¹⁴⁸ Find the pH and the degree of ionization for an 0.10 M solution of formic acid: $HCHO_2$

$$H(LHO_{2} + H_{2}O \rightleftharpoons H_{3}O^{+} + CHO_{2}^{-})$$

$$K_{A} = \begin{bmatrix} H_{2}O^{+} \end{bmatrix} \begin{bmatrix} CHO_{2}^{-} \end{bmatrix} = 1.7 \times 10^{-4}$$

$$K_{A} = \begin{bmatrix} H_{2}O^{+} \end{bmatrix} \begin{bmatrix} CHO_{2}^{-} \end{bmatrix} = 1.7 \times 10^{-4}$$

$$F(HO_{2}^{-})$$

$$H_{3}O^{+} = 0 + X \times X$$

$$H(HO_{2}^{-}) = 1.7 \times 10^{-4}$$

$$H(HO_{2}^{-}) = 0.7 \times 10^{-4}$$

$$\frac{(X)(X)}{O.10 - X} = 1.7 \times 10^{-4}$$

$$\frac{(X)(X)}{O.10 - X} = 1.7 \times 10^{-4}$$

$$\frac{X^{2}}{O.10 - X} = 1.7 \times 10^{-4}$$

$$\int_{O.10^{-} \times X} = 0.7 \times 10^{-4}$$

¹⁴⁹ What is DEGREE OF IONIZATION? The fraction of a weak acid (or base) that ionzies in water:

$$\frac{[(HO_2]]}{[H(HO_2]_{rominal}]} = \frac{0.0041231056}{0.10} = 0.041 = 001$$

Sometimes, we express the DOI in terms of a PERCENTAGE, which we call PERCENT IONIZATION ...

When you do Experiment 16A. By Le Chateleir'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 Kb? $((H_3)_3 N)$

$((H_3)_3N + H_2O \rightleftharpoons ((H_3)_3NH^+ + OH^-)$						
$K_{h} = \frac{\sum ((H_{3})_{3} N H_{4}^{\dagger}) \sum (H_{3})_{3} N H_{4}^{\dagger}}{\sum (H_{3})_{3} N H_{4}^{\dagger}}$						
$\left((H_3)_3 N \right)$ How do we find Kb? First, let's set up the equilibrium problem the way we usually do						
Species		[Initia]]	8	[Equilibrium]	Define "x" as the change in trimethylammonium ion	
((Hz)zNH+		0	+ X	×		
O H-		0	4 X	X		
$((H_3)_3N$		0.25	$-\chi$	0,25-2		
$K_{b} = \frac{(x)(x)}{0.25 - x}$						
$K_b = \frac{\chi^2}{0.2S - \chi}$				If we want to find first find an altern the value of "x"	If we want to find the value of Kb, we must first find an alternate way of figuring out the value of "x"	

Use the pH of 11.63 to find the hydroxide concentration ... and "x" \ldots

Plug in the value of "x" to find Kb \dots

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

¹⁵² 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 <u>WEAK ACIDS</u> tend to form <u>BASIC</u> solutions

- Salts made from <u>WEAK BASES</u> tend to form <u>ACIDI</u>C solutions

$$Na_2(O_3: Na_1O_3 \rightarrow 2Na^+ + CO_3^2)$$

Do any of these ions have acidic or basic properties?

 Ma^{\star} : neutral. Not a proton donor or a proton acceptor

 $(O_3^2 - BASIC, since it can accept protons to form the weak acid CARBONIC ACID in solution.$

$$H_2 (O_3 + 2H_2 O \rightleftharpoons 2H_3 O^{\dagger} + CO_3^{-2}$$

$$ACID BASE$$

SALT OF A WEAK ACID

ex; $NaC_2H_3O_2$ $NaA \longrightarrow Na^{+} + A^{-}$ The salt dissolves completely!

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

+ $H_2 O \longrightarrow HA + OH^- \vdash \dots$ but the ionization of the salt's anion is an EQUILIBRIUM!

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

$$K_b = \frac{[HA][OH^-]}{[A^-]}$$
 This is the base ionization constant for \overline{A}

Since \vec{A} and HA are a conjugate pair, the ionization constants are related!

$$K_{W} = (K_{a,HA})(K_{b,A})$$

1.0 × 10 · 14
1.4 2 p Ka + p Kb

You will generally not find both the Ka AND Kb for a conjugate pair in the literature, since one can be easily converted to the other! xx: NH4CI $\longrightarrow BH^+ + C [-]$ The salt dissociates completely! $BH^+ + H_2O \implies B + H_3O^+ / \dots$ but this ionization is an EQUILIBRIUM process! $K_{a} = \frac{[B][H_{3}0^{+}]}{[R_{H}t]}$ Acid ionization constant for BH⁺ $Kw = (K_{a,BH^{+}})(K_{b,B})$ 1.0×10-16

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!

0.100 M NHy C) ... Find the pH of the solution

$$NH_{Y}(1 \rightarrow NH_{Y}^{+} + C1^{-})$$

 NH_{Y}^{+} ; $NH_{Y}^{+} + H_{2} = NH_{3}^{+} + H_{3} + H$

CHLORIDE ION is NEUTRAL.

So, to find the pH of the solution, we will have to solve the equilibrium of the ammonium ion ...

$$NH_{4}^{+} + H_{2}O \rightleftharpoons NH_{3} + H_{3}O$$

$$K_{4} = \frac{[NH_{3}][H_{3}O^{+}]}{[NH_{4}^{+}]}$$

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$$\begin{split} & \mathsf{N} \mathcal{H}_{\mathsf{Y}}^{\mathsf{T}} + \mathsf{H}_{2} \mathcal{O} \rightleftharpoons \mathcal{N} \mathcal{H}_{\mathsf{Z}}^{\mathsf{T}} + \mathcal{H}_{3} \mathcal{O}^{\mathsf{T}} \\ & \mathsf{K}_{\mathsf{A}} = \frac{(\mathcal{N}\mathcal{H}_{\mathsf{Z}})[\mathcal{H}_{\mathsf{Z}} \mathcal{O}^{\mathsf{T}}]}{(\mathcal{N}\mathcal{H}_{\mathsf{Y}}^{\mathsf{T}})} \\ & \mathsf{K}_{\mathsf{A}} = \frac{(\mathcal{N}\mathcal{H}_{\mathsf{Z}})[\mathcal{H}_{\mathsf{Z}} \mathcal{O}^{\mathsf{T}}]}{(\mathcal{N}\mathcal{H}_{\mathsf{Y}}^{\mathsf{T}})} = \mathsf{S}, \mathsf{S} \mathsf{S} \mathsf{V} \mathsf{I} \mathsf{O}^{\mathsf{T} \mathsf{N}} \\ & \mathsf{K}_{\mathsf{N}, \mathsf{N} \mathsf{H}_{\mathsf{Z}}}^{\mathsf{T}} = \mathsf{I}, \mathfrak{S} \mathsf{X} \mathsf{I} \mathsf{O}^{\mathsf{T} \mathsf{S}} \\ & \mathsf{K}_{\mathsf{A}, \mathsf{N} \mathsf{H}_{\mathsf{A}}^{\mathsf{T}}} \times \mathsf{K}_{\mathsf{O}, \mathsf{N} \mathsf{H}_{\mathsf{Z}}}^{\mathsf{T}} = \mathsf{I}, \mathfrak{O} \times \mathcal{I} \mathsf{O}^{-1 \mathsf{M}} \\ & \mathsf{K}_{\mathsf{A}, \mathsf{N} \mathsf{H}_{\mathsf{A}}^{\mathsf{T}}} \times \mathsf{K}_{\mathsf{O}, \mathsf{N} \mathsf{H}_{\mathsf{Z}}}^{\mathsf{T}} = \mathsf{I}, \mathfrak{O} \times \mathcal{I} \mathsf{O}^{-1 \mathsf{M}} \\ & \mathsf{K}_{\mathsf{A}, \mathsf{N} \mathsf{H}_{\mathsf{A}}^{\mathsf{T}}} \times \mathsf{K}_{\mathsf{O}, \mathsf{N} \mathsf{H}_{\mathsf{Z}}}^{\mathsf{T}} = \mathsf{S}, \mathsf{S} \mathsf{S} \times \mathcal{I} \mathsf{O}^{-1 \mathsf{O}} \\ & \mathsf{K}_{\mathsf{A}, \mathsf{N} \mathsf{H}_{\mathsf{A}}^{\mathsf{T}}} \times \mathsf{K}_{\mathsf{O}, \mathsf{N} \mathsf{H}_{\mathsf{Z}}}^{\mathsf{T}} = \mathsf{S}, \mathsf{S} \mathsf{S} \times \mathcal{I} \mathsf{O}^{-1 \mathsf{O}} \\ & \mathsf{N} \mathsf{H}_{\mathsf{S}} & \mathsf{O} & \mathsf{T} \mathsf{X} \\ & \mathsf{N} \mathsf{H}_{\mathsf{S}} & \mathsf{O} & \mathsf{T} \mathsf{X} \\ & \mathsf{N} \mathsf{H}_{\mathsf{S}} & \mathsf{O} & \mathsf{T} \mathsf{X} \\ & \mathsf{N} \mathsf{H}_{\mathsf{S}}^{\mathsf{T}} & \mathsf{O}, \mathsf{IDO} & \mathsf{N} \mathsf{X} \\ & \mathsf{N} \mathsf{H}_{\mathsf{S}}^{\mathsf{T}} & \mathsf{O}, \mathsf{IDO} & \mathsf{N} \mathsf{X} \\ & \mathsf{N} \mathsf{H}_{\mathsf{S}}^{\mathsf{T}} & \mathsf{O}, \mathsf{IDO} & \mathsf{N} \mathsf{X} \\ & \mathsf{N} \mathsf{H}_{\mathsf{S}}^{\mathsf{T}} & \mathsf{O}, \mathsf{IDO} & \mathsf{N} \mathsf{X} \\ & \mathsf{N} \mathsf{H}_{\mathsf{S}}^{\mathsf{T}} & \mathsf{O}, \mathsf{IDO} & \mathsf{N} \mathsf{X} \\ & \mathsf{N} \mathsf{H}_{\mathsf{S}} & \mathsf{O} & \mathsf{I} \mathsf{N} \\ & \mathsf{N} \mathsf{H}_{\mathsf{S}}^{\mathsf{T}} & \mathsf{O}, \mathsf{IDO} & \mathsf{N} \mathsf{X} \\ & \mathsf{N} \mathsf{H}_{\mathsf{S}}^{\mathsf{T}} & \mathsf{O}, \mathsf{IDO} & \mathsf{N} \mathsf{S} \mathsf{I} \mathsf{I} \mathsf{O}^{\mathsf{T}} \\ & \mathsf{O}, \mathsf{IDO} \mathsf{I} \mathsf{N} \\ & \mathsf{N} \mathsf{S} \\ & \mathsf{N} \mathsf{H}_{\mathsf{S}}^{\mathsf{T}} & \mathsf{O}, \mathsf{IDO} \mathsf{N} \\ & \mathsf{S} \mathsf{S} \mathsf{S} \mathsf{S} \mathsf{S} \mathsf{N} \mathsf{I} \\ & \mathsf{N} \\ & \mathsf{N} \mathsf{S} \\ & \mathsf{O}, \mathsf{N} \mathsf{H}_{\mathsf{S}}^{\mathsf{T}} & \mathsf{O}, \mathsf{I} \mathsf{O} \\ & \mathsf{N} \\ & \mathsf{N} \\ & \mathsf{N} \mathsf{S} \\ & \mathsf{N} \mathsf{S} \\ & \mathsf{N} \mathsf{S} \\ & \mathsf{N} \mathsf{S} \\ & \mathsf{N} \\ & \mathsf{N} \mathsf{S} \\ & \mathsf{N} \mathsf{S} \\ & \mathsf{N} \mathsf{S} \\ & \mathsf{N} \mathsf{S} \\ & \mathsf{N} \\ & \mathsf{N} \\ & \mathsf{N} \mathsf{S} \\ & \mathsf{N} \\ & \mathsf{N$$

$$\bigcirc$$
 .100 M NaC₂H₃O₂, Find pH
NaC₂H₃O₂ \rightarrow Na⁺+C₂H₃O₂⁻

Check the ions released when the salt dissolves to see if they're acidic, basic, or neutral!

 N_{a} + : Not a B-L acid (no H+ to donate). Not likely to be B-L base due to positive charge. So, this ion is neutral.

 $C_2H_3O_2^-$: Has hydrogen atoms, but is more likely to be a B-L base due to the charge.

 $(2H_3O_2^- + H_2O \rightleftharpoons H(2H_3O_2^+ OH^-)$ ACETIC ACID is a weak acid, meaning that it is water-stable. So, we expect that acetate ion can function as a base by accepting a proton from water.

$$S_{0}, K_{b} = \frac{[H(_{2}H_{3}O_{2})][OH]}{[(_{2}H_{3}O_{2})]}$$

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As before, we won't find Kb for acetate ion in the chart. But we CAN find Ka for its conjugate ... acetic acid! See page A-13.

Ka,
$$H(2H_3O_2 = 1.7 \times 10^{-5}$$
 Ka $\times 10^{-10}$
So, Kb, $C_2H_3O_2 = \frac{1.0 \times 10^{-14}}{1.7 \times 10^{-5}} = 5.89 \times 10^{-10}$

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For comparison:

0.100 M sodium acetate, pH = 8.88

0.100 M ammonia, pH = 11.13

0.100 M NaOH (strong base), pH = 13.00

The acetate ion is basic, but it's a very weak base!

$$O.100 M NaCl, Find pH$$

 $NaCl \rightarrow Na^{+}+Cl^{-}$

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Check the ions formed in solution to see if they have acidic or basic properties.

 N_{a} Not B-L acid, since there is no H+ to donate. Not likely to be B-L base due to the positive charge ... which would repel H+

C1: Not B-L acid. Is is a B-L base? (It *is* negatively charged!) $\begin{array}{c} (1 + H_2 D \rightleftharpoons H(1 + OH^-) \\ HYDROCHLORIC ACID: This is a STRONG ACID. \\ This means that HCI is not strable in water; it'll immediately lose any acquired protons! We conclude that chloride ion is NOT an effective B-L base. \end{array}$

Since neither sodium nor chloride ions affect pH, the pH of the solution is set by the water equilibrium. Therefore, the pH of the solution is 7.00 ... just like distilled water.