Feeling Salty? Acid-Base Properties of Salts

Any salt can be written as the product of an acid-base neutralization rxn.

$$HA(aq) + M(OH)((aq) \rightarrow H_2O(l) + \underbrace{MA(aq)}_{\text{salt}}$$

Salts are NOT always neutral! Some salts hydrolyze water to produce aqueous solutions with pHs other than 7.00.

> To determine if and how a salt will affect the pH of a solution, you must determine whether or not the salt ions will **hydrolyze** (split) water to any significant extent.

Hydrolysis reaction of the conjugate base of the weak acid **HA**:

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

OH^- produced = alkaline solution: pH > 7

Hydrolysis reaction of the conjugate acid of the weak base **M**:

$$MH^+ + H_2O \rightleftharpoons M + H_3O^+$$

H^+ produced = acidic solution: pH < 7

How to Tell if an Ion will Hydrolyze Water

1. If given an anion (–),
   a. Add 1 H^+
   b. Ask: is this conjugate acid a strong acid or weak acid?
      i. Conjugate = strong acid? No water hydrolysis
      ii. Conjugate = weak acid? Yes water hydrolysis
2. If given a cation (+),
   a. Add OH's (as many as needed), unless NH_4^+! Its conjugate base = NH_3)
   b. Ask: is this conjugate base a strong base or weak base?
      i. Conjugate = strong base? No water hydrolysis
      ii. Conjugate = weak base? Yes water hydrolysis

Let's Practice!

1. Will HCO_3^- hydrolyze water? Yes! H_2CO_3 is a weak acid.

   $HCO_3^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)} + OH^-_{(aq)}$] basic sol'n

2. Will NH_4^+ hydrolyze water? Yes! NH_3 is a weak base.

   $NH_4^+{}_{(aq)} + H_2O_{(l)} \rightleftharpoons NH_{3(aq)} + H_3O^+_{(aq)}$] acidic sol'n

3. Will NO_3^- hydrolyze water?

   Nope! HNO_3 is a strong acid.

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H^+ produced = acidic solution: pH < 7

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Let's Practice! Write hydrolysis rxn:

1. Will HCO_3^- hydrolyze water? Yes! H_2CO_3 is a weak acid:
   $HCO_{3(aq)}^- + H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)} + OH^-_{(aq)}$] basic sol'n!
2. Will NH_4^+ hydrolyze water? Yes! NH_3 is a weak base:
   $NH_{4(aq)}^+ + H_2O_{(l)} \rightleftharpoons NH_{3(aq)} + H_3O^+_{(aq)}$] acidic sol'n!
3. Will NO_3^- hydrolyze water? Nope! HNO_3 is a strong acid.

Feeling Salty? How to recognize a salt

Remember, in chemistry, salts are neutral ionic compounds (not acids or bases, although an acid or base can be made into a salt ☺).

➔ Look for the presence of commonly soluble cations (like alkali metal cations, *especially* Na^+) and commonly soluble anions (like halogen anions, *especially* Cl^-).

SA + SB = neutral salt
SA + WB = acidic salt
WA + SB = basic salt
→ Strong wins!

More Practice!

1. Which of the following are salts? Circle them.

~~NH_3~~ (base), (NH_4Cl), ~~$H_2PO_4^-$~~ (acid), ($FeBr_2$), ~~$NaOH$~~ (base), ~~$C_6H_5NH_3^+$~~ (acid), ~~HCl~~ (acid), ($NaHCO_3$)

2. Which of the following ions will hydrolyze water? Circle them

(NH_3) ($NH_4^+ = WA$), Cl^- ($HCl = SA$), ($H_2PO_4^-$), ClO_4^- ($HClO_4 = SA$), Na^+ ($NaOH = SB$), (F^-) ($HF = WA$), NO_3^- ($HNO_3 = SA$), (ClO_2^-) ($HClO_2 = WA$)

3. Write the hydrolysis reaction for each of the following ions, and determine if it will produce an acidic or basic solution:

a. NH_4^+ $NH_{4\,(aq)}^+ + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + NH_{3(aq)}$] Acidic Sol'n!

b. CO_3^{2-} $CO_3^{2-} + H_2O_{(l)} \rightleftharpoons HCO_{3\,(aq)}^- + OH^-_{(aq)}$] Basic Sol'n!

4. Determine if the solution formed from each salt below is acidic, basic, or neutral. ⇒ Strong wins!

a. $SrCl_2$ → $Sr^{2+} \Rightarrow Sr(OH)_2$: SB (no hydrolysis)
→ $Cl^- \Rightarrow HCl$: SA (no hydrolysis)
] → neutral Sol'n!

b. $AlBr_3$ → $Al^{3+} \Rightarrow Al(OH)_3$: WB (hydrolysis!)
→ $Br^- \Rightarrow HBr$: SA (no hydrolysis)
] → acidic Sol'n!

c. NH_4NO_3 → $NH_4^+ \Rightarrow NH_3$: WB (hydrolysis!)
→ $NO_3^- \Rightarrow HNO_3$: SA (no hydrolysis)
] → acidic Sol'n!

d. $NaCHO_2$ → $Na^+ \Rightarrow NaOH$: SB (no hydrolysis)
→ $CHO_2^- \Rightarrow HCHO_2$: WA (hydrolysis)
] → basic Sol'n!