

Compare pH to the pH of an 0.100 M solution of the strong base NaOH:

$$\text{pH}_{\text{NH}_3} \approx 11.13$$



So, 0.100 M NaOH has $[\text{OH}^-] = 0.100$

$$\text{pOH} = -\log_{10}(0.100) = 1.00$$

$$\text{pH} = 14.00 - 1.00 = \boxed{13.00}$$

The stronger the base:

- the higher the pH will be for a solution of given concentration
- the higher the HYDROXIDE concentration (compared to the nominal base concentration)

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



$$K_a = \frac{[\text{H}_3\text{O}^+][\text{CHO}_2^-]}{[\text{HCHO}_2]} = 1.7 \times 10^{-4}$$

Value from page
A-13 in Ebbing 10th
edition...

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

$$\frac{(x)(x)}{(0.10-x)} = 1.7 \times 10^{-4}$$

$$\frac{x^2}{0.10-x} = 1.7 \times 10^{-4}$$

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

$$\frac{x^2}{0.10} = 1.7 \times 10^{-4}$$

$$x = 0.0041231056 = [\text{H}_3\text{O}^+]$$

$$\text{pH} = 2.38$$

What is DEGREE OF IONIZATION? It's the fraction of a weak acid or base that ionizes in water!

$$\frac{[\text{CH}_3\text{O}_2^-]}{[\text{HCHO}_2]_{\text{initial}}} = \frac{[\text{H}_3\text{O}^+]}{[\text{HCHO}_2]_{\text{initial}}} = \frac{0.0041231056}{0.10} = \boxed{0.041 = 0.041}$$

Sometimes we express this as a percent to make it clearer ... this is called PERCENT IONIZATION:

$$\% = 0.041 \times 100\% = \boxed{4.1\% \text{ ionized}}$$

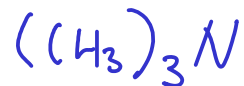
If we DILUTED THE ACID, ...



... amount of water goes up, equilibrium shifts to RIGHT.

When you do Experiment 16A. 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 experiment 16A data on acetic acid.

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



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

How do we find K_b ? Let's set this up like a normal equilibrium problem...

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

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

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

If we want to find K_b , we must use other information to find 'x'. We know pH, which gives us a way to find hydronium and hydroxide concentrations...

$$K_b = \frac{x^2}{0.25 - x} \quad \text{and} \quad \text{pH} = 11.63$$

$$\text{pOH} = 14.00 - 11.63 = 2.37$$

$$[\text{OH}] = 10^{-2.37} = 0.0042657952$$

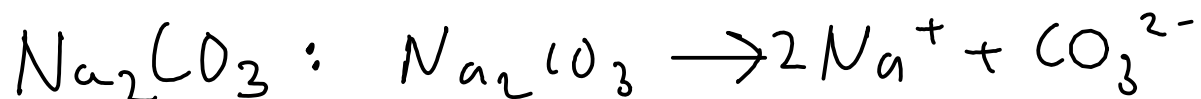
$$\text{So, } x = 0.0042657952$$

Now, just plug in 'x' to the equilibrium expression and we'll have K_b ...

$$K_b = \frac{(0.0042657952)^2}{0.25 - 0.0042657952} = 7.4 \times 10^{-5} = K_b$$

SALTS

- Compounds that result from the reaction of an acid and a base.
- Salts are strong electrolytes (completely dissociate in water) IF SOLUBLE (not all salts dissolve appreciably).
- Most ionic compounds are considered salts (they can be made by some reaction between the appropriate acid and base)
- Salts have acidic and basic properties! The ions that form when salts are dissolved can be acidic, basic, or neutral.
- Salts made from WEAK ACIDS tend to form BASIC solutions
- Salts made from WEAK BASES tend to form ACIDIC solutions



Do any of these ions have acidic or basic properties?

Na^+ : neutral. Not a proton donor or a proton acceptor

CO_3^{2-} : BASIC, since it can accept protons to form the weak acid CARBONIC ACID in solution.



ACID

BASE

SALT OF A WEAK ACID

ex: $\text{NaC}_2\text{H}_3\text{O}_2$ 

For this reaction to occur, HA MUST be stable in water. In other words, a weak acid.



The anion is a BASE. It can accept a proton from water to form the weak (therefore stable as a molecule!) acid HA

$$K_b = \frac{[\text{HA}][\text{OH}^-]}{[\text{A}^-]} \quad \left| \text{--- This is the base ionization constant for } \text{A}^- \right.$$

Since A^- and HA are a conjugate pair, the ionization constants are related!

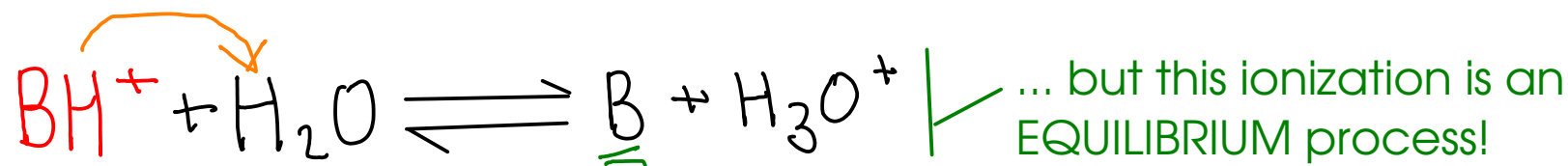
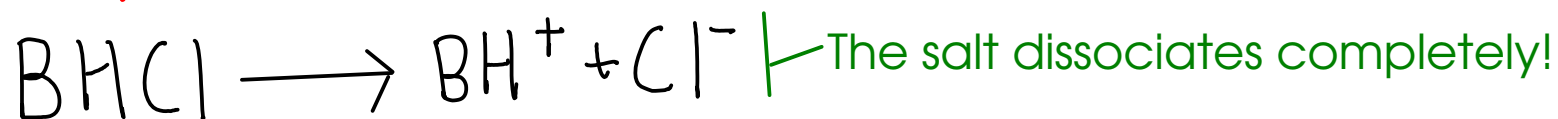
$$K_w = (K_{a,\text{HA}})(K_{b,\text{A}^-})$$

1.0×10^{-14}

$$14 = \text{p}K_a + \text{p}K_b$$

You will generally not find both the K_a AND K_b for a conjugate pair in the literature, since one can be easily converted to the other!

SALT OF A WEAK BASE

ex: NH_4Cl 

$$K_a = \frac{[\text{B}][\text{H}_3\text{O}^+]}{[\text{BH}^+]} \quad \left| \text{Acid ionization constant for } \text{BH}^+ \right.$$

$$K_w = (K_{a,\text{BH}^+})(K_{b,\text{B}})$$

1.0×10^{-14}

Find the pH for salt solutions just like you would find pH for any other weak acid or weak base solutions. Only trick is to find out whether the salt is actually acidic or basic!