CHAPTER EIGHT
Acid and Base Ionizations 2

8.62 What is the ion-product constant for water?

8.63 Write an equation relating $[H^+]$ and $[OH^-]$ in solution at 25°C.

8.64 The ion-product constant for water is 1.0×10^{-14} at 25°C and 3.8×10^{-14} at 40°C. Is the forward process

$$H_2O(l) \leftrightarrow H^+(aq) + OH^-(aq)$$

endothermic or exothermic?

8.65 Define pH. Why do chemists normally choose to discuss the acidity of a solution in terms of pH rather than hydrogen ion concentration, $[H^+]$?

8.66 The pH of a solution is 6.7. From this statement alone, can you conclude that the solution is acidic? If not, what additional information would you need? Can the pH of a solution be zero or negative? If so, give examples to illustrate these values.

8.67 Define pOH. Write the equation relating pH and pOH.

8.68 Calculate the concentration of OH^- ions in a 1.4×10^{-3} *M* HCl solution.

8.69 Calculate the concentration of H^+ ions in a 0.62 *M* NaOH solution.

8.70 Calculate the pH of each of the following solutions: (a) 0.0010 *M* HCl, (b) 0.76 *M* KOH.

8.71 Calculate the pH of each of the following solutions:
(a) 2.8×10^{-4} *M* $Ba(OH)_2$, (b) 5.2×10^{-4} *M* HNO_3.

8.72 Calculate the hydrogen ion concentration in mol/L for solutions with the following pH values: (a) 2.42, (b) 11.21, (c) 6.96, (d) 15.00.

8.73 Calculate the hydrogen ion concentration in mol/L for each of the following solutions: (a) a solution whose pH is 5.20, (b) a solution whose pH is 16.00, (c) a solution whose hydroxide concentration is 3.7×10^{-9} *M*.

8.74 Complete the following table for a solution:

pH	[H+]	Solution is
<7		
	$<1.0 \times 10^{-7}$ M	
		Neutral

8.75 Fill in the word *acidic*, *basic*, or *neutral* for the following solutions:
(a) pOH > 7; solution is
(b) pOH = 7; solution is
(c) pOH < 7; solution is

8.76 The pOH of a solution is 9.40. Calculate the hydrogen ion concentration of the solution.

8.77 Calculate the number of moles of KOH in 5.50 mL of a 0.360 *M* KOH solution. What is the pOH of the solution?

8.78 How much NaOH (in grams) is needed to prepare 546 mL of solution with a pH of 10.00?

8.79 A solution is made by dissolving 18.4 g of HCl in 662 mL of water. Calculate the pH of the solution. (Assume that the volume remains constant.)

8.80 Explain what is meant by the strength of an acid.

8.81 Without referring to the text, write the formulas of four strong acids and four weak acids.

8.82 What are the strongest acid and strongest base that can exist in water?

8.83 H_2SO_4 is a strong acid, but HSO^-_4 is a weak acid. Account for the difference in strength of these two related species.

8.84 Classify each of the following species as a weak or strong acid: (a) HNO_3, (b) HF, (c) H_2SO_4, (d) HSO^-_4 , (e) H_2CO_3, (f) HCO^-_3 , (g) HCl, (h) HCN, (i) HNO_2.

8.85 Classify each of the following species as a weak or strong base: (a) LiOH, (b) CN^-, (c) H_2O, (d) ClO^-_4 , (e) NH^-_2 .

8.86 Which of the following statements is/are true for a 0.10 *M* solution of a weak acid HA?
(a) The pH is 1.00.

(b) $[H^+]$ » $[A^-]$
(c) $[H^+] = [A^-]$
(d) The pH is less than 1.

8.87 Which of the following statements is/are true regarding a 1.0 *M* solution of a strong acid HA?
(a) $[A^-] > [H^+]$
(b) The pH is 0.00.
(c) $[H^+] = 1.0$ *M*
(d) [HA] = 1.0 *M*

8.88 Predict the direction that predominates in this reaction:
$F^-(aq) + H_2O(l) \leftrightarrow HF(aq) + OH^-(aq)$

8.89 Predict whether the following reaction will proceed from left to right to any measurable extent:
$CH_3COOH(aq) + Cl^-(aq) \rightarrow$

8.90 What does the ionization constant tell us about the strength of an acid?

8.91 List the factors on which the K_a of a weak acid depends.

8.92 Why do we normally not quote *K*a values for strong acids such as HCl and HNO_3? Why is it necessary to specify temperature when giving K_a values?

8.93 Which of the following solutions has the highest pH? (a) 0.40 *M* HCOOH, (b) 0.40 *M* $HClO_4$, (c) 0.40 *M* CH_3COOH.

8.94 The K_a for benzoic acid is 6.5×10^{-5}. Calculate the pH of a 0.10 *M* benzoic acid solution.

8.95 A 0.0560-g quantity of acetic acid is dissolved in enough water to make 50.0 mL of solution. Calculate the concentrations of H^+, CH_3COO^-, and CH_3COOH at equilibrium. (K_a for acetic acid = 1.8×10^{-5}.)

8.96 The pH of an acid solution is 6.20. Calculate the K_a for the acid. The acid concentration is 0.010 *M*.

8.97 What is the original molarity of a solution of formic acid (HCOOH) whose pH is 3.26 at equilibrium?

8.98 Calculate the percent ionization of benzoic acid at the following concentrations: (a) 0.20 *M*, (b) 0.00020 *M*.

8.99 Calculate the percent ionization of hydrofluoric acid at the following concentrations: (a) 0.60 *M*, (b) 0.0046 *M*, (c) 0.00028 *M*. Comment on the trends.

8.100 A0.040 *M* solution of a monoprotic acid is 14 percent ionized. Calculate the ionization constant of the acid.

8.101 (a) Calculate the percent ionization of a 0.20 *M* solution of the monoprotic acetylsalicylic acid (aspirin) for which $K_a = 3.0 \times 10^{-4}$. (b) The pH of gastric juice in the stomach of a certain individual is 1.00. After a few aspirin tablets have been swallowed, the concentration of acetylsalicylic acid in the stomach is 0.20 *M*. Calculate the percent ionization of the acid under these conditions. What effect does the nonionized acid have on the membranes lining the stomach? (*Hint:* See the Chemistry in Action essay on p. 638.)

8.102 Use NH_3 to illustrate what we mean by the strength of a base.

8.103 Which of the following has a higher pH? (a) 0.20 *M* NH_3, (b) 0.20 *M* NaOH

8.104 Calculate the pH for each of the following solutions:
(a) 0.10 *M* NH_3, (b) 0.050 *M* C_5H_5N (pyridine).

8.105 The pH of a 0.30 *M* solution of a weak base is 10.66. What is the K_b of the base?

8.106 What is the original molarity of a solution of ammonia whose pH is 11.22?

8.107 In a 0.080 *M* NH_3 solution, what percent of the NH_3 is present as NH^+_4 ?

8.108 Write the equation relating K_a for a weak acid and K_b for its conjugate base. Use NH_3 and its conjugate acid NH to derive the relationship between K_a and K_b. _

8.109 From the relationship $K_aK_b = K_w$, what can you deduce about the relative strengths of a weak acid and its conjugate base?

8.110 Carbonic acid is a diprotic acid. Explain what that means.

8.111 Write all the species (except water) that are present in a phosphoric acid solution. Indicate which species can act as a Brønsted acid, which as a Brønsted base, and which as both a Brønsted acid and a Brønsted base.

8.112 The first and second ionization constants of a diprotic acid H_2A are K_{a1} and K_{a2} at a certain temperature. Under what conditions will $[A^{2-}] = Ka_2$?

8.113 Compare the pH of a 0.040 *M* HCl solution with that of a 0.040 *M* H_2SO_4 solution.

8.114 What are the concentrations of HSO^-_4 , SO^{2-}_4, and H^+ in a 0.20 *M* $KHSO_4$ solution? (*Hint:* H_2SO_4 is a strong acid; K_a for $HSO^-_4 = 1.3 \times 10^{-2}$.)

8.115 Calculate the concentrations of H^+, HCO^-_3, and CO^{2-}_3 in a 0.025 *M* H_2CO_3 solution.