ACIDS AND BASES – 4
ACID BASE SALTS

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SALT SOLUTIONS

- Salts of neutralization reactions can be acidic or basic depending on the strength of acid and base.
- Strong acid (HCl) + strong base (NaOH) –> gives neutral salts (NaCl).
    - Conjugate acid: $Na^+ + H_2O \rightarrow$ No Reaction (NR)
    - Conjugate base: $Cl^- + H_2O \rightarrow$ NR
- Strong acid (HCl) + weak base (NH_3) –> gives weak conjugate acids (NH_4^+), so weak acidic solutions.
    - Conjugate acid: $NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$
- Weak acid (HF) + strong base (NaOH) –> gives weak conjugate bases (F^-), so weak basic solutions.
    - Conjugate base: $F^- + H_2O \rightleftharpoons HF + OH^-$

In General….	Example
A cation that makes solution acidic: • Conjugate acid of weak base • A small highly charged metal	 NH_4^+, $CH_3NH_3^+$ Al^{3+}, Cr^{3+}, Fe^{3+}, Bi^{3+}
An anion that makes a solution basic is: • Conjugate base of a weak acid	 CN^-, NO_2^-, CH_3COO^-
A cation that does not affect pH of solution: • Group I ion	 Li^+, Na^+
An anion that will not affect pH of a solution: • The conjugate base of a strong acid	 Cl^-, NO_3^-, ClO_4^-

IDENTIFYING ACIDIC/BASIC SALTS

- To identify the acidic or basic nature of the salt,
  - break it down into its anion and cation;
  - then see what it is a conjugate acid or base of and
  - then determine the acidity/basicity of the salt.

Examples:

NaBr: Na^+ is the conjugate acid of NaOH, a strong base. Br^- is the conjugate base of HBr, a strong acid. (SA+SB = neutral salt)

$NaC_2H_3O_2$: Na^+ is the conjugate acid of NaOH, a strong base. $C_2H_3O_2^-$ is the conjugate base of $HC_2H_3O_2$, a weak acid. (WA + SB = basic salt; because anion is good conjugate base coming from a weak acid)

NH_4Cl: NH_4^+ is the conjugate acid of NH_3, a weak base. Cl^- is the conjugate base of HCl, a strong acid. (SA + WB = acidic salt; because the cation is a good conjugate acid coming from a weak base)

EXAMPLES: IDENTIFYING ACID/BASE SALTS

Ammonium nitrate, NH_4NO_3, is administered as an intravenous solution to patients whose blood pH has deviated from the normal value of 7.40. Would this substance be used for acidosis (blood pH < 7.40) or alkalosis (blood pH > 7.40)?

Solution:

NH_4^+ is the conjugate acid of a NH_3, a weak base. NH_4^+ is acidic.

NO_3^- is the conjugate base of HNO_3, a strong acid. NO_3^- is neutral.

NH_4NO_3 is acidic, so it could be used for alkalosis

DETERMINING ACID/BASE SALT BY K_a AND K_b

If $K_a > K_b$, the solution is acidic.

If $K_a < K_b$, the solution is basic.

If $K_a = K_b$, the solution is neutral.

Use K_b for NH_3

$$\text{For } NH_4^+ : K_a = \frac{K_w}{K_b} = \frac{1.0 \times 10^{-14}}{1.8 \times 10^{-5}} = 5.6 \times 10^{-10}$$

Use K_a for HF

$$\text{For } F^- : K_b = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{6.8 \times 10^{-4}} = 1.5 \times 10^{-11}$$

$$K_a \text{ for } NH_4^+ > K_b \text{ for } F^-$$

NH_4F is **acidic.**

EXAMPLE: pH OF A SALT SOLUTION -1

Determine the pH of a 0.25 *M* solution of pyridinium nitrate ($C_5H_5NHNO_3$) at 25°C. [Pyridinium nitrate dissociates in water to give pyridinium ions ($C_5H_5NH^+$) (K_b = 1.7 x 10^{-9}), and nitrate ions (NO_3^-).]

Solution:

$$K_a = \frac{K_w}{K_b} = \frac{1.00 \times 10^{-14}}{1.7 \times 10^{-9}} = 5.9 \times 10^{-6} \qquad K_a = \frac{[C_5H_6N][H_3O^+]}{[C_5H_6NH^+]}$$

$$C_5H_5NH^+(aq) + H_2O(l) \longrightarrow C_5H_5N(aq) + H_3O^+(aq)$$

	$C_5H_5NH^+$	C_5H_5N	H_3O^+
Initial	0.25 M	0	0
Change	-x	+x	+x
Eq. conc.	0.25M-x	x	x

$$K_a = \frac{x^2}{(0.25\ M - x)} \cong \frac{x^2}{(0.25\ M)} = 5.9 \times 10^{-6}$$

$$x = \sqrt{(5.9 \times 10^{-6})(0.25\ M)} = 1.2 \times 10^{-3}\ M$$

$$[H_3O^+] = 1.2 \times 10^{-3}\ M$$

$$pH = -\log(1.2 \times 10^{-3}\ M) = 2.92$$

Check: $$\frac{1.2 \times 10^{-3}\ M}{0.25\ M} \times 100 = 0.49\%$$

EXAMPLE: pH OF A SALT SOLUTION - 2

Household bleach is a 5% solution of sodium hypochlorite, NaClO. This corresponds to a molar concentration of about 0.70 *M* NaClO. What is the $[OH^-]$ and the pH of the solution? HClO, $K_a = 3.5 \times 10^{-8}$.

Solution: $K_b = 2.9 \times 10^{-7}$ (Using the K_w expression)

	$ClO^- + H_2O$	$\rightleftharpoons$	$HClO$	$+ OH^-$
Initial	0.70		0	0
Change	-x		+x	+x
Eq. conc	0.70 – x		x	x

$$K_b = \frac{[HClO][OH^-]}{[ClO^-]}$$

$$2.9 \times 10^{-7} = \frac{x^2}{0.70}$$

$$x^2 = 2.0 \times 10^{-7}$$

$$x = 4.5 \times 10^{-4}\ M$$

$$[OH^-] = x = 4.5 \times 10^{-4}\ M$$

$$pH = 14.00 = pOH = 14.00 - \log[OH^-]$$

$$pH = 14.00 - \log(4.5 \times 10^{-4})$$

$$pH = 14.00 - 3.35$$

$$\boxed{pH = 10.65}$$

KEY CONCEPTS

- Identify acidic and basic salts
- Calculate pH of acidic and basic salt solutions