Experiment 10 AQUEOUS SOLUTIONS

Chem 110 Lab

I. INTRODUCTION

A. SOLUTIONS OF ACIDS AND BASES

1. ACIDIC SOLUTIONS are characterized as solutions that: taste sour (The sour taste of lemons and other citrus fruits is due to the presence of citric acid); react with "active" metals, with carbonate salts, and with bases; and change the color of dyes called indicators.

   a. Strong and Weak Acids

      Strong Acids: HCl, HBr, HI, HNO_3, H_2SO_4, $HClO_4$ MEMORIZE

      Weak Acids: all those acids not listed as strong acids.

   b. Examples of reactions of acids with metals (in this case the metal is Zn):

      $Zn(s) + 2\ HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

      $Zn(s) + 2\ HC_2H_3O_2(aq) \rightarrow Zn(C_2H_3O_2)_2(aq) + H_2(g)$

   c. Example of reactions of acids with carbonates:

      $Na_2CO_3(s) + 2\ HCl(aq) \rightarrow 2\ NaCl(aq) + H_2O(l) + CO_2(g)$

      $Na_2CO_3(s) + 2\ HC_2H_3O_2(aq) \rightarrow 2\ NaC_2H_3O_2(aq) + H_2O(l) + CO_2(g)$

2. BASIC SOLUTIONS are characterized as solutions that: taste bitter, make skin feel slippery (soapy) on contact, react with acids, and change the colors of indicators.

   a. Strong Bases (soluble metal hydroxides): LiOH, NaOH, KOH, RbOH, CsOH, $Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$ MEMORIZE

   b. Weak Bases: NH_3 (NH_4OH) and other nitrogen-containing compounds.

3. A NEUTRAL SOLUTION is one that is neither basic nor acidic.

4. NEUTRALIZATION REACTION is the name of the characteristic reaction between acids and bases.

   Example of Neutralization Reaction:

   $HCl(aq) + NaOH(aq) \rightarrow \underset{\text{salt}}{NaCl(aq)} + \underset{\text{water}}{H_2O(l)}$

   When a neutralization reaction occurs there is no visible change in the reaction mixture to indicate that the reaction is complete, therefore an indicator (see below) is added to the mixture.

5. ACID-BASE INDICATORS: Acid-Base indicators are dyes that typically exhibit one color in acidic solutions and another color in basic solutions. Two examples of indicators are litmus and phenolphthalein.

B. SOLUTIONS OF ELECTROLYTES

1. An ELECTROLYTE is a compound whose aqueous solution conducts electricity. It is positively and negatively charged ions in the electrolytic solution that conduct electricity. Therefore, an electrolyte is a compound that 1) is soluble in water and 2) ionizes in water or dissociates into ions when it dissolves. The higher the ion concentration in the solution, the greater its conductivity.

2. STRONG ELECTROLYTES are compounds whose solutions conduct strongly because of high concentration of ions. Those compounds whose solutions usually conduct strongly are the STRONG ACIDS, STRONG BASES, and SOLUBLE SALTS.

3. WEAK ELECTROLYTES are compounds whose solutions conduct weakly because the concentration of ions is relatively low. Compounds whose solutions usually conduct weakly are the WEAK ACIDS and WEAK BASES.

4. NONELECTROLYTES are those compounds whose solutions do not conduct electricity.

II. EXPERIMENT

CAUTION

- Solutions of hydrochloric acid, HCl, and acetic acid, $HC_2H_3O_2$, can harm your eyes, skin, and clothing. Handle with care. Any acid solution spilled on your skin or splashed into your eyes should be rinsed immediately with a large volume of water.
- Solutions of sodium hydroxide, NaOH, and ammonia, NH_3, can harm your skin and your eyes. Any base solution spilled on your skin or splashed into your eyes should be rinsed immediately with a large volume of water.

A. Indicators

1. Take your labeled spot plate to the reagent bench and get samples of about 5 drops of each of the solutions in table 10.1 below. Get a vial of each of the indicator papers: red litmus paper, blue litmus paper and universal indicator paper.

2. First test the solutions using the indicator papers. Do not dip the papers into the solutions! Dip your stirring rod into the solution and then touch it to the paper. (You can use the same piece of indicator paper for more than one sample.) For the litmus papers, indicate the **color** to which the paper changes or, if there is no change of color, write the color that the paper remains. For example, if the solution changes red litmus to blue, write "blue" in the table. If the red litmus paper remains red, write "red" in the table. For the universal indicator paper, write the color the paper changes to, or if there is no change of color, write the color that the paper remains.

3. The phenolphthalein indicator is in a dropper bottle at your bench. Add one drop of the phenolphthalein to each of the solutions and record the color—your choices are "red" or "colorless"—of the mixture in table 10.1.

Table 10.1		INDICATOR COLOR			
Solution	Acidic (A) Basic (B) or Neutral (N)	LITMUS		UNIVERSAL	PHENOLPHTHALEIN
		Red Litmus	Blue Litmus		
1 M HCl					
1 M NaOH					
1 M $HC_2H_3O_2$					
1 M NH_3 (NH_4OH)					
1 M NaCl					

4. If you wanted to test a solution to determine if it was acidic, would you test it with red litmus paper or blue litmus paper?

_____

B. Properties of Acids and Bases

1. Reaction of Acids with an Active Metal, Zinc:

   Put about 5 drops of 1 M HCl solution in one well of your spot plate and 5 drops of 1 M $HC_2H_3O_2$ into another. Add a small small piece of "mossy zinc" into each.

   Observation: _____

   Reaction Equations (find on page 1):

   _____

   _____

   In which acid solution does the zinc react more vigorously?_____

   Dispose of the reaction mixture by first separating solid from liquid by filtration, then throwing the filter paper in the trash can and the liquid in the sink.

2. Reaction of Acids with Carbonates:

   Put about 1 mL of 1 M HCl solution in a labeled test tube and put about 1 mL of 1 M $HC_2H_3O_2$ into another labeled test tube. To each tube add a very small amount of Na_2CO_3.

   Observation: _____

   Reaction Equations (find on page 1):

   _____

   _____

   In which acid solution does the Na_2CO_3 react more vigorously? _____

   Dispose of the reaction mixture by first separating solid from liquid by filtration, then throwing the filter paper in the trash can and the liquid in the sink.

3. Neutralization Reaction—Reaction of Acid and Base:

   a. Add about 1 mL of 1 M HCl solution to a labeled test tube, measure the temperature of the solution, and record in Table 10.2 below.

   b. Add about 1½ mL of 1 M NaOH solution to a labeled test tube, measure the temperature of the solution, and record in Table 10.2 below.

   c. Add 1 drop of phenolphthalein indicator to the HCl solution. Write the color of the solution in Table 10.2. Then add the NaOH solution to the HCl solution and immediately measure the temperature of the mixture. Write the color of the reaction mixture in Table 10.2

Table 10.2	OBSERVATIONS	
	Temperature of Solution	Color of Solution + Phenolphthalein
HCl solution		
NaOH Solution		
Reaction Mixture		

Reaction Equation: _____

Is the reaction exothermic or endothermic? _____

Why was the indicator added to the acid solution? _____

_____

C. Electrolytes (Demonstration)

For each of the aqueous solutions listed in Table 10.3, first complete columns 1 and 2: in column 1 indicate whether the compound dissolved in water is ionic or molecular; in column 2 indicate whether the solute particles in a solution of that compound are ions or molecules. The conductivity of each solution will then be demonstrated. On the basis of the light intensity recorded in column 3, complete column 4, indicating whether the compound is a strong, weak, or nonelectrolyte.

Table 10.3	1	2	3	4
Sample	Solute: MOLECULAR **(M)** or IONIC **(I)** Compound	Solute Particles: IONS **(I)** or MOLECULES **(M)**	Light Intensity: **B**RIGHT **D**IM or **N**ONE	**S**trong **El**ectrolyte **W**eak **El**ectrolyte Or **N**onelectrolyte
Deionized water				
Tap water				
1 M HCl				
1 M $HC_2H_3O_2$				
1 M NaOH				
1 M NH_3				
1 M NaCl				
2% $C_{12}H_{22}O_{11}$				
2% C_2H_6O				
1 M $NH_4C_2H_3O_2$				

Report Experiment 10 AQEOUS SOLUTIONS
Chemistry 110 Lab

Name _____ Date _____
(last) (first)

Instructor's Initials_____

A. Indicators

Table 10.1

Solution	Acidic (A) Or Basic (B)	INDICATOR COLOR			
		LITMUS		UNIVERSAL	PHENOLPHTHALEIN
		Red Litmus	Blue Litmus		
1 M HCl					
1 M NaOH					
1 M $HC_2H_3O_2$					
1 M NH_3 (NH_4OH)					
1 M NaCl					

If you wanted to test a solution to determine if was acidic, would you test it with red litmus paper or blue litmus paper?

_____

B. Properties of Acids and Bases

1. Reaction of Acids with an Active Metal:

   OBSERVATIONS:

   Zn and HCl _____

   Zn and $HC_2H_3O_2$ _____

   In which acid solution does the zinc react more vigorously? _____

2. Reaction of Acids with Carbonates:

   OBSERVATIONS:

   Na_2CO_3 and HCl _____

   Na_2CO_3 and $HC_2H_3O_2$ _____

   In which acid solution does the Na_2CO_3 react more vigorously? _____

3. Neutralization Reaction—Reaction of Acid and Base:

Table 10.2	OBSERVATIONS	
	Temperature of Solution	Color of Solution + Phenolphthalein
HCl solution		
NaOH Solution		
Reaction Mixture		

Why was the indicator added to the solution? _____

_____

	Properties of Acids		Properties of Bases
1		1	
2		2	
3		3	
4		4	

C. Electrolytes

Table 10.3	1	2	3	4
Solution	MOLECULAR **(M)** or IONIC **(I)** Compound	Solute Particles: IONS **(I)** or MOLECULES **(M)**	Light Intensity: BRIGHT DIM or NONE	Strong Electrolyte Weak Electrolyte Or Nonelectrolyte
Deionized water				
Tap water				
1 M HCl				
1 M $HC_2H_3O_2$				
1 M NaOH				
1 M NH_3				
1 M NaCl				
2% $C_{12}H_{22}O_{11}$				
2% C_2H_6O				
1 M $NH_4C_2H_3O_2$				

D. Questions

1. Explain why Zinc and sodium carbonate reacted more vigorously in hydrochloric acid solution than in acetic acid solution.

_____

_____

_____

2. Explain how you would use litmus paper to show that a solution is neutral.

_____

_____

_____

C. CONCENTRATION PROBLEMS

1. The concentration of glucose (molar mass = 180.16) in the aqueous fluid of the spine is 75.0 mg/100g of water. What is the molal concentration of glucose in spinal fluid?

2. The federal limit for cadmium in drinking water is 0.010 mg per liter of solution. What is the molar concentration of a Cd solution that has reached the limit? (molar mass Cd = 112.41)

3. What volume of a .200 M solution of K_2SO_4 solution contains 85.6 g of K_2SO_4? (molar mass K_2SO_4 = 174.26)

4. How many grams of sodium hydroxide are needed to prepare 2.5 liters of a 6.0 M NaOH solution? (molar mass NaOH = 40.00)

5. A solution is prepared by dissolving 571.6 g of H_2SO_4 in enough water to make 1000.0 mL of solution. The solution has a density of 1.3294 g/mL. (molar mass of H_2SO_4 = 98.08)

   a. What is the molar concentration of the solution?

   b. What is the molal concentration of the solution?