ELECTROLYTES AND NONELECTROLYTES

ELECTROLYTES	NONELECTROLYTES
Definition and properties:	Definition and properties:
Examples: a. Strong electrolyte: b. Weak electrolyte:	Examples:

ACIDS AND BASES

Operational Definitions	Operational Definitions
a.	
b.	
c.	
d.	
e.	
Conceptual Definitions	Conceptual Definitions
a. Arrhenius:	a. Arrhenius:
b. Bronsted-Lowry:	b. Bronsted Lowry:
c. Lewis:	c. Lewis:
Additional information:	Additional Information:

Name _____ Date _____ Class _____

CHAPTER 19 REVIEW ACTIVITY

Text Reference: Section 19-9

Acids and Bases

Choose words from the list to fill in the blanks in the paragraphs.

Word List

acid	neutralization
amphiprotic substance	nonelectrolyte
amphoteric substance	operational definition
base	proton acceptor
Brønsted–Lowry definition	proton donor
conceptual definition	salt
conjugate pair	strong conjugate acid
dissociation	strong conjugate base
hydrogen ion	strong electrolyte
hydronium ion	weak conjugate acid
hydroxide ion	weak conjugate base
ionization	weak electrolyte
ionization constant	

A substance whose water solution does not conduct an electric current is called a(n) __(1)__. A substance whose water solution is a poor conductor is a(n) __(2)__. One whose solution is a good conductor is a(n) __(3)__. The ability to conduct an electric current can result from __(4)__, the action of water on ionic solids to produce and disperse hydrated ions. The ability to conduct can also result from __(5)__, the formation of charged particles by means of the reaction between water molecules and molecular substances.

According to Arrhenius, a(n) __(6)__ is a substance that, when mixed with water, produces the positively charged __(7)__. This charged particle is hydrated by a water molecule, producing a(n) __(8)__. The equilibrium constant for the formation of charged particles by an acid is called the __(9)__ of the acid.

A(n) __(10)__ is based on directly observable properties or effects, whereas a(n) __(11)__ is based on the interpretation of observed facts. According to the __(12)__, an acid is a(n) __(13)__ and a base is a(n) __(14)__. A substance that can act as either is called a(n) __(15)__ or a(n) __(16)__.

An acid-base pair in which the acid and base are on opposite sides of an equation and are related by the transfer of a proton is called a(n) __(17)__. A strong acid has a(n) __(18)__, and a weak acid has a(n) __(19)__.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____

PROPERTIES OF ARRHENIUS ACIDS AND BASES

According to Arrhenius, an acid ionizes in water to give _____ or _____ while a base ionizes to give _____.

A. _A_c_i_d_s

1. Two common household acids, vinegar and _____ taste _____.

2. Acids turn the indicator litmus _____ and the indicator phenolphthalein _____.

3. Many metals such as _____ react with acids to produce _____ gas.

equation:

4. Neutralization: acids react with bases to form a _____ and _____.

equation:

5. Acids conduct electricity and are therefore _____.

6. The strength of an acid depends on the degree to which it _____ in water. The _____ reperesents this mathematically.

B. _B_a_s_e_s

1. Two bases commonly found in the home are _____ and _____.

2. Most bases feel _____ because they react with ____ _____ to form a __ ___.

3. Bases taste _____. (Don't try to test this!!!)

4. Bases turn the indicator litmus _____ and the indicator phenolphthalein _____.

5. Neutralization: bases react with acids to form a _____ and _____.

equation:

6. Bases conduct electricity and are therefore _____.

7. The strength of a base depends on the degree to which it _____ in water. The _____ represents this mathematically.

8. Bases _____ fats and oils.

Chem 3-5/

Bronsted Acid-Base Theory

In this theory, an acid is defined as a proton donor and a base is defined as a proton acceptor. H^+ IS A PROTON

When an acid donates a proton, it becomes a conjugate base.

When a base accepts a proton, it becomes a conjugate acid.

An acid and its conjugate base, and a base and its conjugate acid are referred to as a conjugate acid-base pair.

Thus, for the reaction: $NH_3 + HOH \longrightarrow NH_4^+ + OH^-$

$\left.\begin{array}{l} NH_3 \text{ and } NH_4^+ \\ H_2O \text{ and } OH^- \end{array}\right\}$ are the conjugate acid-base pairs

I. For the reaction: $HF + H_2O \longrightarrow H_3O^+ + F^-$

a) the conjugate base of HF is _____

b) the conjugate acid of H_2O is _____

c) the two conjugate acid-base pairs are _____ _____

II. For each reaction below:

(1) identify the acid, base, conjugate acid and conjugate base.
(2) list the two conjugate acid-base pairs

a) $H_2SO_4 + H_2O \longrightarrow H_3O^+ + HSO_4^-$

b) $H_2O + NH_2^- \longrightarrow NH_3 + OH^-$

c) $HCO_3^- + H_2O \longrightarrow H_2CO_3 + OH^-$

d) $NH_4^+ + CO_3^{-2} \longrightarrow NH_3 + HCO_3^-$

e) $H_2O + H_2O \longrightarrow H_3O^+ + OH^-$

f) $NH_3 + HCl \longrightarrow NH_4^+ + Cl^-$

g) $H_3O^+ + OH^- \longrightarrow 2H_2O$

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.

Example: $HCl + OH^- \rightarrow Cl^- + H_2O$ (H^+)

The HCl acts as an acid, the OH^- as a base. This reaction is reversible in that the H_2O can give back the proton to the Cl^-.

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

Example: $H_2O + Cl^- \leftrightarrow OH^- + HCl$ (H^+, H^+)

Acid Base Base Acid

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

ONJUGATE ACID-BASE PAIRS

Name _____

e exercise, Bronsted-Lowry Acids and Bases, it was shown that after an acid has given 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^-	
	$H_2PO_4^-$		
6.	H_2O		
7.		SO_4^{-2}	
8.	HPO_4^{-2}		
9.	NH_4^+		
10.		H_2O	

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

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

ROBLEMS--TITRATIONS NAME_____

. If 6 ml. of 1M HCl is exactly neutralized by 3 ml. of KOH. What is the molarity of the KOH?

2. A 30 ml. sample of HCl is completely neutralized by 10 ml. of a 1.5M NaOH solution. What is the molarity of the HCl solution?

ow many ml of 2.0M NaOH are needed to exactly neutralize 50 ml of 2.0M HCl?

4. How many liters of 2.5M HCl are required to exactly neutralize 1.5 liters of 5.0M NaOH?

5. A 2.0 ml sample of NaOH solution is exactly neutralized by 4.0 ml of a 3.0M HCl solution. What is the concentration of the NaOH solution?

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:

$$N_A \times V_A = N_B \times V_B \quad \text{where } N = \text{normality}$$

$$^*H\,M_A V_A = {}^*OH\,M_B V_B \quad V = \text{volume}$$

note: $^*H\,M_A = N_A$, $^*OH\,M_B = N_B$

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?

   _____

The Formation of Salts from Acids and Bases

strong base $NaOH$ + strong acid HCl → $NaCl$ — salt of a strong base and a strong acid

NEUTRAL

strong base $NaOH$ + weak acid $HC_2H_3O_2$ → $NaC_2H_3O_2$ — salt of a strong base and a weak acid

BASIC

weak base NH_3 + strong acid H_2SO_4 → $(NH_4)_2SO_4$ — salt of a weak base and a strong acid

ACIDIC

weak base NH_3 + weak acid $HC_2H_3O_2$ → $NH_4C_2H_3O_2$ — salt of a weak base and a weak acid

BASIC OR ACIDIC OR NEUTRAL

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. $CaSO_3$			
5. $AlBr_3$			
6. CuI_2			
7. MgF_2			
8. $NaNO_3$			
9. $LiC_2H_3O_2$			
10. $ZnCl_2$			
11. $SrSO_4$			
12. $Ba(PO_4)_2$			

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Activity 7-6
The pH Scale

The pH scale was developed to provide a convenient method of describing the concentration of hydrogen ions in aqueous solution, particularly dilute solution.

1. What is the mathematically stated definition of pH? _____

2. What values on the pH scale correspond to:
   a. The acid range? _____
   b. Neutrality? _____
   c. The basic range? _____

3. Complete the following table showing the pH value for each $[H_3O^+]$ given.

$[H_3O^+]$	pH	$[H_3O^+]$	pH
0.0010		1.0×10^{-7}	
0.0100		1.0×10^{-9}	
1.0×10^{-4}		1.0×10^{-13}	

Experiments show that in pure water

$$[H^+] = [OH^-] = 1.0 \times 10^{-7}$$

Experiments also show that for any aqueous solution at 25°C, the ion-product, K_w, is equal to a constant value:

$$K_w = [H^+] \times [OH^-] = 1.0 \times 10^{-14}$$

A description of alkaline properties, pOH, can then be defined as $-\log [OH^-]$. From the equations above, it can be seen that

$$pH + pOH = 14$$

Complete the following table by finding the missing values.

	pH	H_3O^+	pOH	OH^-
4.			2.0	
5.		1.0×10^{-3}		
6.				1.0×10^{-4}
7.	8.0			
8.	9.0			
9.			10.0	
10.				1.0×10^{-5}

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			

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Hydrogen and Hydroxide Ion Concentration

In an aqueous solution at 25°C, the product of $[H^+]$ and $[OH^-]$ equals 1.0×10^{-14}. This fact allows the calculation of the concentration of either of the ions, given the concentration of the other ion. The negative logarithm of $[H^+]$ is called pH. When $[H^+]$ is simply 1 multiplied by some power of 10, pH equals the absolute value of that power.

Solve each of the following problems and questions. Show your calculations or state the reasons for your answers.

1. a. What is the hydroxide ion concentration in pure water? 1a. _____

   b. What is the pH of pure water? b. _____

2. a. What is the concentration of hydrogen ion in a 0.1 *M* solution of NaOH? 2a. _____

   b. What is the pH of this solution? b. _____

3. a. What is the concentration of hydroxide ion in a 0.001 *M* solution of HCl? 3a. _____

   b. What is the pH of this solution? b. _____

4. a. What is the concentration of hydrogen ion in a solution whose pH = 5? 4a. _____

   b. What is the concentration of hydroxide ion in this solution? b. _____

   Is the solution acidic, basic, or neutral? Explain. c. _____

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CHAPTER 20 Text Reference: Section 20-7

Non-SI Supplementary Problems

In this chapter you have learned how to relate the concentration of the hydrogen ion, $H^+(aq)$, to the concentration of the hydroxide ion, $OH^-(aq)$, by using the expression:

$$K_w = [H^+][OH^-]$$

$$1.0 \times 10^{-14} = [H^+][OH^-]$$

The SI unit used to express the concentration of the hydrogen and hydroxide ions is mol/dm^3. It is not unusual to encounter problems in which the non-SI unit of concentration, (1 mol/L = 1 mol/dm^3). In this section you will practice using this unit to calculate both the concentrations of the ions and the pH of solutions.

Example:

What is the concentration of the hydroxide ion if the hydrogen ion concentration is 1.0×10^{-3}?

$$K_w = [H^+][OH^-]$$

$$1.0 \times 10^{-14} = [H^+][OH^-]$$

$$[OH^-] = \frac{1.0 \times 10^{-14}}{[H^+]}$$

$$= \frac{1.0 \times 10^{-14}}{1.0 \times 10^{-3}}$$

$$[OH^-] = 1.0 \times 10^{-11} \text{ mol/L}$$

Problems involving the pH of a solution are solved as explained in the chapter, except that the concentration of the hydrogen ion is expressed in mol/L.

Example:

What is the pH of a solution whose hydrogen ion concentration is 1.0×10^{-2} mol/L?

$$pH = -\log [H^+]$$

$$= -\log (1.0 \times 10^{-2})$$

$$= 2$$

Exercises

1. Calculate the hydroxide ion concentration in mol/L of solution that has a hydrogen ion concentration of 1×10^{-5} mol/L?

2. What is the concentration of the hydrogen ion in mol/L in a solution of KOH in which the hydroxide ion concentration is 0.0010 M?

3. a. What is the hydroxide ion concentration in mol/L of a solution if 0.080 grams of NaOH are dissolved in 2.0 liters of solution?
   b. What is the hydrogen ion concentration of this solution?

4. a. A solution is found to have equal concentrations of the hydrogen and hydroxide ions. What is the concentration of the hydrogen and hydroxide ions in this solution in mol/L?
   b. What is the pH of this solution?

5. a. What is the pH of a solution if the concentration of the hydrogen ion is 1.0×10^{-2} mol/L?
   b. What is the concentration of the hydroxide ion in mol/L in this solution?

6. What is the pH of a solution if the hydroxide ion concentration is 1.0×10^{-4}?

7. a. What is the concentration of the hydrogen ion in a solution that has a pH of 8?
   b. What is the hydroxide ion concentration of this solution?

8. a. What is the concentration of the hydrogen ion in mol/L in a solution that has a volume of 2.50 L and contains 5.33 grams of HCl?
   b. What is the pH of this solution?

9. a. What volume of NaOH solution would contain 4.00 grams of NaOH if the $[H^+]$ of the solution was 1.0×10^{-12}?

10. a. What is the concentration of the hydrogen ion in mol/L of a solution with a pH of 4.2?
    b. What is the hydroxide ion concentration of this solution?