# 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 prodon 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 contant for Ā

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

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

$1.0 \times 10^{-14}$

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 $BH^+$

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

$1.0 \times 10^{-14}$

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

$NH_4Cl \rightarrow NH_4^+ + Cl^-$

Acidic, basic, or neutral salt?

This is the WEAK BASE ammonia. Stable in water. ✓

$NH_4^+$: $NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$ ✓

$Cl^-$: $Cl^- + H_2O \rightleftharpoons HCl + OH^-$ ✗

This is a STRONG ACID, which does not exist as a stable molecule in water.

The conjugate of a strong acid or base is NEUTRAL - does not affect pH!

$NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$ This equilibrium affects the pH, so it is the equilibrium we'll need to solve to find pH!

$NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$

$K_a = \dfrac{[NH_3][H_3O^+]}{[NH_4^+]} = \boxed{5.56 \times 10^{-10}}$

Where do we get this Ka?

$K_{b,NH_3} = 1.8 \times 10^{-5}$

$K_a \times K_b = 1.0 \times 10^{-14}$

| | initial | Δ | equilibrium |
|---|---|---|---|
| $[NH_3]$ | 0 | $+x$ | $x$ |
| $[H_3O^+]$ | 0 | $+x$ | $x$ |
| $[NH_4^+]$ | .100 | $-x$ | $.100 - x$ |

Define "x" to be the amount of ammonium ion that reacts!

$$\frac{x^2}{.100 - x} = 5.56 \times 10^{-10}$$

$x \ll .100$

$$\frac{x^2}{.100} = 5.56 \times 10^{-10}$$

$x = 7.45 \times 10^{-6}$

$7.45 \times 10^{-6} = [H_3O^+]$

$\boxed{5.13 = pH}$

Compare to:
pH = 1.00 for 0.100 M strong acid
pH = 2.16 for 0.100 M nitrous acid