

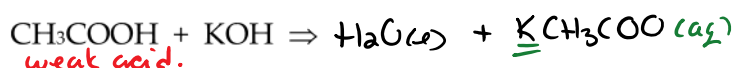
# IV) Hydrolysis

March 5, 2018 1:48 PM

## IV) Hydrolysis

When any acid (strong or weak) reacts with a strong hydroxide base, the reaction is 100% (due to the strong base):  
↳ drives FWD rxn.

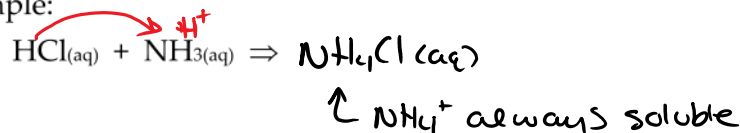
Examples:



In general, the products are water and salt.  
These reactions are called neutralization reactions.

When a strong acid reacts with a base that does not contain hydroxide, it is still a neutralization reaction, however the only product is a salt. The reaction is 100% because a strong acid is reacting. (no OH = not H<sub>2</sub>O) *→ weak base*

Example:



The salts that are produced can be soluble or insoluble (use your solubility table). The insoluble salts will form a solid and precipitate out of solution. The soluble salts will stay in solution as cations and anions and may act as weak acids or bases. For example, the salt produced above was NH<sub>4</sub>Cl<sub>(aq)</sub>.

Is it soluble (use your solubility table)?

↳ yes, NH<sub>4</sub><sup>+</sup> always (aq)

Therefore, how will it actually exist in solution?



Is the cation or anion a weak acid or base?

*weak acid.*

*conj. base of strong acid (not really a base)*

So what will that ion do in solution?  $(aq) = \text{dissolved in } H_2O$   
*weak (∴ equilibrium)*



The reaction you just wrote above is a **hydrolysis reaction**, and it can **cause salt solutions to be acidic or basic** (acidic in the example above due to  $H_3O^+$  formation).

So, whenever a salt is dissolved in solution OR whenever a salt is formed due to an acid reacting with a base, **the resulting salt solution may be acidic or basic if a hydrolysis reaction occurs**. If not, the solution will be neutral.  
*= (not always ... some  $\oplus$  and  $\ominus$  ions are not acids or bases)*

The ions that make up the salts produced from the neutralization reactions **may or may not undergo hydrolysis**. Here are the guidelines:

~~hydrolysis~~ 1. Ions that will not undergo hydrolysis are... ( $\ominus$  spectator ions)  
 • conjugate bases of strong acids (b/c not really bases)  
 $Cl^-$ ,  $Br^-$ ,  $I^-$ ,  $NO_3^-$ ,  $ClO_4^-$  → one-way rxn.  
 (exception:  $HSO_4^-$  is NOT a base... but it IS a weak acid, so it will hydrolyze acidically)

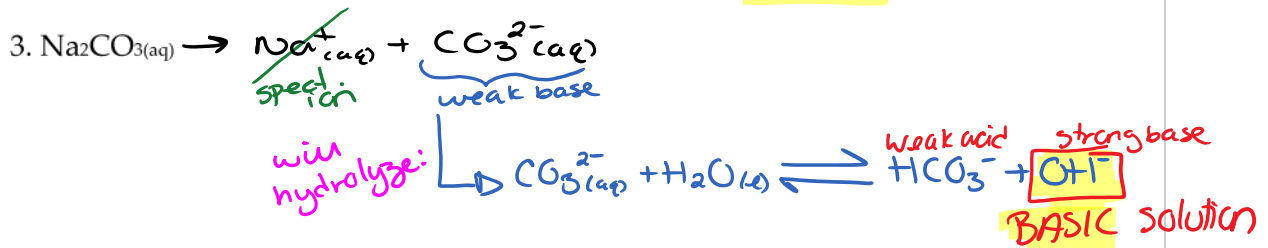
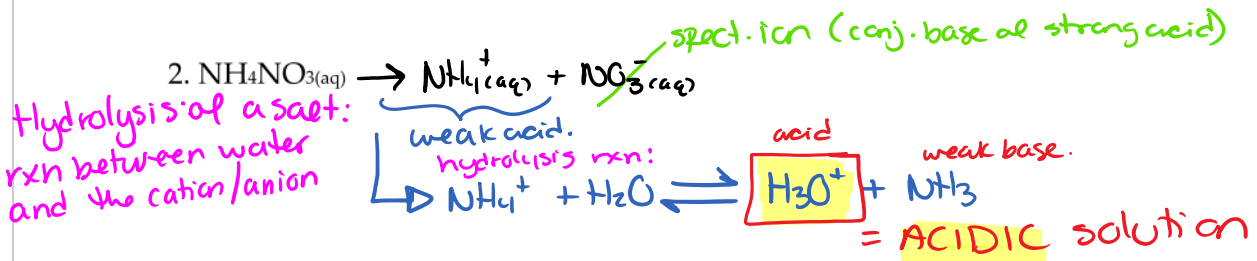
~~hydrolysis~~ 2. Ions that will not undergo hydrolysis are... ( $\oplus$  spectator ions)  
 • conjugate acids of strong bases (b/c they are not really acids)  
 $Li^+$ ,  $Na^+$ ,  $K^+$ ,  $Rb^+$ ,  $Cs^+$ ,  $Mg^{2+}$ ,  $Ca^{2+}$ ,  
 $Sr^{2+}$ ,  $Ba^{2+}$  (group 1+2 cations)  
 (exception:  $OH^-$  (strong base) and  $NH_3$  (weak base) are not acids at all.)

✓ hydrolysis !!

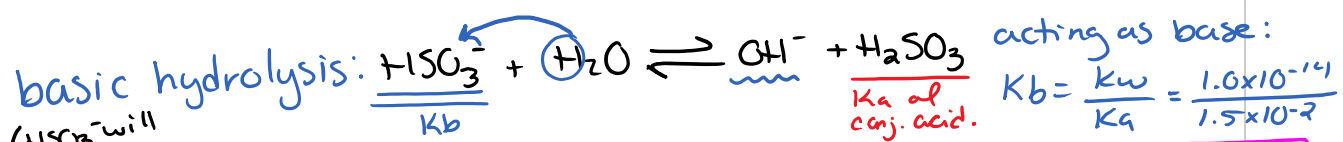
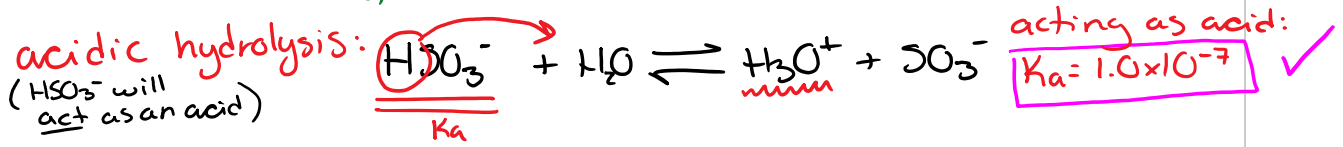
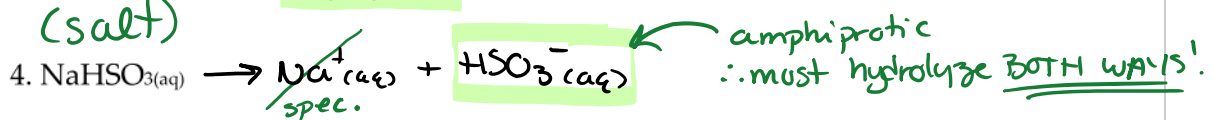
3. Ions that will undergo hydrolysis are... weak acids + weak bases that exist at equilibrium.

Write a dissociation equation for each salt, and then predict whether the resulting salt solutions will be acidic, basic, or neutral, and write any hydrolysis equations as support.

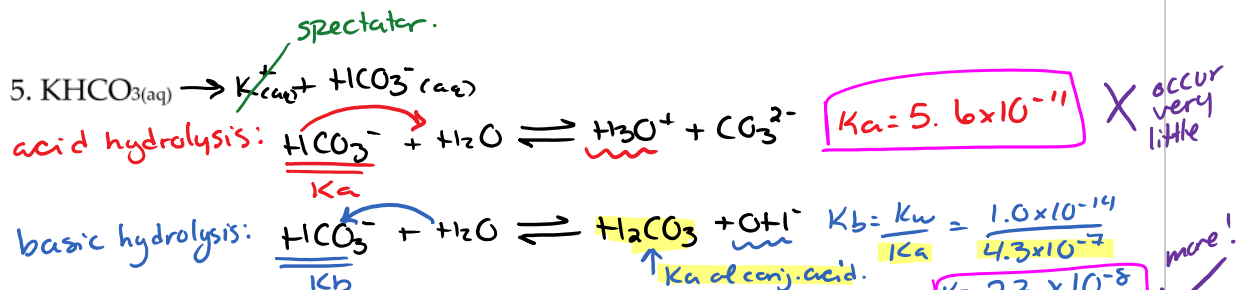
neutralization product (salt)

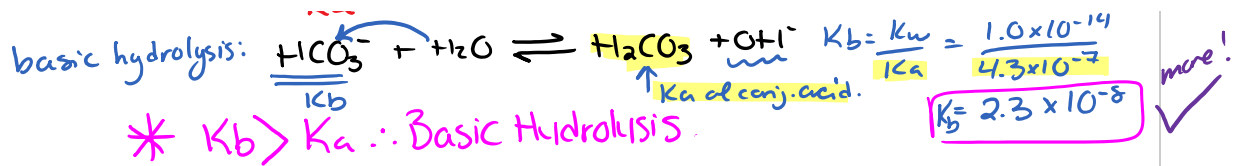


Sometimes, an ion is amphiprotic, so will it act more as an acid or a base?



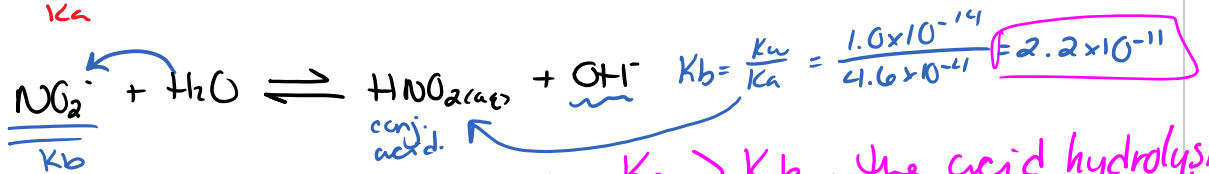
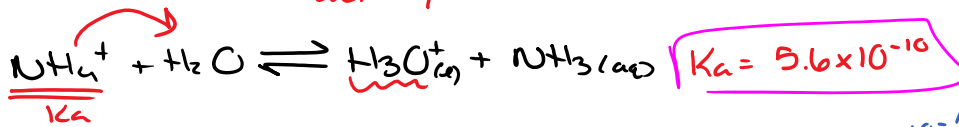
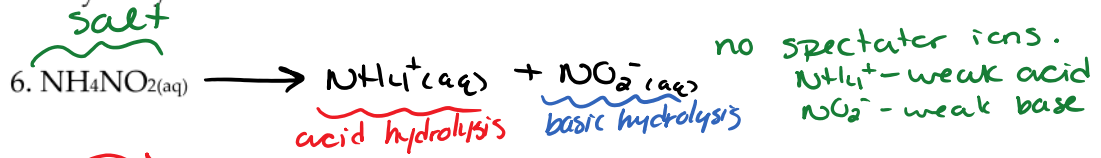
compare  $K_a$  to  $K_b$   $K_a > K_b \therefore \text{HSO}_3^-$  will hydrolyze acidically  $K_b = 6.7 \times 10^{-13}$  ✗



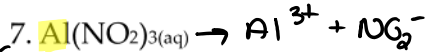


If an ion is amphiprotic, write an acidic hydrolysis with a  $K_a$  value, and a basic hydrolysis with a  $K_b$  value. Whichever  $K$  value is greater, that reaction will occur to a greater extent.

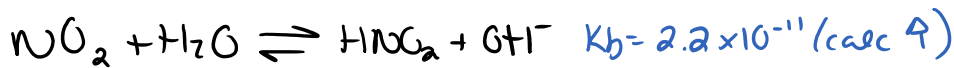
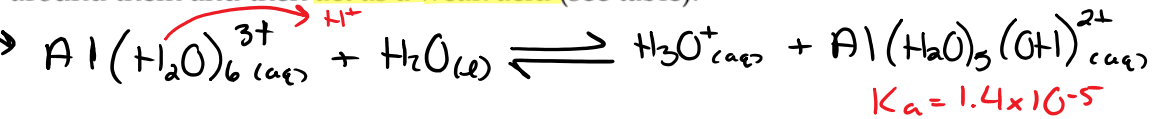
How do you predict if the solution is acidic or basic when both ions in the salt hydrolyze? (similar to the amphiprotic)



since  $K_a > K_b$ , the acid hydrolysis will occur to a greater extent.

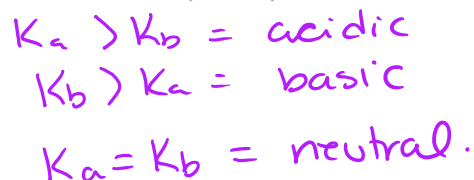


\*when  $\text{Al}^{3+}$ ,  $\text{Cr}^{3+}$ , or  $\text{Fe}^{3+}$  exist in solution, they will gain six water molecules around them and then act as a weak acid (see table).



$K_a > K_b \therefore$  acidic hydrolysis.

Summarize how you can predict whether a salt solution with two ions that hydrolyze will be acidic, basic, or neutral:



#### Assignment 5: Hydrolysis Exercises

1. Hydrolysis Mini-Lab – answer the questions from the lab for #1 of this assignment.
2. Write dissociation equations, and any hydrolysis equation(s) occurring when the following salts are added to water and predict whether the resulting solution will be acidic, basic, or neutral.
  - a.  $\text{Na}_2\text{HPO}_4$
  - b.  $\text{Cr}(\text{SO}_4)_3$
3.  $\text{NH}_3$  is titrated with  $\text{HI}$ . When the two react in the titration, what salt is formed? Does the salt undergo hydrolysis? If so, what is the hydrolysis equation and will the resulting pH be above or below 7?
4. In a titration, which of the following combinations would result in an equivalence point with pH greater than 7.0? \*Hint: find the resulting salt from each reaction and see if and how it undergoes hydrolysis
  - A.  $\text{HCl}$  and  $\text{NaOH}$
  - B.  $\text{HNO}_3$  and  $\text{NH}_3$
  - C.  $\text{HBr}$  and  $\text{NaCH}_3\text{COO}$
  - D.  $\text{CH}_3\text{COOH}$  and  $\text{NaOH}$
5. Calculate the pH of a 0.20M  $\text{KCN}$  solution (Type 1  $K_b$  problem after considering hydrolysis).