More Acid/Base: Properties, Strength, Lewis Acids and Bases

Ch. 16 Sec 8 Acid-Base Properties of Salt Solutions

<u>What are the acid-base properties and strengths of each component of the salt?</u>

Since ions can exhibit acid or base properties (i.e., donate or accept protons), salt solutions can be acidic or basic.

-- Nearly all salts are strong electrolytes.

-- <u>hydrolysis</u>:

(refer to Hydrolysis of Salts on-line)

- Anions derived from weak acids react with water to form OH^-, and are thus basic.
- Anions of strong acids do NOT influence pH. $\rightleftharpoons$
- Anions that still have ionizable protons (e.g., HSO_3^-) are <u>amphoteric</u>.

Does Na_2HPO_4 form an acidic or a basic solution in water?

Real question is: How does HPO_4^{2-} behave?

Like an acid...

...or a base?

From a reference table, we find...

(a) $H_3PO_4 \rightleftharpoons H^+ + H_2PO_4^-$

(b) $H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-}$

(c) $HPO_4^{2-} \rightleftharpoons H^+ + PO_4^{3-}$

Predicting pH for salts derived from a... **(give examples of reactions)**

(1) ...strong base and a strong acid

(2) ...strong base and a weak acid

(3) ...weak base and a strong acid

(4) ...weak base and a weak acid

For aqueous solutions, Kw = Ka x Kb

Ch 16 Sec 9 -HYDROLYSIS REACTIONS:

1. Salts of SA and SB---neither the cation nor the anion reacts with water.

NaCl ---> Na+ + Cl-

H_2O + H_2O <---> H_3O^+ + OH-

Na+ doesn't react with OH-

Cl- doesn't react with H_3O+

2. Salts of SB with WA - Basic solutions results because anions of WA react with water to form OH- ions.

*Consider a solution of $NaC_2H_3O_2$. It is the salt of NaOH and $HC_2H_3O_2$.

$$K_b \text{ (hydrolysis constant)} = \frac{[HC_2H_3O_2]\,[OH^-]}{[C_2H_3O_2^-]}$$

The value of Kb is found by Kw = Ka x Kb

Ex. #1 So, calculate [OH-] and pH for a 0.10 M solution of $NaC_2H_3O_2$.

Ka = 1.7×10^{-5}

Step 1: Solve for Kb with: Kb = Kw/Ka

$1.0 \times 10^{-14}/1.7 \times 10^{-5} = 5.9 \times 10^{-10}$

Step 2: React anion with water

	$C_2H_3O_2^-$ + H_2O <--->	$HC_2H_3O_2$ +	OH-
I	.10M		
C	-x	+x	+x
E	.10M-x	x	x

$$\frac{x^2}{0.10} = 5.9 \times 10^{-10}$$

x = [OH-] = 7.7×10^{-6} M

pH = 8.89 (basic)

Anions of Weak Acids

$$NaClO(aq) \rightleftharpoons Na^+(aq) + ClO^-(aq)$$

Ex #2 What mass of NaClO is required to make 2.0 L of a pH 10.50 solution? The K_b for ClO^- is 3.3×10^{-7}.

ans: 44.3 g

Ex. #3 Calculate [OH-], pH and percent hydrolysis for the fluoride ion in 0.10 M sodium fluoride solution. First, calculate the hydrolysis constant for F-, the anion of hydrofluoric acid. **(do the math involved here)**

First – write the equation for the hydrolysis and the mass action expression.

Next – calculate the hydrolysis constant for F-, the anion of hydrofluoric acid. The Ka for HF= 7.2×10^{-4}.

$K_b = 1.4 \times 10^{-11}$

$[OH^-] = 1.18 \times 10^{-6}$

pOH = 5.93

pH = 8.07

% hydrolysis = 0.001%

3. Salts of WB and SA: Produces acidic solutions because cations of weak bases react with water to form H_3O^+

Consider a solution of ammonium chloride (the salt of ammonia and hydrochloric acid)

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

$$Ka = \frac{[NH_3][H_3O^+]}{[NH_4^+]}$$

Ex #4 Find the pH of a 0.20 M solution of ammonium nitrate: NH_4NO_3

(step 1) Ka = Kw/Kb $1.0 \times 10^{-14} / 1.7 \times 10^{-5} = 5.9 \times 10^{-10}$

Now, you do the ICE diagram and solve. Answer: pH = 4.96 (acidic)

4. Salts of WB and WA; cation and anion undergo hydrolysis

5. Hydrated Metal Ions as Acids: a number of hydrated metal ions can act as acids by undergoing hydrolysis in aqueous solution; transition metal ions do this.

$[Fe(H_2O)_6]^{3+} + H_2O \longleftrightarrow [Fe(H_2O)_5OH]^{2+} + H_3O^+$

One of the 6 water molecules attached to ion (III) in the complex ion $[Fe(H_2O)_6$ loses a proton to a free water molecule.

Ch 16 Sec 10 Acid-Base Behavior and Chemical Structure

(1) For binary acids,

- Down a group...bond strength is the determining factor.

  ...bond strength ___ and acid strength ___

- Across a period...polarity governs. ...polarity ___ and acid strength:

(2) For oxyacids (oxyoacids),

A. Consider H_2SO_4 (an acid) and $Ca(OH)_2$ (a base).

```
        O
        |
H–O–S–O–H                H–O–Ca–O–H
        |
        O
```

The electronegativity of S is similar to that of O, so the S–O bonds are covalent.

The electronegativity of Ca is low, while for O, it is high. Thus, the Ca–O This means that...bonds are ionic.

B. For oxyacids with the same number of OH groups and/or the same number of O atoms, acid strength increases with increasing electronegativity of the central atom.

ex HClO
HBrO
HIO

C. For oxyacids with the same central atom, acid strength increases as the number of oxygens attached to the central atom increases.

ex HClO $HClO_2$ $HClO_3$ $HClO_4$

Carboxylic acids contain the ________________________.

-- these are the largest category of organic acids

-- acid strength increases with the addition of more electronegative atoms

ex CH_3COOH vs. CF_3COOH

Ch. 16 Sec 11 Lewis Acids and Lewis Bases

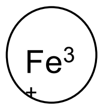
The “Lewis” definitions greatly broaden the range of acids because many species other than H-containing ones can accept an e^- pair.

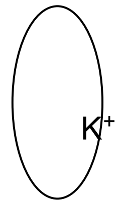
The simple term “acid” suggests that we are referring to an Arrhenius or a Bronsted-Lowry acid, ex, an H-containing substance in an aqueous solution. If you are referring to a Lewis acid, then use the term “Lewis acid.” Substances with an incomplete octet (ex. BF_3) or ones having vacant orbitals (ex. Fe^{3+}) can function as Lewis acids.

The (+) charge attracts (ex. accepts) the lone pairs of e^- on the O of a water molecule.

This process is hydration, and it is responsible for most salts dissolving in H_2O.

Cation size and cation charge determine the extent to which the pH is affected.





-- short distance

-- strong interaction

-- larger distance

-- weaker interaction