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:

_____ **a.** H_2SO_4

_____ **b.** H_2SO_3

_____ **c.** H_2S

_____ **d.** $HClO_4$

_____ **e.** hydrogen cyanide

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

3. Write formulas for the following acids:

_____ **a.** nitrous acid

_____ **b.** hydrobromic acid

_____ **c.** phosphoric acid

_____ **d.** acetic acid

_____ **e.** hypochlorous acid

4. Calcium selenate has the formula $CaSeO_4$.

_____ **a.** What is the formula for selenic acid?

_____ **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.

_____

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

a. aluminum metal with dilute nitric acid

_____

b. calcium hydroxide solution with acetic acid

_____

Name _____ Date _____ Class _____

SECTION 1 continued

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

a. the ionization of $HClO_3$ in water

_____

b. NH_3 functioning as an Arrhenius base

_____

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

_____

_____

_____

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.

_____

_____

_____

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.

_____

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

_____

_____ **c.** Identify all spectator ions in this system.

_____ **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.

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

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

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

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

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

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.

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.

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

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

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

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.

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.

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

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:

_____ **a.** What is the conjugate base of H_2SO_3?

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

_____ **c.** What is the conjugate base of H_2O?

_____ **d.** What is the conjugate acid of H_2O?

_____ **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.

_____ CO_3^{2-}

_____ HCO_3^-

_____ NH_3

_____ **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.

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

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.

_____ **a.** Identify that neutral compound.

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

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

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

_____ **b.** calcium hydroxide combined with nitrous acid

_____ **c.** hydrobromic acid combined with barium hydroxide

_____ **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.

_____ **b.** In this system there are two spectator ions. Identify them.

_____ **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.

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.

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.

Name _____ Date _____ Class _____

CHAPTER 14 REVIEW

Acids and Bases

MIXED REVIEW

SHORT ANSWER Answer the following questions in the space provided.

1. _____ **a.** Write the formula for hypochlorous acid.

_____ **b.** Write the name for $HF(aq)$.

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

_____ **a.** What is the conjugate base of H_2S?

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

_____ **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?

_____ **a.** acid 1

_____ **b.** acid 2

_____ **c.** base 2

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

_____ **a.** sulfurous acid combined with potassium hydroxide

_____ **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.

_____ **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.

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

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?

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.

e. _____ 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.

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?

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.

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

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

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

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

_____ **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.

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

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

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

_____ **d.** The pOH of a solution is 5.0. Calculate the $[OH^-]$.

_____ **e.** The pH of a solution is 1.0. Calculate the $[OH^-]$.

3. Calculate the following values.

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

_____ **b.** The pOH of a solution is 3.5. Calculate the $[OH^-]$.

_____ **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.

_____ **a.** Calculate $[OH^-]$ in this solution.

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

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

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

_____

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.

_____

_____

_____ **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.

_____ **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.

_____

_____

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

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

Name _____ Date _____ Class _____

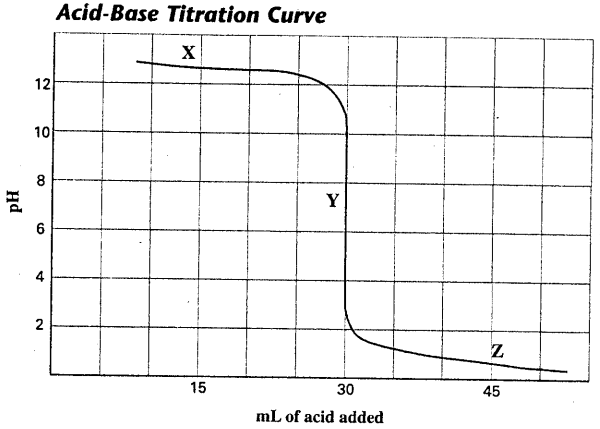
CHAPTER 15 REVIEW

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.



_____ **a.** Which point represents the equivalence point?

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

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

_____ **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.

Name _____ Date _____ Class _____

SECTION 2 continued

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

_____ **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.

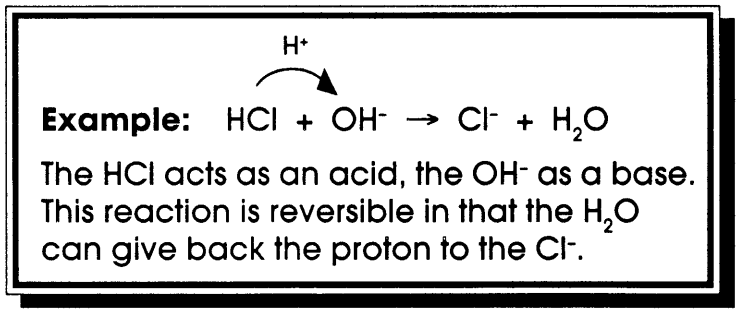
_____ **a.** What is the mole ratio of chemical equivalents in this system?

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

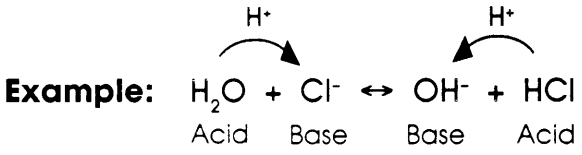
BRONSTED-LOWRY ACIDS AND BASES

Name _____

According to Bronsted-Lowry theory, an acid is a proton (H^+) donor, and a base is a proton acceptor.



Label the Bronsted-Lowry acids and bases in the following reactions and show the direction of proton transfer.



1. $H_2O + H_2O \leftrightarrow H_3O^+ + OH^-$

2. $H_2SO_4 + OH^- \leftrightarrow HSO_4^- + H_2O$

3. $HSO_4^- + H_2O \leftrightarrow SO_4^{-2} + H_3O^+$

4. $OH^- + H_3O^+ \leftrightarrow H_2O + H_2O$

5. $NH_3 + H_2O \leftrightarrow NH_4^+ + OH^-$

CONJUGATE ACID-BASE PAIRS

Name _____

In the exercise, Bronsted-Lowry Acids and Bases, it was shown that after an acid has given up its proton, it is capable of getting back that proton and acting as a base. Conjugate base is what is left after an acid gives up a proton. The stronger the acid, the weaker the conjugate base. The weaker the acid, the stronger the conjugate base.

Fill in the blanks in the table below.

Conjugate Pairs

	ACID	BASE	EQUATION
1.	H_2SO_4	HSO_4^-	$H_2SO_4 \leftrightarrow H^+ + HSO_4^-$
2.	H_3PO_4		
3.		F^-	
4.		NO_3^-	
5.	$H_2PO_4^-$		
6.	H_2O		
7.		SO_4^{-2}	
8.	HPO_4^{-2}		
9.	NH_4^+		
10.		H_2O	

Which is a stronger base, HSO_4^- or $H_2PO_4^-$? _____

Which is a weaker base, Cl^- or NO_2^-? _____

pH AND pOH

Name _____

The pH of a solution indicates how acidic or basic that solution is.

pH range of 0 - 7 acidic
7 neutral
7-14 basic

Since $[H^+]\ [OH^-] = 10^{-14}$ at 25° C, if $[H^+]$ is known, the $[OH^-]$ can be calculated and vice versa.

$pH = -\log [H^+]$ So if $[H^+] = 10^{-6}$ M, pH = 6.
$pOH = -\log [OH^-]$ So if $[OH^-] = 10^{-8}$ M, pOH = 8.
Together, pH + pOH = 14.

Complete the following chart.

	$[H^+]$	pH	$[OH^-]$	pOH	Acidic or Basic
1.	10^{-5} M	5	10^{-9} M	9	Acidic
2.		7			
3.			10^{-4} M		
4.	10^{-2} M				
5.				11	
6.		12			
7.			10^{-5} M		
8.	10^{-11} M				
9.				13	
10.		6			

pH AND pOH CONTINUED

Name _____

Calculate the pH of the solutions below.

1. 0.01 M HCl

2. 0.0010 M NaOH

3. 0.050 M $Ca(OH)_2$

4. 0.030 M HBr

5. O.150 M KOH

6. 2.0 M $HC_2H_3O_2$ (Assume 5.0% dissociation.)

7. 3.0 M HF (Assume 10.0% dissociation.)

8. 0.50 M HNO_3

9. 2.50 M NH_4OH (Assume 5.00% dissociation.)

10. 5.0 M HNO_2 (Assume 1.0% dissociation.)

ACID-BASE TITRATION

Name _____

To determine the concentration of an acid (or base), we can react it with a base (or acid) of known concentration until it is completely neutralized. This point of exact neutralization, known as the endpoint, is noted by the change in color of the indicator.

We use the following equation:

$$N_A \times V_A = N_B \times V_B$$

where N = normality
V = volume

Solve the problems below.

1. A 25.0 mL sample of HCl was titrated to the endpoint with 15.0 mL of 2.0 N NaOH. What was the normality of the HCl? What was its molarity?

_____

_____

2. A 10.0 mL sample of H_2SO_4 was exactly neutralized by 13.5 mL of 1.0 M KOH. What is the molarity of the H_2SO_4? What is the normality?

_____

_____

3. How much 1.5 M NaOH is necessary to exactly neutralize 20.0 mL of 2.5 M H_3PO_4?

_____

4. How much of 0.5 M HNO_3 is necessary to titrate 25.0 mL of 0.05 M $Ca(OH)_2$ solution to the endpoint?

_____

5. What is the molarity of a NaOH solution if 15.0 mL is exactly neutralized by 7.5 mL of a 0.02 M $HC_2H_3O_2$ solution?

_____

HYDROLYSIS OF SALTS

Name _____

Salt solutions may be acidic, basic or neutral, depending on the original acid and base that formed the salt.

Strong Acid + Strong Base → Neutral Salt

Strong Acid + Weak Base → Acidic Salt

Weak Acid + Strong Base → Basic Salt

A weak acid and a weak base will produce any type of solution depending on the relative strengths of the acid and base involved.

Complete the table below for each of the following salts.

Salt	Parent Acid	Parent Base	Type of Solution
1. KCl			
2. NH_4NO_3			
3. Na_3PO_4			
4. $CaSO_4$			
5. $AlBr_3$			
6. CuI_2			
7. MgF_2			
8. $NaNO_3$			
9. $LiC_2H_3O_2$			
10. $ZnCl_2$			
11. $SrSO_4$			
12. $Ba_3(PO_4)_2$			