M solution of ammonia, NH_3 , $K_b = 1.8 \times 10^{-5}$?

Step #3: Set up the law of mass action



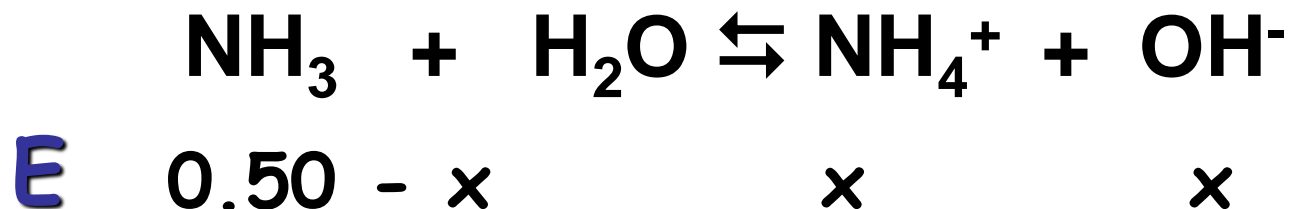
$$1.8 \times 10^{-5} = \frac{(x)(x)}{(0.50 - x)} \approx \frac{x^2}{(0.50)}$$

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

A Weak Base Equilibrium Problem

What is the pH of a 0.50 M solution of ammonia, NH_3 , $K_b = 1.8 \times 10^{-5}$?

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

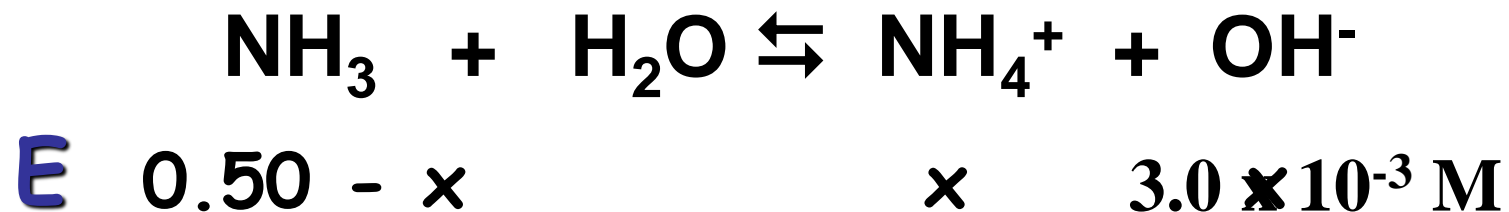


$$1.8 \times 10^{-5} = \frac{x^2}{(0.50)} \quad [\text{OH}^-] = 3.0 \times 10^{-3} \text{ M}$$

A Weak Base Equilibrium Problem

What is the pH of a 0.50 M solution of ammonia, NH_3 , $K_b = 1.8 \times 10^{-5}$?

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



$$pOH = -\log(3.0 \times 10^{-3}) = 2.52$$

$$pH = 14 - pOH = 14 - 2.52 = 11.48$$

Remember! Everyone always forgets!

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.

$$K_a \times K_b = K_w$$

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

Weird Fact!

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

The % ionization for a weak acid
INCREASES as concentration **DECREASES**!

Let's pretend we cut the [] in half

$$Q = \frac{\left[\frac{1}{2}\right]\left[\frac{1}{2}\right]}{\left[\frac{1}{2}\right]} = \frac{1}{2} \quad (\text{of whatever the original was})$$

If Q decreases...

Reaction shifts to make more products...

More ionization! **Higher % ionization!**

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