Experiment 9
pH of Solutions

OUTCOMES

After completing this experiment, the student should be able to:

- calibrate a pH probe for an acidic or basic solution.
- perform a serial dilution.
- calculate the expected pH of a strong or weak acid or base or of a salt.

DISCUSSION

The **pH scale** indicates how acidic or basic an aqueous solution is. The symbol "pH" is derived from the French for "hydrogen power." The pH of a solution is defined as the negative of the log of the concentration of H_3O^+ in the solution. Solutions with low pH values (less than 7) are considered acidic; solutions with high pH values (greater than 7) are considered basic. A solution with a pH of 7 is considered to be neutral. Because the pH scale is a logarithmic scale, a change of 1 pH unit corresponds to a 10-fold change in H_3O^+ concentration.

In this experiment, you will be making a variety of acidic and basic solutions via serial dilution and measuring their pH's using a pH probe. A **serial dilution** is the repeated dilution of a solution to achieve a range of concentrations. It is commonly performed in experiments requiring highly dilute solution with great accuracy and is used extensively in biochemistry, microbiology, and pharmacology. To perform a serial dilution, a small amount of a well-mixed stock solution is transferred into a new container and additional solvent is added to dilute the solution. This diluted sample is then used as the "stock" solution to make the next dilution. Doing this several times gives the range of concentrations, usually with a 10-fold decrease in concentration as each dilution is achieved.

To measure the pH of the solutions, you will be using a pH probe and the *LoggerPro* software. It will be necessary for the probe to calibrated each time you switch between acidic and basic solutions. Your instructor will demonstrate how to do this calibration. While measuring the pH of acidic solution, the pH probe should be calibrated in an acidic range (4 - 7). While measuring the pH of basic solutions, the pH probe should be calibrated in a basic range (7 - 10). Failure to calibrate the probe correctly may result in pH measurements which are off from the correct values.

PROCEDURE

⚠ ***Wear safety glasses or goggles at all times for this experiment.***
⚠ ***Avoid skin contact with the chemicals in this experiment.***
⚠ ***Never pipet by mouth.***

You are expected to work in pairs to make your pH measurements. However, you may combine some groups to speed the preparation of your solutions.

Procedure 1: Strong Acid and Base

1. Prepare 50.0 mL of the following solutions by serial dilution from the stock HCl solution: 0.10 *M* HCl, 0.010 *M* HCl, and 0.0010 *M* HCl.

2. Calibrate the pH probe for acidic solution and measure the pH of each HCl solution.

3. Prepare 50.0 mL of the following solutions by serial dilution from the stock NaOH solution: 0.10 *M* NaOH, 0.010 *M* NaOH, and 0.0010 *M* NaOH.

4. Calibrate the pH probe for basic solution and measure the pH of each NaOH solution.

Procedure 2: Weak Acid and Base

1. Prepare 50.0 mL of the following solutions by serial dilution from the stock $HC_2H_3O_2$ solution: 0.10 *M* $HC_2H_3O_2$, 0.010 *M* $HC_2H_3O_2$, and 0.0010 *M* $HC_2H_3O_2$.

2. Calibrate the pH probe for acidic solution and measure the pH of each $HC_2H_3O_2$ solution.

3. Prepare 50.0 mL of the following solutions by serial dilution from the stock NH_3 solution: 0.10 *M* NH_3, 0.010 *M* NH_3, and 0.0010 *M* NH_3.

4. Calibrate the pH probe for basic solution and measure the pH of each NH_3 solution.

Procedure 3: Acidic and Basic Salts

1. Prepare 50.0 mL of each of the following solutions from the corresponding stock solutions: 0.10 *M* $NaHCO_3$, 0.10 *M* $NaC_2H_3O_2$, and 0.10 *M* NH_4Cl.

2. Calibrate the pH probe for acidic solution and measure the pH of each solution. Some of the solutions will correspond to a basic pH. If this is the case, ignore the measurement obtained for the solution and continue on to step 3.

3. Calibrate the pH probe for basic solution and measure the pH of each solution that had a basic pH in step 2.

⚠ ***Dispose of all chemicals in the proper waste container.***

DATA ANALYSIS

1. Calculate the expected pH of *each* solution in procedures 1 - 3.

2. Prepare a table that shows the expected pH and actual pH of each solution in procedures 1 - 3.

3. Rank all of the **0.10 M solutions** used in the lab from lowest to highest pH. Compare this ranking to the actual rank that was expected using your textbook.

POSTLAB ACTIVITY

You will be turning in a worksheet for this experiment. It will be completed either individually or in pairs, according to your instructor's directions. The tables and calculations that you generated in the data analysis will be incorporated into the worksheet. If you used an *Excel* spreadsheet and entered formulas in the cells to calculate the expected pH of the solutions, you may embed the spreadsheet in the worksheet to show the calculations. If you did not use *Excel* formulas for the calculations, you will need to show a set of sample calculations for *one trial of each of the seven different substances* tested (HCl, NaOH, $HC_2H_3O_2$, NH_3, $NaHCO_3$, $NaC_2H_3O_2$, and NH_4Cl).

Follow your instructor's directions for submitting the worksheet. If you are submitting electronically, please use the following convention for naming your worksheet: *Lastname1 Lastname2 pH*. If you are emailing the worksheet, use a subject line of *Chem 1062: pH Lab*.