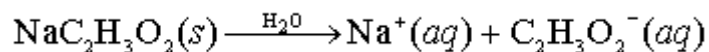


16 • Acids, Bases and salts

16.9 Salts Lab

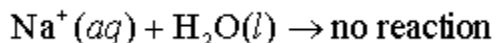
We have seen that a conjugate acid or a conjugate base can react with water to produce either hydronium ion or hydroxide ion. This behavior is called **hydrolysis**. The conjugate acids and bases that we have encountered are ions. As such, they can be added to a solution in the form of a salt. For example, acetate ion is the conjugate base of acetic acid. We can add acetate ion to a solution by adding sodium acetate.



Recall that soluble ionic salts are strong electrolytes. Because of acetate's tendency to hydrolyze water, a solution of sodium acetate is basic.



The acetate ion contributes (by hydrolysis of water) to the OH^- concentration. The sodium ion does not react with water. It is the conjugate acid of a *strong* base, sodium hydroxide, and is therefore a *weak* conjugate acid. Remember: *weak conjugates* do *not* react with water.



The acidity or basicity of a salt depends on the salt's constituent ion. We can think of all salts as the products of acid-base neutralization reactions. For example, hydrochloric acid and sodium hydroxide react to form water and sodium chloride. HCl is a strong acid; therefore its conjugate, chloride ion, is weak. Sodium hydroxide is a strong base; therefore its conjugate, sodium ion, is weak. When both of the ions of the salt are *weak* conjugates, the solution is neutral. A solution of sodium chloride has a pH of 7.

The pH of a salt solution can be predicted qualitatively by considering the ionic constituents of the salt.

1. Salts derived from a strong base and a strong acid: The solution has a pH of 7.
2. Salts derived from a strong base and a weak acid: The solution has a pH above 7.
3. Salts derived from a weak base and strong acid: The solution has a pH below 7.
4. Salts derived from a weak base and a weak acid: The solution has a pH greater than 7.

pH of Salts Lab

Materials:

- o (10) large test tubes
- o (2) test tube racks
- o Wash bottle
- o Glass stir rods
- o pH paper
- o Digital pH Probe
- o The salts listed in the table

Salt	Source of Conjugate Cation (weak or strong)	Source of Conjugate Anion (weak or strong)	Which one determine pH?	Predicted pH Range (acidic or basic)	pH (pH paper)	pH (probe)
NaCl						
NH ₄ Cl						
Al(NO ₃) ₃						
KBr						
Na ₂ CO ₃						
(NH ₄) ₂ CO ₃						
NaClO						
Ca(NO ₃) ₂						
NH ₄ C ₂ H ₃ O ₂						
Na ₂ C ₂ O ₄						
CuCl ₂						
NaC ₂ H ₃ O ₂						

Postlab Questions:

1. There were (2) salts in this lab that were derived from weak acids and bases. Write the salts below and look-up the K_a and K_b values for the acids and bases of these conjugates. Determine if the salt is acidic or basic by comparing the equilibrium values. Show how the stronger conjugate hydrolyzes in water to determine the pH.

a) Salt Formula _____ Predicted pH [Acidic / Basic / Neutral] (circle one)

anion: _____ K_b value _____

cation: _____ K_a value _____

Hydrolysis equation _____

a) Salt Formula _____ Predicted pH [Acidic / Basic / Neutral] (circle one)

anion: _____ K_b value _____

cation: _____ K_a value _____

Hydrolysis equation _____

Helpful Tables

TABLE 4.2 Common Strong Acids and Bases

Strong Acids	Strong Bases
Hydrochloric, HCl	Group 1A metal hydroxides (LiOH, NaOH, KOH, RbOH, CsOH)
Hydrobromic, HBr	Heavy group 2A metal hydroxides [Ca(OH) ₂ , Sr(OH) ₂ , Ba(OH) ₂]
Hydroiodic, HI	
Chloric, HClO ₃	
Perchloric, HClO ₄	
Nitric, HNO ₃	
Sulfuric, H ₂ SO ₄	

Table 17.3 • Ionization Constants for Some Acids and Their Conjugate Bases

Acid Name	Acid	K_a	Base	K_b	Base Name
Perchloric acid	HClO ₄	large	ClO ₄ ⁻	very small	perchlorate ion
Sulfuric acid	H ₂ SO ₄	large	HSO ₄ ⁻	very small	hydrogen sulfate ion
Hydrochloric acid	HCl	large	Cl ⁻	very small	chloride ion
Nitric acid	HNO ₃	large	NO ₃ ⁻	very small	nitrate ion
Hydronium ion	H ₃ O ⁺	1.0	H ₂ O	1.0×10^{-14}	water
Sulfurous acid	H ₂ SO ₃	1.2×10^{-2}	HSO ₃ ⁻	8.3×10^{-13}	hydrogen sulfite ion
Hydrogen sulfate ion	HSO ₄ ⁻	1.2×10^{-2}	SO ₄ ²⁻	8.3×10^{-13}	sulfate ion
Phosphoric acid	H ₃ PO ₄	7.5×10^{-3}	H ₂ PO ₄ ⁻	1.3×10^{-12}	dihydrogen phosphate ion
Hexaaquairon(III) ion	Fe(H ₂ O) ₆ ³⁺	6.3×10^{-3}	Fe(H ₂ O) ₅ OH ²⁺	1.6×10^{-12}	pentaquahydroxoiron(III) ion
Hydrofluoric acid	HF	7.2×10^{-4}	F ⁻	1.4×10^{-11}	fluoride ion
Nitrous acid	HNO ₂	4.5×10^{-4}	NO ₂ ⁻	2.2×10^{-11}	nitrite ion
Formic acid	HCO ₂ H	1.8×10^{-4}	HCO ₂ ⁻	5.6×10^{-11}	formate ion
Benzoic acid	C ₆ H ₅ CO ₂ H	6.3×10^{-5}	C ₆ H ₅ CO ₂ ⁻	1.6×10^{-10}	benzoate ion
Acetic acid	CH ₃ CO ₂ H	1.8×10^{-5}	CH ₃ CO ₂ ⁻	5.6×10^{-10}	acetate ion
Propanoic acid	CH ₃ CH ₂ CO ₂ H	1.3×10^{-5}	CH ₃ CH ₂ CO ₂ ⁻	7.7×10^{-10}	propanoate ion
Hexaaquaaluminum ion	Al(H ₂ O) ₆ ³⁺	7.9×10^{-6}	Al(H ₂ O) ₅ OH ²⁺	1.3×10^{-9}	pentaquahydroxoaluminum ion
Carbonic acid	H ₂ CO ₃	4.2×10^{-7}	HCO ₃ ⁻	2.4×10^{-8}	hydrogen carbonate ion
Hexaaquacopper(II) ion	Cu(H ₂ O) ₆ ²⁺	1.6×10^{-7}	Cu(H ₂ O) ₅ OH ⁺	6.25×10^{-8}	pentaquahydroxocopper(II) ion
Hydrogen sulfide	H ₂ S	1×10^{-7}	HS ⁻	1×10^{-7}	hydrogen sulfide ion
Dihydrogen phosphate ion	H ₂ PO ₄ ⁻	6.2×10^{-8}	HPO ₄ ²⁻	1.6×10^{-7}	hydrogen phosphate ion
Hydrogen sulfite ion	HSO ₃ ⁻	6.2×10^{-8}	SO ₃ ²⁻	1.6×10^{-7}	sulfite ion
Hypochlorous acid	HClO	3.5×10^{-8}	ClO ⁻	2.9×10^{-7}	hypochlorite ion
Hexaaqualead(II) ion	Pb(H ₂ O) ₆ ²⁺	1.5×10^{-8}	Pb(H ₂ O) ₅ OH ⁺	6.7×10^{-7}	pentaquahydroxolead(II) ion
Hexaaquacobalt(II) ion	Co(H ₂ O) ₆ ²⁺	1.3×10^{-9}	Co(H ₂ O) ₅ OH ⁺	7.7×10^{-6}	pentaquahydroxocobalt(II) ion
Boric acid	B(OH) ₃ (H ₂ O)	7.3×10^{-10}	B(OH) ₄ ⁻	1.4×10^{-5}	tetrahydroxoborate ion
Ammonium ion	NH ₄ ⁺	5.6×10^{-10}	NH ₃	1.8×10^{-5}	ammonia
Hydrocyanic acid	HCN	4.0×10^{-10}	CN ⁻	2.5×10^{-5}	cyanide ion
Hexaaquairon(II) ion	Fe(H ₂ O) ₆ ²⁺	3.2×10^{-10}	Fe(H ₂ O) ₅ OH ⁺	3.1×10^{-5}	pentaquahydroxoiron(II) ion
Hydrogen carbonate ion	HCO ₃ ⁻	4.8×10^{-11}	CO ₃ ²⁻	2.1×10^{-4}	carbonate ion
Hexaaquanickel(II) ion	Ni(H ₂ O) ₆ ²⁺	2.5×10^{-11}	Ni(H ₂ O) ₅ OH ⁺	4.0×10^{-4}	pentaquahydroxonickel(II) ion
Hydrogen phosphate ion	HPO ₄ ²⁻	3.6×10^{-13}	PO ₄ ³⁻	2.8×10^{-2}	phosphate ion
Water	H ₂ O	1.0×10^{-14}	OH ⁻	1.0	hydroxide ion
Hydrogen sulfide ion*	HS ⁻	1×10^{-19}	S ²⁻	1×10^5	sulfide ion
Ethanol	C ₂ H ₅ OH	very small	C ₂ H ₅ O ⁻	large	ethoxide ion
Ammonia	NH ₃	very small	NH ₂ ⁻	large	amide ion
Hydrogen	H ₂	very small	H ⁻	large	hydride ion

*The values of K_a for HS⁻ and K_b for S²⁻ are estimates.

