

118 **Dissolving Salts in Water**

pH above 7 ?

pH 7 ?

pH below 7 ?

Chapter 16.9

119 **Anions of a Strong Acid**

- HCl, HBr, HI, HNO₃, H₂SO₄, HClO₄, HClO₃
- What would happen if any of the anions (the pathetic conjugate base) of a SA were put into water?
- Putting XCl in water will dissolve to produce Cl⁻ ions.
✓ $XCl \rightarrow X^+ + Cl^-$
- If the Cl⁻ could interact with water as an acid, this is what would occur
✓ $Cl^- + H_2O \rightarrow HCl + OH^-$ however, these HCl particles would immediately dissociate (They are after all a SA) to give this
✓ $HCl + OH^- \rightarrow H^+ + Cl^- + OH^-$ these H⁺ and OH⁻ ions would immediately find each other
✓ $H^+ + Cl^- + OH^- \rightarrow Cl^- + H_2O$ which is right back where we started, thus no change to pH.

120 **Cations of a Strong Base**

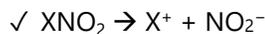
- NaOH, KOH, LiOH, Ca(OH)₂, Sr(OH)₂, and Ba(OH)₂
- What would happen if any of the cations (the pathetic conjugate acid) of a SB were put into water?
- Putting KX into water would dissolve to produce K⁺ ions.
✓ $KX \rightarrow K^+ + X^-$
- If the K⁺ could interact with water, this is what might occur.
✓ $K^+ + H_2O \rightarrow KOH + H^+$ however these KOH particles would immediately dissociate (They are after all a SB.)
✓ $KOH + H^+ \rightarrow K^+ + OH^- + H^+$ these H⁺ and OH⁻ ions would immediately find each other
✓ $K^+ + OH^- + H^+ \rightarrow K^+ + H_2O$ which is right back where we started, thus no change to pH

121 **Up until now, when a soluble salt dissolved, we thought that's all there was to it, and for NaCl, that's all there is to it. But for many salts, there's more to the story.....**

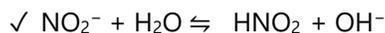
- When salts such as sodium fluoride or ammonium nitrate dissolve, we must consider how the dissolved ions will interact with the water
 - $NaF \rightarrow Na^+ + F^-$
 - $NH_4NO_3 \rightarrow NH_4^+ + NO_3^-$
- Now, knowing what you know about conjugate acids and bases, what will happen after the salt breaks into ions?
 - $H_2O + F^- \rightleftharpoons HF + OH^-$
 - $NH_4^+ + H_2O \rightleftharpoons H_3O^+ + NH_3$
 - and this affects the pH of the solution.

122 **Anions of a Weak Acid**

- HF, HNO₂, HC₂H₃O₂, HC₇H₅O₂, HClO, HCN
- What would happen if any of the anions (attached to a metal, X instead of H) of a WA were put into water?
- Putting XNO₂ in water will dissolve to produce NO₂⁻ ions.



- The NO_2^- can interact with water as a weak base



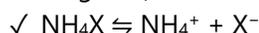
- ✓ This interaction of the NO_2^- ion with water causes the formation of OH^- thus the pH rises above 7.

123 **Cations of a Weak Base**

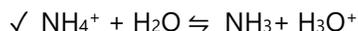
- $NH_3 \rightleftharpoons NH_4^+$, $C_5H_5N \rightleftharpoons C_5H_5NH^+$,
- $H_2NOH \rightleftharpoons H_3NOH^+$, $NH_2CH_3 \rightleftharpoons NH_3CH_3^+$

- What happens when a conjugate acid of a WB is put into water?

- Putting NH_4X in water will dissolve to produce NH_4^+ ions.



- The NH_4^+ can interact with water as a weak acid



- ✓ This interaction NH_4^+ ion with water causes the formation of H^+ thus the pH drops below 7.

124 **In Summary, Salts: Acidic, Basic, or Neutral?**

- Anions (the pathetic conjugate base) of a strong acid

- Cation (the pathetic conjugate acid) of a strong base

- ✓ The X^- ions that are the pathetic conjugate base of a strong acid, and the M^+ ions that are the pathetic conjugate acid of a strong base, will not be able to hydrolyze in water and thus will hang around as spectator ions having no effect on pH.

- Anions (the conjugate base) of a weak acid

- ✓ A^- ions that are the conjugate bases of weak acids will hydrolyze in water causing the pH to rise.

- Cations of a weak base

- ✓ positive ions (usually containing N) that are conjugate acids of weak bases will hydrolyze in water causing the pH to drop.

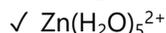
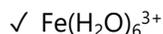
- Metallic ions (more on the next three slides ☹️)

- ✓ Fe^{3+} , Zn^{2+} , Cr^{3+} , Al^{3+} attract the unshared pairs of e^- on solvating water molecules, weakening the bonds, causing an H^+ to ionize causing the pH to drop.

125 **Hydration Shells**

- All ions are hydrated in water - surrounded by H_2O molecules.

- hydrated cations can be represented as



- ✓ The amount of waters represented around the ion vary from ion to ion. You would not be expected to predict the amount.

- Sometimes a salt solution may have lower entropy than the solid salt and water since the water molecules become more ordered.

126 **Hydrated Metallic Ions**

- For metals other than column I and II

- Ions such as; Fe^{3+} , Zn^{2+} , Cr^{3+} , Al^{3+}

- The cation attracts the electron pairs on the water towards the cation causing the O-H bond in the water molecule to become even more polarized, weakening it enough that one H^+ will be released into solution.



- The strength of the metal ion as an acid is affected by
 - ✓ charge
 - higher charge = stronger acid
 - ✓ size
 - smaller size = stronger acid

127 **Know the SA & SB...**

1 Strong Acids

- HCl
- HI
- HBr
- HNO₃
- H₂SO₄
- HClO₄
- HClO₃
-

2 Strong Bases

- LiOH
- NaOH
- KOH
- RbOH
- CsOH
- Ba(OH)₂
- Sr(OH)₂
- Ca(OH)₂

128 **Salt Hydrolysis**

- Negative ions are bases (or pathetic)
- Positive ions are acids (or pathetic)

129 **Which chemicals below will produce a pH below 7 when dissolved in water?**

Select all that apply. Be ready to comment on any increase in pH, and those that still = 7

- 1
- A. CsI
 - B. HBr
 - C. FeCl₃
 - D. KCN
 - E. HCN
 - F.

- 2
- F. CaSO₃
 - G. NH₄NO₃
 - H. NaOH
 - I. NH₃

131 **Which chemicals below will produce a pH above 7 when dissolved in water?**

Select all that apply. Be ready to comment on any decrease in pH

- 1 A. $\text{NaC}_2\text{H}_3\text{O}_2$
B. $\text{Au}(\text{NO}_3)_3$
C. $\text{Ca}_3(\text{PO}_4)_2$
D. KF
E. NH_4ClO_4
- 2 F. NaClO
G. $\text{Ca}(\text{OH})_2$
H. $\text{HC}_2\text{H}_3\text{O}_2$
I. $(\text{C}_2\text{H}_3)_2\text{NH}$

133 **Which chemicals below will produce a solution with $\text{pH} = 7$ when dissolved in water? Select all that apply.**

- 1 A. $\text{Ca}(\text{CN})_2$
B. AlCl_3
C. NaCl
D. $\text{Ba}(\text{ClO}_3)_2$
- 2 E. RbI
F. NaNO_2
G. HF

135 **Problem Types**

136 **Calculate the volume of 0.034 M potassium hydroxide required to neutralize 25.0 ml of 0.050 M nitric acid.**

- Write the overall neutralization reaction.
- Write the net ionic reaction

138 **Calculate the volume of 0.034 M potassium hydroxide required to neutralize 25.0 ml of 0.050 M nitrous acid.**

140 Calculate the volume of 0.0045 M perchloric acid required to neutralize 65.0 ml of 0.0072 M barium hydroxide.

142 Calculate the pH after mixing 35 ml of 0.025 M Acetic acid with 40 ml of 0.030 M NaOH

144 Calculate the $[H^+]$ after mixing 100. ml of 0.62 M hydrofluoric acid with 250. ml of 0.248 M KOH

- Write out any relevant reactions that you should be thinking about when doing this problem to this problem

- 146 Calculate the pH after mixing 25 ml of 0.25 M ammonia with 40. ml of 0.11 M HCl. K_b of ammonia is 1.8×10^{-5}
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