

Find the pH and the degree of ionization for an 0.10 M solution of formic acid: HCHO_2



$$K_a = \frac{[\text{H}_3\text{O}^+][\text{CHO}_2^-]}{[\text{HCHO}_2]} = 1.8 \times 10^{-4} \quad (\text{Appendix H, OpenStax})$$

Set up an equilibrium chart to reduce the number of variables in the K_a expression.

Species	[Initial]	Δ	[Equilibrium]
H_3O^+	0	+X	X
CHO_2^-	0	+X	X
HCHO_2	0.10	-X	0.10 - X

Let "x" equal the change in hydronium ion concentration.

$$\frac{(x)(x)}{(0.10 - x)} = 1.8 \times 10^{-4}$$

Assume $x \ll 0.10$
 $0.10 - x \approx 0.10$

$$\frac{x^2}{0.10} = 1.8 \times 10^{-4}$$

$$x = 0.0042426407 = [\text{H}_3\text{O}^+]$$

$$\text{So, } \boxed{\text{pH} = 2.37}$$

... but what about degree of ionization?



Degree of ionization is the fraction of a weak acid or base that ionizes in solution.

Here, that's:

$$\frac{[\text{CHO}_2^-]}{[\text{HCHO}_2]_{\text{nominal}}} = \frac{[\text{H}_3\text{O}^+]}{[\text{HCHO}_2]_{\text{nominal}}}$$

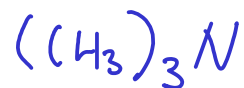
$$\frac{0.0042426407 \text{ M H}_3\text{O}^+}{0.10 \text{ M HCHO}_2} = \boxed{0.042 = 4.2\% \text{ for } 0.10 \text{ M HCHO}_2}$$

Often, we express DOI as a percentage ... call PERCENT IONIZATION;

$$\% \text{ ionization} = \text{DOI} \times 100 = 4.2\% \text{ ionized}$$

From the pH lab: By Le Chateleur's Principle, adding water to the equilibrium should force it to the right - meaning that more acid will ionize - even as the pH goes up!. Therefore, the degree of (or percent) ionization should INCREASES as the concentration of the acid DECREASES. Check this with your experimental data on acetic acid solutions.

An aqueous solution of 0.25 M trimethylamine has a pH of 11.63. What's the experimental value of K_b ?



$$K_b = \frac{[(\text{CH}_3)_3\text{NH}^+][\text{OH}^-]}{[(\text{CH}_3)_3\text{N}]}$$

We don't know K_b ... so how do we proceed? Let's make an equilibrium chart to reduce the number of variables!

Species	[Initial]	Δ	[Equilibrium]
OH^-	0	+x	x
$(\text{CH}_3)_3\text{NH}^+$	0	+x	x
$(\text{CH}_3)_3\text{N}$	0.25	-x	0.25-x

Let "x" equal the change in hydroxide ion concentration

Plug back into K_b expression:

$$K_b = \frac{(x)(x)}{(0.25-x)}$$

$$K_b = \frac{x^2}{0.25-x}$$

Now what? We have fewer variables now, but we still have two!

$$K_b = \frac{(x)(x)}{(0.25-x)}$$

If we had some way to determine "x", we could use it to find K_b ! We can use pH identities and the solution's measured pH of 11.63 to find the hydroxide ion concentration ... which is equal to "x".

$$\begin{array}{l|l} \text{pH} + \text{pOH} = 14.00 & [\text{OH}^-] = 10^{-\text{pH}} \\ 11.63 + \text{pOH} = 14.00 & [\text{OH}^-] = 10^{-2.37} \\ \text{pOH} = 2.37 & [\text{OH}^-] = 0.0042657952 = x \end{array}$$

We've found "x" ... just plug back into the K_b expression to find our answer, K_b .

$$\begin{aligned} K_b &= \frac{(x)(x)}{(0.25-x)} = \frac{x^2}{0.25-x} = \frac{(0.0042657952)^2}{0.25 - 0.0042657952} \\ &= \boxed{7.4 \times 10^{-5} = K_b} \end{aligned}$$