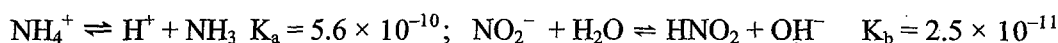


- c. $C_5H_5NHClO_4 \rightarrow C_5H_5NH^+ + ClO_4^-$ acidic; $C_5H_5NH^+$ is a weak acid, and ClO_4^- has no effect on pH.

$$C_5H_5NH^+ \rightleftharpoons H^+ + C_5H_5N \quad K_a = \frac{K_w}{K_{b,C_5H_5N}} = \frac{1.0 \times 10^{-14}}{1.7 \times 10^{-9}} = 5.9 \times 10^{-6}$$

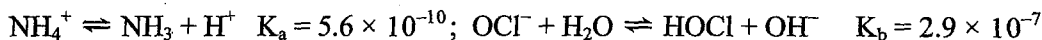
- d. $NH_4NO_2 \rightarrow NH_4^+ + NO_2^-$ acidic; NH_4^+ is a weak acid ($K_a = 5.6 \times 10^{-10}$), and NO_2^- is a weak base ($K_b = 2.5 \times 10^{-11}$). Because $K_{a,NH_4^+} > K_{b,NO_2^-}$, the solution is acidic.



- e. $KOCl \rightarrow K^+ + OCl^-$ basic; OCl^- is a weak base, and K^+ has no effect on pH.

$$OCl^- + H_2O \rightleftharpoons HOCl + OH^- \quad K_b = \frac{K_w}{K_{a,HOCl}} = \frac{1.0 \times 10^{-14}}{3.5 \times 10^{-8}} = 2.9 \times 10^{-7}$$

- f. $NH_4OCl \rightarrow NH_4^+ + OCl^-$ basic; NH_4^+ is a weak acid, and OCl^- is a weak base. Because $K_{b,OCl^-} > K_{a,NH_4^+}$, the solution is basic.



Relationships Between Structure and Strengths of Acids and Bases

131. a. $HIO_3 < HBrO_3$; as the electronegativity of the central atom increases, acid strength increases.
- b. $HNO_2 < HNO_3$; as the number of oxygen atoms attached to the central nitrogen atom increases, acid strength increases.
- c. $HOI < HOCl$; same reasoning as in a.
- d. $H_3PO_3 < H_3PO_4$; same reasoning as in b.
133. a. $H_2O < H_2S < H_2Se$; as the strength of the H-X bond decreases, acid strength increases.
- b. $CH_3CO_2H < FCH_2CO_2H < F_2CHCO_2H < F_3CCO_2H$; as the electronegativity of neighboring atoms increases, acid strength increases.
- c. $NH_4^+ < HONH_3^+$; same reason as in b.
- d. $NH_4^+ < PH_4^+$; same reason as in a.
135. In general, metal oxides form basic solutions when dissolved in water, and nonmetal oxides form acidic solutions in water.
- a. Basic; $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$; $Ca(OH)_2$ is a strong base.
- b. Acidic; $SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$; H_2SO_3 is a weak diprotic acid.
- c. Acidic; $Cl_2O(g) + H_2O(l) \rightarrow 2 HOCl(aq)$; $HOCl$ is a weak acid.

Lewis Acids and Bases

137. A Lewis base is an electron pair donor, and a Lewis acid is an electron pair acceptor.
- a. $\text{B}(\text{OH})_3$, acid; H_2O , base b. Ag^+ , acid; NH_3 , base c. BF_3 , acid; F^- , base
139. $\text{Al}(\text{OH})_3(\text{s}) + 3 \text{H}^+(\text{aq}) \rightarrow \text{Al}^{3+}(\text{aq}) + 3 \text{H}_2\text{O}(\text{l})$ (Brønsted-Lowry base, H^+ acceptor)
- $\text{Al}(\text{OH})_3(\text{s}) + \text{OH}^-(\text{aq}) \rightarrow \text{Al}(\text{OH})_4^-(\text{aq})$ (Lewis acid, electron pair acceptor)
141. Fe^{3+} should be the stronger Lewis acid. Fe^{3+} is smaller and has a greater positive charge. Because of this, Fe^{3+} will be more strongly attracted to lone pairs of electrons as compared to Fe^{2+} .

Additional Exercises

143. At $\text{pH} = 2.000$, $[\text{H}^+] = 10^{-2.000} = 1.00 \times 10^{-2} \text{ M}$
- At $\text{pH} = 4.000$, $[\text{H}^+] = 10^{-4.000} = 1.00 \times 10^{-4} \text{ M}$
- Moles H^+ present = $0.0100 \text{ L} \times \frac{0.0100 \text{ mol H}^+}{\text{L}} = 1.00 \times 10^{-4} \text{ mol H}^+$
- Let V = total volume of solution at $\text{pH} = 4.000$:
- $$1.00 \times 10^{-4} \text{ mol/L} = \frac{1.00 \times 10^{-4} \text{ mol H}^+}{V}, \quad V = 1.00 \text{ L}$$
- Volume of water added = $1.00 \text{ L} - 0.0100 \text{ L} = 0.99 \text{ L} = 990 \text{ mL}$
145. The light bulb is bright because a strong electrolyte is present; that is, a solute is present that dissolves to produce a lot of ions in solution. The pH meter value of 4.6 indicates that a weak acid is present. (If a strong acid were present, the pH would be close to zero.) Of the possible substances, only HCl (strong acid), NaOH (strong base), and NH_4Cl are strong electrolytes. Of these three substances, only NH_4Cl contains a weak acid (the HCl solution would have a pH close to zero, and the NaOH solution would have a pH close to 14.0). NH_4Cl dissociates into NH_4^+ and Cl^- ions when dissolved in water. Cl^- is the conjugate base of a strong acid, so it has no basic (or acidic properties) in water. NH_4^+ , however, is the conjugate acid of the weak base NH_3 , so NH_4^+ is a weak acid and would produce a solution with a $\text{pH} = 4.6$ when the concentration is $\sim 1.0 \text{ M}$. NH_4Cl is the solute.
147. a. In the lungs there is a lot of O_2 , and the equilibrium favors $\text{Hb}(\text{O}_2)_4$. In the cells there is a lower concentration of O_2 , and the equilibrium favors HbH_4^{4+} .
- b. CO_2 is a weak acid, $\text{CO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{HCO}_3^- + \text{H}^+$. Removing CO_2 essentially decreases H^+ , which causes the hemoglobin reaction to shift right. $\text{Hb}(\text{O}_2)_4$ is then favored, and O_2 is not released by hemoglobin in the cells. Breathing into a paper bag increases CO_2 in the blood, thus increasing $[\text{H}^+]$, which shifts the hemoglobin reaction left.