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

Na_2CO_3 : $Na_2CO_3 \rightarrow 2Na^+ + CO_3^{2-}$

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.

$$H_2CO_3 + 2H_2O \rightleftharpoons 2H_3O^+ + CO_3^{-2}$$

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.

$$A^- + H_2O \rightleftharpoons HA + OH^-$$

... 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 A^-

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

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

1.0×10^{-14}

$$14 = pK_a + pK_b$$

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!

SALT OF A WEAK BASE

ex: NH_4Cl

$$BHCl \longrightarrow BH^+ + Cl^-$$

The salt dissociates completely!

$$BH^+ + H_2O \rightleftharpoons B + H_3O^+$$

... but this ionization is an EQUILIBRIUM process!

$$K_a = \frac{[B][H_3O^+]}{[BH^+]}$$

Acid ionization constant for BH^+

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

$K_w = 1.0 \times 10^{-14}$

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!

0.100 M NH_4Cl ... Find the pH of the solution

$NH_4Cl \rightarrow NH_4^+ + Cl^-$ Can either of these ions function as a B-L acid or base?

NH_4^+: $NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$ Since ammonia is a WEAK base, we know it's stable in water, making ammonium ion function as an acid.

Cl^-: $Cl^- + H_2O \rightleftharpoons HCl + OH^-$ Since HCl is a strong acid, we know it's NOT stable in water, and that chloride ion shouldn't be able to accept the proton.

So, to figure out the pH of the solution, we need to look at ammonium ion's equilibrium $NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$; $K_a = \frac{[NH_3][H_3O^+]}{[NH_4^+]}$

Species	[Initial]	Δ	[Equilibrium]
NH_3	0	+x	x
H_3O^+	0	+x	x
NH_4^+	0.100	-x	0.100 - x

$$\frac{(x)(x)}{(0.100 - x)} = K_a$$

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$$\frac{x^2}{0.100-x} = 5.56\times10^{-10}$$

$x \ll 0.100$, 50

$0.100 - x \simeq 0.100$

$$\frac{x^2}{0.100} = 5.56\times10^{-10}$$

$$x = 7.45\times10^{-6} = [H_3O^+]$$

$pH = 5.12$

We need Ka for ammonium ion. No value for this Ka on page A-13, but on page A-14 we find the Kb for ammonia, the conjugate of ammonium ion...

$K_{b,NH_3} = 1.8\times10^{-5}$

$$K_a \times K_b = K_w$$

$$K_a(1.8\times10^{-5}) = 1.0\times10^{-14}$$

$$K_{a,NH_4^+} = 5.56\times10^{-10}$$

0.100 M $NaC_2H_3O_2$, Find pH

$$NaC_2H_3O_2 \rightarrow Na^+ + C_2H_3O_2^-$$

Na^+: Neutral (doesn't seem to be a way for it to either donate or accept protons...)

$C_2H_3O_2^-$: $C_2H_3O_2^- + H_2O \rightleftharpoons HC_2H_3O_2 + OH^-$

Acetic acid is WEAK and stable in water, so we think acetate will be basic!

So we'll need to solve acetate ion's equilibrium...

$$C_2H_3O_2^- + H_2O \rightleftharpoons HC_2H_3O_2 + OH^- ; \quad K_b = \frac{[HC_2H_3O_2][OH^-]}{[C_2H_3O_2^-]}$$

Species	[Initial]	Δ	[Equilibrium]
$HC_2H_3O_2$	0	+X	X
OH^-	0	+X	X
$C_2H_3O_2^-$	0.100	−X	0.100−X

$$\frac{(x)(x)}{(0.100-x)} = K_b$$

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$$\frac{x^2}{0.100-x} = 5.88\times10^{-10}$$

$x \ll 0.100$, so
$0.100 - x \approx 0.100$

$$\frac{x^2}{0.100} = 5.88\times10^{-10}$$

$$x = 7.67\times10^{-6} = [OH^-]$$

$$pOH = 5.12$$

$$pH = 14.00 - pOH = 14.00 - 5.12 = \boxed{8.88}$$

We need Kb for acetate ion. We won't find it on page A-14. We WILL find Ka for the conjugate, acetic acid, on the previous page A-13...

$$K_{a,\,HC_2H_3O_2} = 1.7\times10^{-5}$$

$$K_a \times K_b = K_w$$

$$(1.7\times10^{-5})(K_b) = 1.0\times10^{-14}$$

$$K_b = 5.88\times10^{-10}$$

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!