pH CALCULATIONS
Experiment #3

Purpose:

1. To use universal indicator paper to determine the pH of several aqueous solutions
2. To calculate the $[H^+]$, pOH and $[OH^-]$ of different aqueous samples from measured pH values.
3. To master the pH scale and pH measurement
4. To distinguish between strong and weak acids and bases by pH measurements.
5. To determine the effect of concentration on the pH of strong and weak acids.

Procedure:

IN ORDER TO OBTAIN RELIABLE DATA IT IS IMPERATIVE THAT YOU <u>DO NOT</u> ACCIDENTALLY <u>SWITCH THE DROPPERS</u> OF THE REAGENT BOTTLES. SWITCHING THE DROPPERS WILL RUIN THE EXPERIMENT FOR YOU AND FOR THE ENTIRE CLASS, SINCE THE CONTENTS OF THE BOTTLES WILL BE CONTAMINATED.

PART I: pH OF ACIDIC SOLUTIONS

Prepare a clean piece of paper towel and four pieces of universal pH paper.

Using the dropper from the first reagent bottle (HCl, 0.1 M) moisten all four areas of the universal pH paper and carefully observe the colors of all four areas of the paper.

Compare the colors of the paper to the color chart provided.

Record the pH in your Laboratory Notebook.

Repeat this procedure for the other three aqueous acidic solutions and record the respective pH.

Avoid contaminating the droppers or the pH papers.

If you are not sure of your observations or if your observations indicate unexpected results, repeat the test and/or consult your instructor.

Before continuing your work at another station:

1. Complete both Data Tables
2. Plot a graph for: A)   the concentration of $[H^+]$ as a function of the Concentration of the Acid for the **STRONG ACID**.
Connect the three data points with a straight line. If the line is not straight (does not cross all data points), repeat your tests and/or consult your instructor.
Label this line **"STRONG ACID"**
(Write in the appropriate units on the vertical axis)
2. Plot a graph for: B)   the concentration of $[H^+]$ as a function of the Concentration of the Acid for the **WEAK ACID**.
Connect the three data points with a straight line. If the line not straight (does not cross all data points), repeat your tests and/or consult your instructor.
Label this line "**WEAK ACID**"
(Write in the appropriate units on the vertical axis)

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PART II: pH OF BASIC SOLUTIONS

Prepare a clean piece of paper towel and four pieces of universal pH paper.

Using the dropper from the first reagent bottle (NaOH, 0.1 M) moisten all four areas of the universal pH paper and carefully observe the colors of all four areas of the paper.

Compare the colors of the paper to the color chart provided.

Record the pH in your Laboratory Notebook.

Repeat this procedure for the other three aqueous basic solutions and record the respective pH.

Avoid contaminating the droppers or the pH papers.

If you are not sure of your observations or if your observations indicate unexpected results, repeat the test and/or consult your instructor.

Before continuing your work at another station:

1. Complete both Data Tables
2. Plot a graph for: A)   the concentration of $[H^+]$ as a function of the Concentration of the Acid for the **STRONG BASE**.
Connect the three data points with a straight line. If the line is not straight (does not cross all data points), repeat your tests and/or consult your instructor.
Label this line **"STRONG BASE"**
(Write in the appropriate units on the vertical axis)
2. Plot a graph for: B)   the concentration of $[H^+]$ as a function of the Concentration of the Acid for the **WEAK BASE**.
Connect the three data points with a straight line. If the line not straight (does not cross all data points), repeat your tests and/or consult your instructor.
Label this line "**WEAK BASE**"
(Write in the appropriate units on the vertical axis)
3. Complete the "SUMMARY OF ACIDIC AND BASIC SOLUTIONS" chart by filling in all the boxes with the respective formulas and concentrations.
4. If time permits you may answer some or all of the questions that follow this section in the laboratory. Otherwise, these questions may be answered at home.

PART III: IDENTIFICATION OF UNKNOWN

You and your partner will be assigned one unknown each. Record the number of your unknown on the instructor's sign- out sheet and in your Laboratory Notebook.

Your unknown has a molarity of 0.1 M.

Determine the pH of your unknown by using universal pH paper. Since your unknown is in a vial, you may dip the pH paper directly in the solution of the unknown. Make sure that all areas of the pH paper are moistened. If needed, a glass rod may be used.

Answer all the questions in this section, and identify the unknown.

Your unknown is a solution used in PART I or PART II of this experiment.

EXPERIMENT #3

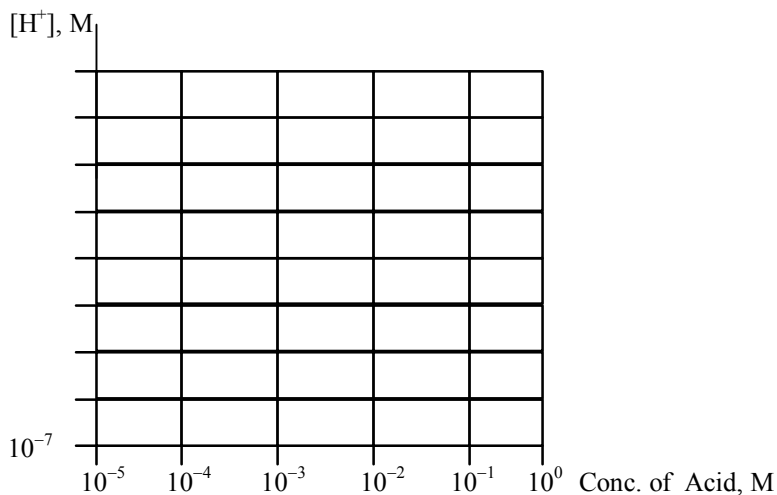## pH CALCULATIONS
REPORT FORM

NAME : _____

PARTNER: _____

PART I: SOLUTIONS OF ACIDS

Substance tested	Concentration in 1×10^{-n}, M	pH	$[H^+]$ 1×10^{-n}, M	pOH	$[OH^-]$ 1×10^{-n}, M	Strong Acid, or Weak Acid
HCl, 0.1 M						
HCl, 0.001 M						
HCl, 0.00001 M		5*				
$HC_2H_3O_2$, 0.1 M						
$HC_2H_3O_2$, 0.001 M						
$HC_2H_3O_2$, 0.00001 M		5*				

$[H^+]$ AS A FUNCTION OF ACID CONCENTRATION

Type of Acid	Concentration of Acid, M	$[H^+]$ 1×10^{-n}, M
	1×10^{-1}	
STRONG	1×10^{-3}	
	1×10^{-5}	
	1×10^{-1}	
WEAK	1×10^{-3}	
	1×10^{-5}	

$[H^+]$, M

10^{-7}

10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} Conc. of Acid, M

* These solutions are not available in the laboratory. The pH measurement provided is to be used along with the other data obtained by measurement.

EXPERIMENT #3

PART II: SOLUTIONS OF BASES

Substance tested	Concentration in 1×10^{-n} , M	pH	$[H^+]$ 1×10^{-n} , M	pOH	$[OH^-]$ 1×10^{-n} , M	Strong Base or Weak Base
NaOH, 0.1 M						
NaOH, 0.001 M						
NaOH, 0.00001 M		**9****				
NH$_4$OH, 0.1 M						
NH$_4$OH, 0.001 M						
NH$_4$OH, 0.00001 M		**9****				

$[H^+]$ AS A FUNCTION OF BASE CONCENTRATION

Type of Base	Concentration of Base, M	$[H^+]$ 1×10^{-n}, M
STRONG	1×10^{-1}	
	1×10^{-3}	
	1×10^{-5}	
WEAK	1×10^{-1}	
	1×10^{-2}	
	1×10^{-3}	

$[H^+]$, M

10^{-14}

10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} Conc. of Base, M

* These solutions are not available in the laboratory. The pH measurement provided is to be used along with the other data obtained by measurement.
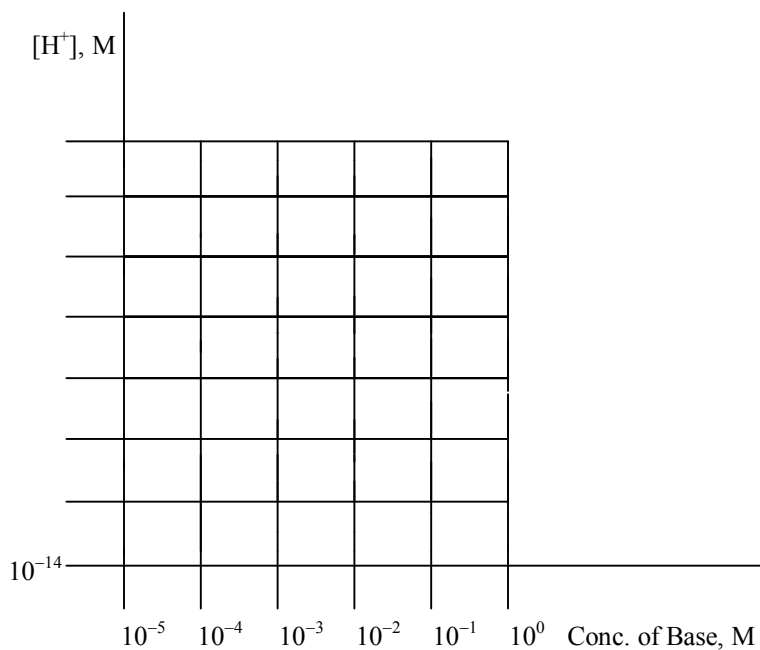
SUMMARY OF pH OF ACIDIC AND BASIC SOLUTION

$$\textbf{A} \quad \textbf{C} \quad \textbf{I} \quad \textbf{D} \quad \textbf{I} \quad \textbf{C} \quad \textbf{NEUTRAL} \quad \textbf{B} \quad \textbf{A} \quad \textbf{S} \quad \textbf{I} \quad \textbf{C}$$

pH ⟹   0 — 1 — 2 — 3 — 4 — 5 — 6 — 7 — 8 — 9 — 10 — 11 — 12 — 13 — 14

1.
Strong Acids and Bases
Formulas and Concentrations
(expressed as: 1×10^{-n})

2.
Weak Acids and Bases
Formulas and Concentrations
(expressed as: 1×10^{-n})
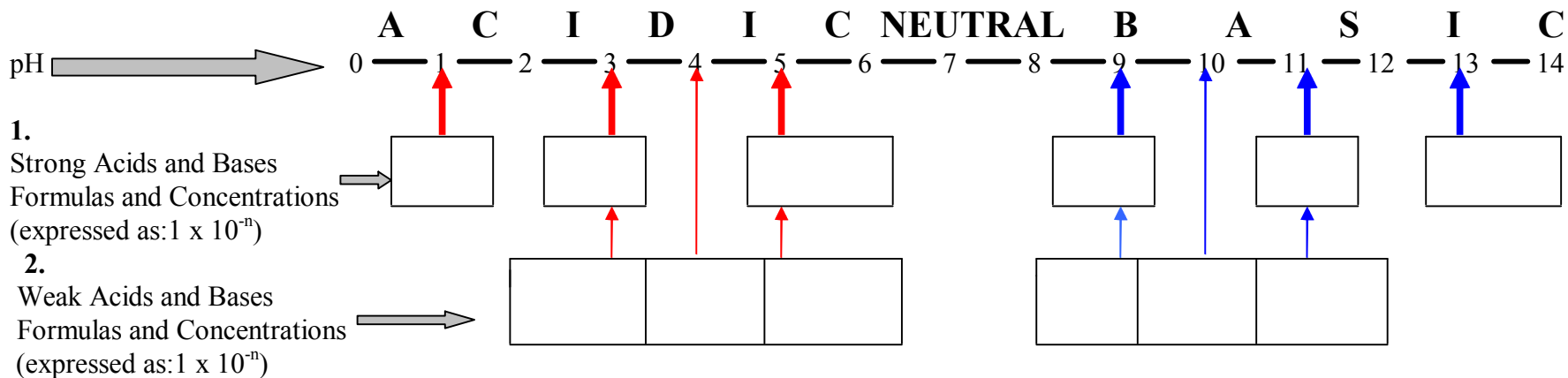
PART III: IDENTIFICATION OF UNKNOWN

Unknown Number: _____
Concentration: **0.1 M**

pH: _____   pOH: _____

$[H^+]$: _____ M $[OH^-]$: _____ M

ACID or BASE: _____

STRONG or WEAK: _____

FORMULA OF UNKNOWN: _____

Questions concerning the pH of acidic solutions.

A careful analysis of your graphs in Part I & Part II and the Summary on page 3 will assist you in answering the questions that follow:

For all aqueous solutions, the pH lies between _____ and _____
Infinitely dilute solutions (very low concentrations) will have the same pH as water, that is _____

1. For solutions of acids:
   A) The pH lies between: _____ and   _____ ,

      The corresponding [H⁺] ion concentration lies between: _____ and   _____

      B) The _____ the pH value, the _____ the solution.
               (lower or higher)   (more acidic or less acidic)

2. What is the relationship between the **concentration of strong acids** and the **[H⁺] ion concentration** of their solutions?

3. In general, what is the relationship between the **concentration of weak acids** and the **[H⁺] ion concentration** of their solutions?

4. In general, at a given molarity, solutions of _____ are
                                   (weak acids or strong acids)
   _____ than solutions of than solutions of _____
   (more acidic or less acidic)   (weak acids or strong acids)

   What is the reason for this difference in the behavior of strong acids versus weak acids?

5. How does the pH of a weak acid compare to the pH of a strong acid of the same molarity, if both acids are very dilute (very low concentrations)?

   _____

   What is the reason for this similarity in the behavior of strong acids versus weak acids in very dilute solutions (very low concentrations)?

Questions concerning the pH of basic solutions.

A careful analysis of your graphs in Part I & Part II and the Summary on page 3 will assist you in answering the questions that follow:

For all aqueous solutions, the pH lies between _____ and _____   Infinitely dilute solutions (very low concentrations) will have the same pH as water, that is _____

6. For solutions of bases:

   A) The pH lies between: _____ and   _____,

   The corresponding $[H^+]$ ion concentration lies between: _____ and   _____

   B) The _____ the pH value, the _____ the solution.
            (lower or higher)   (more basic or less basic)

7. What is the relationship between the **concentration of strong bases** and the **$[OH^-]$ ion concentration** of their solutions?

8. In general, what is the relationship between the **concentration of weak bases** and the **$[OH^-]$ ion concentration** of their solutions?

9. In general, at a given molarity, solutions of _____ are
                                         (weak bases or strong bases)
   _____ than solutions of than solutions of _____
     (more basic or less basic)   (weak bases or strong bases)

   What is the reason for this difference in the behavior of strong bases versus weak bases?

10. How does the pH of a weak base compare to the pH of a strong base of the same molarity, if both bases are very dilute (very low concentrations)?

   _____

   What is the reason for this similarity in the behavior of strong bases versus weak bases in very dilute solutions (very low concentrations)?