Name _____ Date _____ Class _____

CHAPTER 14 REVIEW

Acids and Bases

SECTION 1

SHORT ANSWER **Answer the following questions in the space provided.**

1. Name the following compounds as acids:

sulfuric acid — **a.** H_2SO_4

sulfurous acid — **b.** H_2SO_3

hydrosulfuric acid — **c.** H_2S

perchloric acid — **d.** $HClO_4$

hydrocyanic acid — **e.** hydrogen cyanide

2. H_2S — Which (if any) of the acids mentioned in item **1** are binary acids?

3. Write formulas for the following acids:

HNO_2 — **a.** nitrous acid

HBr — **b.** hydrobromic acid

H_3PO_4 — **c.** phosphoric acid

CH_3COOH — **d.** acetic acid

HClO — **e.** hypochlorous acid

4. Calcium selenate has the formula $CaSeO_4$.

H_2SeO_4 — **a.** What is the formula for selenic acid?

H_2SeO_3 — **b.** What is the formula for selenous acid?

5. Use an activity series to identify two metals that will not generate hydrogen gas when treated with an acid.

Choose from Cu, Ag, Au, Pt, Pd, or Hg.

6. Write balanced chemical equations for the following reactions of acids and bases:

a. aluminum metal with dilute nitric acid

$2Al(s) + 6HNO_3(aq) \rightarrow 2Al(NO_3)_3(aq) + 3H_2(g)$

b. calcium hydroxide solution with acetic acid

$Ca(OH)_2(aq) + 2CH_3COOH(aq) \rightarrow Ca(CH_3COO)_2(aq) + 2H_2O(l)$

Name _____ Date _____ Class _____

SECTION 1 continued

7. Write net ionic equations that represent the following reactions:

a. the ionization of $HClO_3$ in water

$HClO_3(aq) + H_2O(l) \rightarrow H_3O^+(aq) + ClO_3^-(aq)$

b. NH_3 functioning as an Arrhenius base

$NH_3(aq) + H_2O(l) \rightleftarrows NH_4^+(aq) + OH^-(aq)$

8. **a.** Explain how strong acid solutions carry an electric current.

Strong acids ionize completely in solution. These ions are free to move, making it possible for an electric current to pass through the solution.

b. Will a strong acid or a weak acid conduct electricity better, assuming all other factors remain constant? Explain why one is a better conductor.

Strong acids conduct electricity better because they have many more ions present per liter of solution than do weak acids of the same concentration.

9. Most acids react with solid carbonates, as in the following equation:

$$CaCO_3(s) + HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g) \text{ (unbalanced)}$$

a. Balance the above equation.

$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

b. Write the net ionic equation for the above reaction.

$CO_3^-(aq) + 2H^+(aq) \rightarrow H_2O(l) + CO_2(g)$

Ca^{2+} and Cl^- **c.** Identify all spectator ions in this system.

1.1 L **d.** How many liters of CO_2 form at STP if 5.0 g of $CaCO_3$ are treated with excess hydrochloric acid? Show all your work.

Name _____ Date _____ Class _____

CHAPTER 14 REVIEW

Acids and Bases

SECTION 2

SHORT ANSWER **Answer the following questions in the space provided.**

1. **a.** Write the two equations that show the two-stage ionization of sulfurous acid in water.

stage 1: $H_2SO_3(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + HSO_3^-(aq)$

stage 2: $HSO_3^-(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + SO_3^{2-}(aq)$

b. Which stage of ionization usually produces more ions? Explain your answer.

Stage 1; for most polyprotic acids, the concentration of ions formed in the first ionization is the greatest.

2. **a.** Define a Lewis base. Can OH^- function as a Lewis base? Explain your answer.

A Lewis base is a species that donates an electron pair to form a covalent bond. Yes, OH^- is a Lewis base. It has an electron pair available to donate. For example, $OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$.

b. Define a Lewis acid. Can H^+ function as a Lewis acid? Explain your answer.

A Lewis acid is a species that accepts an electron pair to form a covalent bond. H^+ is a Lewis acid because it can accept an electron pair from a base. For example, $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$.

3. Identify the Brønsted-Lowry acid and the Brønsted-Lowry base on the reactant side of each of the following equations for reactions that occur in aqueous solution. Explain your answers.

a. $H_2O(l) + HNO_3(aq) \rightarrow H_3O^+(aq) + NO_3^-(aq)$

HNO_3 is the Brønsted-Lowry acid because it donates a proton to the H_2O. The H_2O is the Brønsted-Lowry base because it is the proton acceptor.

b. $HF(aq) + HS^-(aq) \rightarrow H_2S(aq) + F^-(aq)$

HF is the Brønsted-Lowry acid because it donates a proton to the HS^-. The HS^- is the Brønsted-Lowry base because it is the proton acceptor.

SECTION 2 continued

4. a. Write the equation for the first ionization of H_2CO_3 in aqueous solution. Assume that water serves as the reactant that attaches to the hydrogen ion released from the H_2CO_3. Which of the reactants is the Brønsted-Lowry acid, and which is the Brønsted-Lowry base? Explain your answer.

$H_2CO_3(aq) + H_2O(l) \rightleftarrows HCO_3^-(aq) + H_3O^+(aq)$. The H_2CO_3 is the Brønsted-Lowry acid because it donates a proton to the H_2O. The H_2O is the Brønsted-Lowry base because it accepts the proton.

b. Write the equation for the second ionization, that of the ion that was formed by the H_2CO_3 in the reaction you described above. Again, assume that water serves as the reactant that attaches to the hydrogen ion released. Which of the reactants is the Brønsted-Lowry acid, and which is the Brønsted-Lowry base? Explain your answer.

$HCO_3^-(aq) + H_2O(l) \rightarrow CO_3^{2-}(aq) + H_3O^+(aq)$. The HCO_3^- is the Brønsted-Lowry acid because it donates a proton to the H_2O. The H_2O is the Brønsted-Lowry base because it accepts the proton.

c. What is the name for a substance, such as H_2CO_3, that can donate two protons?

a diprotic acid

5. a. How many electron pairs surround an atom of boron (B, element 5) bonded in the compound BCl_3?

three

b. How many electron pairs surround an atom of nitrogen (N, element 7) in the compound NF_3?

four

c. Write an equation for the reaction between the two compounds above. Assume that they react in a 1:1 ratio to form one molecule as product.

$BCl_3 + NF_3 \rightarrow BCl_3NF_3$

d. Assuming that the B and the N are covalently bonded to each other in the product, which of the reactants is the Lewis acid? Is this reactant also a Brønsted-Lowry acid? Explain your answers.

BCl_3 is the Lewis acid because it accepts an electron pair in forming a covalent bond. It is not a Brønsted-Lowry acid, because it is not donating a proton.

e. Which of the reactants is the Lewis base? Explain your answer.

NF_3 is the Lewis base because it donates an electron pair in forming a covalent bond.

Name _____ Date _____ Class _____

CHAPTER 14 REVIEW

Acids and Bases

SECTION 3

SHORT ANSWER **Answer the following questions in the space provided.**

1. Answer the following questions according to the Brønsted-Lowry definitions of acids and bases:

HSO_3^- **a.** What is the conjugate base of H_2SO_3?

NH_3 **b.** What is the conjugate base of NH_4^+?

OH^- **c.** What is the conjugate base of H_2O?

H_3O^+ **d.** What is the conjugate acid of H_2O?

$H_2AsO_4^-$ **e.** What is the conjugate acid of $HAsO_4^{2-}$?

2. Consider the reaction described by the following equation:

$$NH_4^+(aq) + CO_3^{2-}(aq) \rightleftarrows NH_3(aq) + HCO_3^-(aq)$$

a. If NH_4^+ is considered acid 1, identify the other three terms as acid 2, base 1, and base 2 to indicate the conjugate acid-base pairs.

base 2 CO_3^{2-}

acid 2 HCO_3^-

base 1 NH_3

True **b.** A proton has been transferred from acid 1 to base 2 in the above reaction. True or False?

3. Consider the neutralization reaction described by the equation: $HCO_3^-(aq) + OH^-(aq) \rightleftarrows CO_3^{2-}(aq) + H_2O(l)$

a. Label the conjugate acid-base pairs in this system.

$HCO_3^-(aq) + OH^-(aq) \rightleftarrows CO_3^{2-}(aq) + H_2O(l)$

acid 1 base 2 base 1 acid 2

b. Is the forward or reverse reaction favored? Explain your answer.

The forward reaction is favored. The weaker acid and weaker base are produced in the forward reaction. HCO_3^- competes more strongly with H_2O to donate a proton, and OH^- competes more strongly with CO_3^{2-} to acquire a proton, causing the forward reaction to be favored.

Name _____ Date _____ Class _____

SECTION 3 continued

4. **Table 6** on page 485 of the text lists several amphoteric species, but only one other than water is neutral.

NH_3 **a.** Identify that neutral compound.

b. Write two equations that demonstrate this compound's amphoteric properties.

(Answers will vary, but one equation should form NH_4^+, the other NH_2^-.)

$NH_3(aq) + HCl(aq) \rightarrow NH_4^+(aq) + Cl^-(aq)$

$NH_3(aq) + H^-(aq) \rightarrow NH_2^-(aq) + H_2(g)$

5. Write the formula for the salt formed in each of the following neutralization reactions:

K_3PO_4 **a.** potassium hydroxide combined with phosphoric acid

$Ca(NO_2)_2$ **b.** calcium hydroxide combined with nitrous acid

$BaBr_2$ **c.** hydrobromic acid combined with barium hydroxide

Li_2SO_4 **d.** lithium hydroxide combined with sulfuric acid

6. Consider the following unbalanced equation for a neutralization reaction:

$$H_2SO_4(aq) + NaOH(aq) \rightarrow Na_2SO_4(aq) + H_2O(l)$$

a. Balance the equation.

$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

Na^+ and SO_4^{2-} **b.** In this system there are two spectator ions. Identify them.

1:2 **c.** For the reaction to completely consume all reactants, what should be the mole ratio of acid to base?

7. The gases that produce acid rain are often referred to as NO_x and SO_x.

a. List three specific examples of these gases.

Some examples are NO, NO_2, SO_2, and SO_3.

b. Coal- and oil-burning power plants oxidize any sulfur in their fuel as it burns in air, and this forms SO_2 gas. The SO_2 is further oxidized by O_2 in our atmosphere, forming SO_3 gas. The SO_3 gas can combine with water to form sulfuric acid. Write balanced chemical equations to illustrate these three reactions.

$S(s) + O_2(g) \rightarrow SO_2(g)$

$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$

c. Industrial plants making fertilizers and detergents release nitrogen oxide gases into the air. Write a balanced equation for converting $N_2O_5(g)$ into nitric acid by reacting it with water.

$N_2O_5(g) + H_2O(l) \rightarrow 2HNO_3(aq)$

Name _____ Date _____ Class _____

CHAPTER 14 REVIEW

Acids and Bases

MIXED REVIEW

SHORT ANSWER **Answer the following questions in the space provided.**

1. HClO — **a.** Write the formula for hypochlorous acid.

hydrofluoric acid — **b.** Write the name for HF(*aq*).

$H_2C_2O_4$ — **c.** If $Pb(C_2O_4)_2$ is lead(IV) oxalate, what is the formula for oxalic acid?

acetic acid — **d.** Name the acid that is present in vinegar.

2. Answer the following questions according to the Brønsted-Lowry acid-base theory. Consult **Table 6** on page 485 of the text as needed.

HS^- — **a.** What is the conjugate base of H_2S?

PO_4^{3-} — **b.** What is the conjugate base of HPO_4^{2-}?

NH_4^+ — **c.** What is the conjugate acid of NH_3?

3. Consider the reaction represented by the following equation:

$$OH^-(aq) + HCO_3^-(aq) \rightarrow H_2O(l) + CO_3^{2-}(aq)$$

If OH^- is considered base 1, what are acid 1, acid 2, and base 2?

H_2O — **a.** acid 1

HCO_3^- — **b.** acid 2

CO_3^{2-} — **c.** base 2

4. Write the formula for the salt that is produced in each of the following neutralization reactions:

K_2SO_3 — **a.** sulfurous acid combined with potassium hydroxide

$Ca_3(PO_4)_2$ — **b.** calcium hydroxide combined with phosphoric acid

5. Carbonic acid releases H_3O^+ ions into water in two stages.

a. Write equations representing each stage.

stage 1: $H_2CO_3(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + HCO_3^-(aq)$

stage 2: $HCO_3^-(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + CO_3^{2-}(aq)$

stage 1 — **b.** Which stage releases more ions into solution?

Name _____ Date _____ Class _____

MIXED REVIEW continued

6. Glacial acetic acid is a highly viscous liquid that is close to 100% CH_3COOH. When it mixes with water, it forms dilute acetic acid.

a. When making a dilute acid solution, should you add acid to water or water to acid? Explain your answer.

Add acid to water to achieve a thorough mixing of a denser acid with a slow release of heat and to avoid splashing concentrated acid.

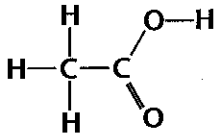
b. Glacial acetic acid does not conduct electricity, but dilute acetic acid does. Explain this statement.

Glacial acetic acid exists as neutral molecules. In the presence of water, some of those molecules ionize into H^+ and CH_3COO^-, which cause the solution to conduct electricity.

c. Dilute acetic acid does not conduct electricity as well as dilute nitric acid at the same concentration. Is acetic acid a strong or weak acid?

weak

d. Although there are four H atoms per molecule, acetic acid is monoprotic. Show the structural formula for CH_3COOH, and indicate the H atom that ionizes.



The H bonded to the O ionizes.

e. **30. g** How many grams of glacial acetic acid should be used to make 250 mL of 2.00 M acetic acid? Show all your work.

7. The overall effect of acid rain on lakes and ponds is partially determined by the geology of the lake bed. In some cases, the rock is limestone, which is rich in calcium carbonate. Calcium carbonate reacts with the acid in lake water according to the following (incomplete) ionic equation:

$$CaCO_3(s) + 2H_3O^+(aq) \rightarrow$$

a. Complete the ionic equation begun above.

$CaCO_3(s) + 2H_3O^+(aq) \rightarrow Ca^{2+}(aq) + CO_2(g) + 3H_2O(l)$

b. If this reaction is the only reaction involving H_3O^+ occurring in the lake, does the concentration of H_3O^+ in the lake water increase or decrease? What effect does this have on the acidity of the lake water?

It decreases, making the lake water less acidic.

Name _____ Date _____ Class _____

CHAPTER 15 REVIEW

Acid-Base Titration and pH

SECTION 1

SHORT ANSWER **Answer the following questions in the space provided.**

1. Calculate the following values without using a calculator.

1×10^{-8} M — **a.** The $[H_3O^+]$ is 1×10^{-6} M in a solution. Calculate the $[OH^-]$.

1×10^{-5} M — **b.** The $[H_3O^+]$ is 1×10^{-9} M in a solution. Calculate the $[OH^-]$.

1×10^{-2} M — **c.** The $[OH^-]$ is 1×10^{-12} M in a solution. Calculate the $[H_3O^+]$.

2×10^{-2} M — **d.** The $[OH^-]$ in part **c** is reduced by half, to 0.5×10^{-12} M. Calculate the $[H_3O^+]$.

inversely — **e.** The $[H_3O^+]$ and $[OH^-]$ are ____ (directly, inversely, or not) proportional in any system involving water.

2. Calculate the following values without using a calculator.

12.0 — **a.** The pH of a solution is 2.0. Calculate the pOH.

9.27 — **b.** The pOH of a solution is 4.73. Calculate the pH.

3.0 — **c.** The $[H_3O^+]$ in a solution is 1×10^{-3} M. Calculate the pH.

1×10^{-5} M — **d.** The pOH of a solution is 5.0. Calculate the $[OH^-]$.

1×10^{-13} M — **e.** The pH of a solution is 1.0. Calculate the $[OH^-]$.

3. Calculate the following values.

4.631 — **a.** The $[H_3O^+]$ is 2.34×10^{-5} M in a solution. Calculate the pH.

3.16×10^{-4} M — **b.** The pOH of a solution is 3.5. Calculate the $[OH^-]$.

2.2×10^{-7} M — **c.** The $[H_3O^+]$ is 4.6×10^{-8} M in a solution. Calculate the $[OH^-]$.

PROBLEMS **Write the answer on the line to the left. Show all your work in the space provided.**

4. $[H_3O^+]$ in an aqueous solution = 2.3×10^{-3} M.

4.3×10^{-12} M — **a.** Calculate $[OH^-]$ in this solution.

Name _____ Date _____ Class _____

SECTION 1 continued

2.64 **b.** Calculate the pH of this solution.

11.36 **c.** Calculate the pOH of this solution.

d. Is the solution acidic, basic, or neutral? Explain your answer.

acidic because the pH is less than 7.0

5. Consider a dilute solution of 0.025 M $Ba(OH)_2$ in answering the following questions.

a. What is the $[OH^-]$ in this solution? Explain your answer.

0.050 M; in solution, $Ba(OH)_2$ releases two OH^- ions per molecule, so $[OH^-]$ is two times the $[Ba(OH)_2]$.

12.70 **b.** What is the pH of this solution?

6. Vinegar purchased in a store may contain 6 g of CH_3COOH per 100 mL of solution.

1 M **a.** What is the molarity of the solute?

b. The actual $[H_3O^+]$ in the vinegar solution in part **a** is 4.2×10^{-3} M. In this solution, has more than 1% or less than 1% of the acetic acid ionized? Explain your answer.

less than 1%; 1% of 1 M would equal 1×10^{-2} hydronium ions, but in fact, less than that amount has been produced.

weak **c.** Is acetic acid strong or weak, based on the ionization information from part **b**?

2.38 **d.** What is the pH of this vinegar solution?

Name _____ Date _____ Class _____

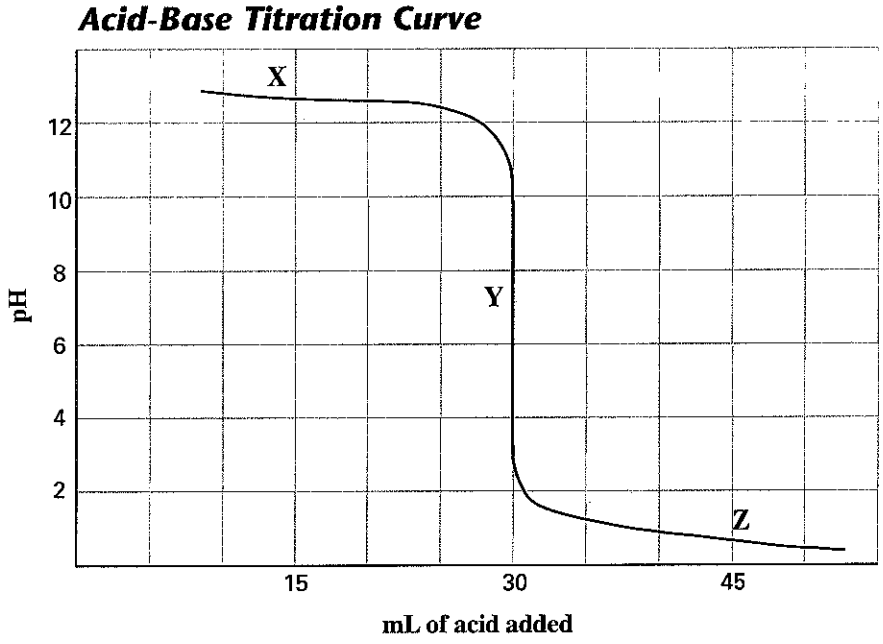
CHAPTER 15 REVIEW

Acid-Base Titration and pH

SECTION 2

SHORT ANSWER **Answer the following questions in the space provided.**

1. Below is a pH curve from an acid-base titration. On it are labeled three points: X, Y, and Z.



Y — **a.** Which point represents the equivalence point?

Z — **b.** At which point is there excess acid in the system?

X — **c.** At which point is there excess base in the system?

7.5×10^{-3} mol — **d.** If the base solution is 0.250 M and there is one equivalent of OH^- ions for each mole of base, how many moles of OH^- ions are consumed at the end point of the titration?

PROBLEMS **Write the answer on the line to the left. Show all your work in the space provided.**

2. A standardized solution of 0.065 M HCl is titrated with a saturated solution of calcium hydroxide to determine its molarity and its solubility. It takes 25.0 mL of the base to neutralize 10.0 mL of the acid.

a. Write the balanced molecular equation for this neutralization reaction.

$Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$

Name _____ Date _____ Class _____

SECTION 2 continued

0.013 M **b.** Determine the molarity of the $Ca(OH)_2$ solution.

0.96 g/L **c.** Based on your answer to part **b**, calculate the solubility of the base in grams per liter of solution. (Hint: What is the concentration of $Ca(OH)_2$ in the saturated solution?)

3. It is possible to carry out a titration without any indicator. Instead, a pH probe is immersed in a beaker containing the solution of unknown molarity, and a solution of known molarity is slowly added from a buret. Use the titration data below to answer the following questions.

Volume of KOH(*aq*) in the beaker = 30.0 mL

Molarity of HCl(*aq*) in the buret = 0.50 M

At the instant pH falls from 10 to 4, the volume of acid added to KOH = 27.8 mL.

1:1 **a.** What is the mole ratio of chemical equivalents in this system?

0.46 M **b.** Calculate the molarity of the KOH solution, based on the above data.

Name _____ Date _____ Class _____

CHAPTER 15 REVIEW

Acid-Base Titration and pH

MIXED REVIEW

SHORT ANSWER **Answer the following questions in the space provided.**

1. Calculate the following values without using a calculator.

4.0 **a.** The $[H_3O^+]$ in a solution is 1×10^{-4} M. Calculate the pH.

1×10^{-13} M **b.** The pH of a solution is 13.0. Calculate the $[H_3O^+]$.

1×10^{-9} M **c.** The $[OH^-]$ in a solution is 1×10^{-5} M. Calculate the $[H_3O^+]$.

9.28 **d.** The pH of a solution is 4.72. Calculate the pOH.

14.00 **e.** The $[OH^-]$ in a solution is 1.0 M. Calculate the pH.

2. Calculate the following values.

8.204 **a.** The $[H_3O^+]$ in a solution is 6.25×10^{-9} M. Calculate the pH.

4.6×10^{-3} M **b.** The pOH of a solution is 2.34. Calculate the $[OH^-]$.

3×10^{-4} M **c.** The pH of milk of magnesia is approximately 10.5. Calculate the $[OH^-]$.

PROBLEMS **Write the answer on the line to the left. Show all your work in the space provided.**

3. A 0.0012 M solution of H_2SO_4 is 100% ionized.

0.0024 M **a.** What is the $[H_3O^+]$ in the H_2SO_4 solution?

4.2×10^{-12} M **b.** What is the $[OH^-]$ in this solution?

2.62 **c.** What is the pH of this solution?

Name _____ Date _____ Class _____

MIXED REVIEW continued

4. In a titration, a 25.0 mL sample of 0.150 M HCl is neutralized with 44.45 mL of $Ba(OH)_2$.

a. Write the balanced molecular equation for this reaction.

$2HCl(aq) + Ba(OH)_2(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$

0.0422 M **b.** What is the molarity of the base solution?

5. 3.09 g of boric acid, H_3BO_3, are dissolved in 200 mL of solution.

0.250 M **a.** Calculate the molarity of the solution.

b. H_3BO_3 ionizes in solution in three stages. Write the equation showing the ionization for each stage. Which stage proceeds furthest to completion?

stage 1: $H_3BO_3(s) + H_2O(l) \rightleftarrows H_3O^+(aq) + H_2BO_3^-(aq)$

stage 2: $H_2BO_3^-(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + HBO_3^{2-}(aq)$

stage 3: $HBO_3^{2-}(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + BO_3^{3-}(aq)$

Stage 1 proceeds furthest to completion.

1.3×10^{-5} M **c.** What is the $[H_3O^+]$ in this boric acid solution if the pH = 4.90?

less than 1% **d.** Is the percentage ionization of this H_3BO_3 solution more than or less than 1%?

Name _____ Date _____ Class _____

CHAPTER 18 REVIEW

Chemical Equilibrium

SECTION 3

SHORT ANSWER **Answer the following questions in the space provided.**

1. a Lime juice turns litmus paper red, indicating that lime juice is

(a) acidic.
(b) basic.
(c) neutral.
(d) alkaline

2. d Addition of the salt of a weak acid to a solution of the weak acid

(a) lowers the concentration of the nonionized acid and the concentration of the H_3O^+ ion.
(b) lowers the concentration of the nonionized acid and raises the concentration of the H_3O^+ ion.
(c) raises the concentration of the nonionized acid and the concentration of the H_3O^+ ion.
(d) raises the concentration of the nonionized acid and lowers the concentration of the H_3O^+ ion.

3. b Salts of a weak acid and a strong base produce solutions that are

(a) acidic only.
(b) basic only.
(c) neutral only.
(d) either acidic, basic, or neutral.

4. a If an acid is added to a solution of a weak base and its salt,

(a) more water is formed and more weak base ionizes.
(b) hydronium ion concentration decreases.
(c) more hydroxide ion is formed.
(d) more nonionized weak base is formed.

5. a. In the space below each of the following equations, correctly label the two conjugate acid-base pairs as *acid 1, acid 2, base 1,* and *base 2.*

(a) $CO_3^{2-}(aq) + H_3O^+(aq) \rightleftarrows HCO_3^-(aq) + H_2O(l)$

base 1 **acid 2** **acid 1** **base 2**

(b) $HPO_4^{2-}(aq) + H_2O(l) \rightleftarrows OH^-(aq) + H_2PO_4^-(aq)$

base 1 **acid 2** **base 2** **acid 1**

b **b.** Which reaction in part **a** is an example of hydrolysis?

a **c.** As the first reaction in part **a** proceeds, the pH of the solution

(a) increases.
(b) decreases.
(c) stays at the same level.
(d) fluctuates.

SECTION 3 continued

6. Write the formulas for the acid and the base that could form the salt $Ca(NO_3)_2$.

The acid is $HNO_3(aq)$ and the base is $Ca(OH)_2(aq)$.

7. Consider the following equation for the reaction of a weak base in water:

$$NH_3(aq) + H_2O(l) \rightleftarrows NH_4^+(aq) + OH^-(aq)$$

Write the equilibrium expression for K.

$$K = \frac{[NH_4^+][OH^-]}{[NH_3]}$$

PROBLEMS Write the answer on the line to the left. Show all your work in the space provided.

8. An unknown acid X hydrolyzes according to the equation in part **a** below.

a. In the space below the equation, correctly label the two conjugate acid-base pairs in this system as *acid 1, acid 2, base 1,* and *base 2.*

$$HX(aq) + H_2O(l) \rightleftarrows X^-(aq) + H_3O^+(aq)$$

acid 1 base 2 base 1 acid 2

b. Write the equilibrium expression for K_a for this system.

$$K_a = \frac{[X^-][H_3O^+]}{[HX]}$$

1.0×10^{-8} **c.** Experiments show that at equilibrium $[H_3O^+] = [X^-] = 2.0 \times 10^{-5}$ mol/L and $[HX] = 4.0 \times 10^{-2}$ mol/L. Calculate the value of K_a based on these data.

12 Solutions

Section: Types of Mixtures

1. a	2. b
3. c	4. b
5. d	6. c
7. a	8. a
9. b	10. c

Section: The Solution Process

1. d	2. a
3. d	4. c
5. a	6. c
7. a	8. d
9. d	10. d

Section: Concentration of Solutions

1. c	2. a
3. a	4. d
5. c	6. d
7. a	8. d
9. b	10. c

13 Ions in Aqueous Solutions and Colligative Properties

Section: Compunds in Aqueous Soutions

1. d	2. a
3. a	4. c
5. a	6. d
7. c	8. a
9. b	10. b

Section: Colligative Properties of Solutions

1. b	2. b
3. d	4. b
5. c	6. a
7. c	8. b
9. c	10. b

14 Acids and Bases

Section: Properties of Acids and Bases

1. d	2. c
3. b	4. a
5. a	6. a
7. a	8. c
9. d	10. b

Section: Acid-Base Theories

1. c	2. b
3. a	4. b
5. b	6. a
7. d	8. c
9. b	10. d

Section: Acid-Base Reactions

1. c	2. c
3. c	4. d
5. b	6. c
7. d	8. c
9. a	10. a

15 Acid-Base Titration and pH

Section: Aqueous Solutions and the Concept of pH

1. d	2. d
3. d	4. b
5. c	6. b
7. a	8. b
9. d	10. d

Section: Determining pH and Titrations

1. d	2. b
3. c	4. a
5. c	6. b
7. b	8. b
9. c	10. a

16 Reaction Energy

Section: Thermochemistry

1. d	2. a
3. b	4. a
5. c	6. c
7. c	8. b
9. c	10. b

Section: Driving Forces of Reactions

1. b	2. a
3. d	4. a
5. b	6. a
7. a	8. b
9. c	10. d