Chapter 17 Practice – Acids and Bases

AP Chemistry 2011-12

1984

33. The pH of 0.1-molar ammonia is approximately

(A) 1 (B) 4 (C) 7 (D) 11 (E) 14

48. Which of the following ions is the strongest Lewis acid?

(A) Na^+
(B) Cl^-
(C) CH_3COO^-
(D) Mg^{2+}
(E) Al^{3+}

49. Each of the following can act as both a Bronsted acid and a Bronsted base EXCEPT

(A) HCO_3^-
(B) $H_2PO_4^-$
(C) NH_4^+
(D) H_2O
(E) HS^-

53. Which, if any, of the following species is in the greatest concentration in a 0.100-molar solution of H_2SO_4 in water?

(A) H_2SO_4 molecules
(B) H_3O^+ ions
(C) HSO_4^- ions
(D) SO_4^{2-} ions
(E) All species are in equilibrium and therefore have the same concentrations.

71. Which of the following reactions does NOT proceed significantly to the right in aqueous solutions?

(A) $H_3O^+ + OH^- \leftrightarrows 2\ H_2O$
(B) $HCN + OH^- \leftrightarrows H_2O + CN^-$
(C) $Cu(H_2O)_4^{2+} + 4\ NH_3 \leftrightarrows Cu(NH_3)_4^{2+} + 4H_2O$
(D) $H_2SO_4 + H_2O \leftrightarrows H_3O^+ + HSO_4^-$
(E) $H_2O + HSO_4^- \leftrightarrows H_2SO_4 + OH^-$

75. If the acid dissociation constant, K_a, for an acid HA is 8×10^{-4} at 25°C, what percent of the acid is dissociated in a 0.50-molar solution of HA at 25°C?

(A) 0.08%
(B) 0.2%
(C) 1%
(D) 2%
(E) 4%

1989

34. All of the following species can function as Bronsted-Lowry bases in solution EXCEPT

(A) H_2O
(B) NH_3
(C) S^{2-}
(D) NH_4^+
(E) HCO_3^-

46. As the number of oxygen atoms increases in any series of oxygen acids, such as HXO, HXO_2, HXO_3, which of the following is generally true?

(A) The acid strength varies unpredictably.
(B) The acid strength decreases only if X is a nonmetal.
(C) The acid strength decreases only if X is a metal.
(D) The acid strength decreases whether X is a nonmetal or a metal.
(E) The acid strength increases.

54. Which of the following is the correct equilibrium expression for the hydrolysis of CO_3^{2-} ?

(A) $K = [HCO_3^-] / ([CO_3^{2-}] [H_3O^+])$

(B) $K = ([HCO_3^-] [OH^-]) / [CO_3^{2-}]$

(C) $K = ([CO_3^{2-}] [OH^-]) / [HCO_3^-]$

(D) $K = [CO_3^{2-}] / ([CO_2] [OH^-]^2)$

(E) $K = ([CO_3^{2-}] [H_3O^+]) / [HCO_3^-]$

55. $H_2PO_4^- + HBO_3^{2-} \leftrightarrows HPO_4^{2-} + H_2BO_3^-$

The equilibrium constant for the reaction represented by the equation above is greater than 1.0. Which of the following gives the correct relative strengths of the acids and bases in the reaction?

	Acids		Bases
(A)	$H_2PO_4^- > H_2BO_3^-$	and	$HBO_3^{2-} > HPO_4^{2-}$
(B)	$H_2BO_3^- > H_2PO_4^-$	and	$HBO_3^{2-} > HPO_4^{2-}$
(C)	$H_2PO_4^- > H_2BO_3^-$	and	$HPO_4^{2-} > HBO_3^{2-}$
(D)	$H_2BO_3^- > H_2PO_4^-$	and	$HPO_4^{2-} > HBO_3^{2-}$
(E)	$H_2PO_4^- = H_2BO_3^-$	and	$HPO_4^{2-} = HBO_3^{2-}$

56. A 0.20-molar solution of a weak monoprotic acid, HA, has a pH of 3.00. The ionization constant of this acid is

(A) 5.0×10^{-7}

(B) 2.0×10^{-7}

(C) 5.0×10^{-6}

(D) 5.0×10^{-3}

(E) 2.0×10^{-3}

74. Equal volumes of 0.10-molar H_3PO_4 and 0.20-molar KOH are mixed. After equilibrium is established, the type of ion in solution in largest concentration, other than the K^+ ion, is

(A) $H_2PO_4^-$

(B) HPO_4^{2-}

(C) PO_4^{3-}

(D) OH^-

(E) H_3O^+

1994

22. $HSO_4^- + H_2O \leftrightarrows H_3O^+ + SO_4^{2-}$

In the equilibrium represented above, the species that act as bases include which of the following?

I. HSO_4^-

II. H_2O

III. SO_4^{2-}

(A) II only

(B) III only

(C) I and II

(D) I and III

(E) II and III

31. $H_2C_2O_4 + 2\ H_2O \leftrightarrows 2\ H_3O^+ + C_2O_4^{2-}$

Oxalic acid, $H_2C_2O_4$, is a diprotic acid with $K_1 = 5 \times 10^{-2}$ and $K_2 = 5 \times 10^{-5}$. Which of the following is equal to the equilibrium constant for the reaction represented above?

(A) 5×10^{-2}

(B) 5×10^{-5}

(C) 2.5×10^{-6}

(D) 5×10^{-7}

(E) 2.5×10^{-8}

50. Which of the following acids can be oxidized to form a stronger acid?

(A) H_3PO_4

(B) HNO_3

(C) H_2CO_3

(D) H_3BO_3

(E) H_2SO_3

61. A 1-molar solution of which of the following salts has the highest pH ?

(A) $NaNO_3$
(B) Na_2CO_3
(C) NH_4Cl
(D) $NaHSO_4$
(E) Na_2SO_4

66. What is the pH of a 1.0×10^{-2}-molar solution of HCN? (For HCN, $K_a = 4.0 \times 10^{-10}$.)

(A) 10
(B) Between 7 and 10
(C) 7
(D) Between 4 and 7
(E) 4

74. A solution of calcium hypochlorite, a common additive to swimming-pool water, is

(A) basic because of the hydrolysis of the OCl^- ion
(B) basic because $Ca(OH)_2$ is a weak and insoluble base
(C) neutral if the concentration is kept below 0.1 molar
(D) acidic because of the hydrolysis of the Ca^{2+} ions
(E) acidic because the acid HOCl is formed

1999

38. A molecule or an ion is classified as a Lewis acid if it

(A) accepts a proton from water
(B) accepts a pair of electrons to form a bond
(C) donates a pair of electrons to form a bond
(D) donates a proton to water
(E) has resonance Lewis electron-dot structures

45. What is the $H^+(aq)$ concentration in 0.05 M HCN(aq)? (The K_a for HCN is 5.0×10^{-10}.)

(A) 2.5×10^{-11} M
(B) 2.5×10^{-10} M
(C) 5.0×10^{-10} M
(D) 5.0×10^{-6} M
(E) 5.0×10^{-4} M

$$HC_2H_3O_2(aq) + CN^-(aq) \leftrightarrows HCN(aq) + C_2H_3O_2^-(aq)$$

62. The reaction represented above has an equilibrium constant equal to 3.7×10^4. Which of the following can be concluded from this information?

(A) $CN^-(aq)$ is a stronger base than $C_2H_3O_2^-(aq)$.
(B) HCN (aq) is a stronger acid than $HC_2H_3O_2$ (aq).
(C) The conjugate base of $CN^-(aq)$ is $C_2H_3O_2^-(aq)$.
(D) The equilibrium constant will increase with an increase in temperature.
(E) The pH of a solution containing equimolar amounts of $CN^-(aq)$ and $HC_2H_3O_2$ (aq) is 7.0.

2002

$$2\ NH_3 \leftrightarrows NH_4^+ + NH_2^-$$

22. In liquid ammonia, the reaction represented above occurs. In the reaction NH_4^+ acts as

(A) a catalyst
(B) both an acid and a base
(C) the conjugate acid of NH_3
(D) the reducing agent
(E) the oxidizing agent

30. At 25°C, aqueous solutions with a pH of 8 have a hydroxide ion concentration, $[OH^-]$, of

(A) 1×10^{-14} M
(B) 1×10^{-8} M
(C) 1×10^{-6} M
(D) 1 M
(E) 8 M

64. Ascorbic acid, $H_2C_6H_6O_6(s)$, is a diprotic acid with $K_1 = 7.9 \times 10^{-5}$ and $K_2 = 1.6 \times 10^{-12}$. In a 0.005 M aqueous solution of ascorbic acid, which of the following species is present in the lowest concentration?

(A) $H_2O(l)$
(B) $H_3O^+(aq)$
(C) $H_2C_6H_6O_6(aq)$
(D) $HC_6H_6O_6^-(aq)$
(E) $C_6H_6O_6^{2-}(aq)$

1990 D

8. Give a brief explanation for each of the following.

(a) For the diprotic acid H_2S, the first dissociation constant is larger than the second dissociation constant by about 10^5 ($K_1 \cong 10^5 \times K_2$).

(b) In water, NaOH is a base but HOCl is an acid.

(c) HCl and HI are equally strong acids in water but, in pure acetic acid, HI is a stronger acid than HCl.

(d) When each is dissolved in water, HCl is a much stronger acid than HF.

1993 D (Required)

5. The following observations are made about reaction of sulfuric acid, H_2SO_4. Discuss the chemical processes involved in each case. Use principles from acid-base theory, oxidation-reduction, and bonding and/or intermolecular forces to support your answers.

(a) When zinc metal is added to a solution of dilute H_2SO_4, bubbles of gas are formed and the zinc disappears.

(b) As concentrated H_2SO_4 is added to water, the temperature of the resulting mixture rises.

(c) When a solution of $Ba(OH)_2$ is added to a dilute H_2SO_4 solution, the electrical conductivity decreases and a white precipitate forms.

1996 A

$$HOCl \leftrightarrows OCl^- + H^+$$

2. Hypochlorous acid, HOCl, is a weak acid commonly used as a bleaching agent. The acid-dissociation constant, K_a, for the reaction represented above is 3.2×10^{-8}.

(a) Calculate the $[H^+]$ of a 0.14-molar solution of HOCl.

(b) Write the correctly balanced net ionic equation for the reaction that occurs when NaOCl is dissolved in water and calculate the numerical value of the equilibrium constant for the reaction.

(c) Calculate the pH of a solution made by combining 40.0 milliliters of 0.14-molar HOCl and 10.0 milliliters of 0.56-molar NaOH.

(d) *after Ch 18*: How many millimoles of solid NaOH must be added to 50.0 milliliters of 0.20-molar HOCl to obtain a buffer solution that has a pH of 7.49? Assume that the addition of the solid NaOH results in a negligible change in volume.

(e) Household bleach is made by dissolving chlorine gas in water, as represented below.

$$Cl_2(g) + H_2O \rightarrow H^+ + Cl^- + HOCl(aq)$$

Calculate the pH of such a solution if the concentration of HOCl in the solution is 0.065 molar.

1997 A

2. The overall dissociation of oxalic acid, $H_2C_2O_4$, is represented below. The overall dissociation constant is also indicated.

$$H_2C_2O_4 \leftrightarrows 2\ H^+ + C_2O_4^{2-} \qquad K = 3.78 \times 10^{-6}$$

(a) What volume of 0.400-molar NaOH is required to neutralize completely a 5.00×10^{-3}-mole sample of pure oxalic acid?

(b) Give the equations representing the first and second dissociations of oxalic acid. Calculate the value of the first dissociation constant, K_1, for oxalic acid if the value of the second dissociation constant, K_2, is 6.40×10^{-5}.

(c) To a 0.015-molar solution of oxalic acid, a strong acid is added until the pH is 0.5. Calculate the $[C_2O_4^{2-}]$ in the resulting solution. (Assume the change in volume is negligible.) *This is a common ion problem; we will address more thoroughly in Ch 18.*

(d) Calculate the value of the equilibrium constant, K_b, for the reaction that occurs when solid $Na_2C_2O_4$ is dissolved in water.

2009 part A, question #1

Answer the following questions that relate to the chemistry of halogen oxoacids.

(a) Use the information the table below to answer part (a)(i).

Acid	K_a at 298 K
HOCl	2.9×10^{-8}
HOBr	2.4×10^{-9}

(i) Which of the two acids is stronger, HOCl or HOBr? Justify your answer in terms of K_a.

(ii) Draw a complete Lewis electron-dot diagram for the acid that you identified in part (a)(i).

(iii) Hypoiodous acid has the formula HOI. Predict whether HOI is a stronger acid or a weaker acid than the acid that you identified in part (a)(i). Justify your prediction in terms of chemical bonding.

(b) Write the equation for the reaction that occurs between hypochlorous acid and water.

(c) A 1.2 M NaOCl solution is prepared by dissolving solid NaOCl in distilled water at 298 K. The hydrolysis reaction $OCl^-(aq) + H_2O(l) \leftrightarrows HOCl(aq) + OH^-(aq)$ occurs.

(i) Write the equilibrium-constant expression for the hydrolysis reaction that occurs between $OCl^-(aq)$ and $H_2O(l)$.

(ii) Calculate the value of the equilibrium constant at 298 K for the hydrolysis reaction.

(iii) Calculate the value of $[OH^-]$ in the 1.2 M NaOCl solution at 298 K.