EXPERIMENT 8

pH of Acid, Base and Salt Solutions

PURPOSE:

To determine experimentally the pH of several acids, base and salt solutions with the aid of a pH meter and to compare the experimentally determined values with the theoretical, calculated pH values.

PRINCIPLES:

A pH meter and its electrodes form a sensitive electrochemical device that will allow an accurate, reproducible, and reliable measurement of the pH of a solution.
A pH meter is essentially a voltmeter that measures the voltage of an electric current flowing through a solution between two electrodes. There is a direct relationship between the voltage and the pH of a solution. As a result, the meter on the instrument is calibrated directly in pH units.
Two electrodes are required. One of them is called a glass electrode. This electrode is sensitive to the concentration of H^+ ions in the solution. The other electrode is called the reference electrode and its operation is independent of the composition of the solution.
The two electrodes are sometimes combined into a single entity called a combination electrode.
Although the operating rules for a pH meter will depend on the model and the manufacturer, there are several steps that must be followed with any pH meter:

1. The electrodes should always be kept in a solution except when you are transferring them from one solution to another. When you transfer them, you will want to avoid contaminating the solutions.
   During the transfer:
   (a) Rinse the electrodes with a stream of deionized water and catch the water in a beaker.
   (b) Remove the excess water from the electrode with tissue paper (Kimwipe) before you immerse the electrode in the next solution.
   (c) Do not touch the electrodes with your hands
   (d) Handle the electrodes with care since they are fragile
2. If there is a knob that adjusts the meter for different temperatures, it should be set to the temperature of the solution whose pH is to be measured. More often than not, this temperature is also the temperature of the laboratory.
3. The pH meter must be **calibrated** with a solution whose pH is known before you can measure an unknown pH with accuracy.
   These solutions of known pH are called **buffer solutions.**
4. Place your solution in the smallest container that is consistent with the experiment.
   If you are using a combination electrode, you can measure the pH of a few milliliters of a solution in a large test tube. If two electrodes, a 50 mL beaker may be used.
5. You should be able to read the pH of a solution about 10 seconds after the electrode(s) have been immersed. The reading should be steady and not suddenly changing.
   If sudden changes do occur, consult your laboratory instructor.
   Your laboratory instructor may issue additional operating rules of the pH meter.

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PROCEDURE:

I. Measure and record the pH of each of the following solutions.
Use a clean and carefully rinsed large test tube or a 50 mL beaker for each measurement

1.	Hydrochloric acid	$HCl(aq)$	0.010 M
2.	Acetic acid	$HC_2H_3O_2(aq)$	0.010 M
3.	Sodium hydroxide	$NaOH(aq)$	0.0010 M
4.	Aqueous ammonia	$NH_3(aq)$	0.010 M
5.	Sodium acetate	$NaC_2H_3O_2(aq)$	0.010 M
6.	Ammonium chloride	$NH_4Cl(aq)$	0.010 M

Use a clean and carefully rinsed large test tube or a 50 mL beaker for each measurement

II. Calculate and record the expected pH of each of these solutions by using appropriate equilibrium constants, where appropriate.

III. Compare your measured, experimentally determined pH values with those calculated. Calculate the Percent Error in each case and express it to the appropriate number of significant figures.
Recall:

$$\% \text{ Error} = \frac{\text{Experimental Value} - \text{Theoretical Value}}{\text{Theoretical Value}} \times 100$$

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REPORT FORM

Name: ________________________________

Note: 1. All measured pH values should be recorded to the nearest ± 0.01 pH unit.
2. Use $K_w = 1.00 \times 10^{-14}$

1. 0.010 M HCl

Measured Value: pH =

Calculated Value: pH =

% Error:

Show calculations below:

2. 0.010 M $HC_2H_3O_2$ ($K_a = 1.75 \times 10^{-5}$)

Measured Value: pH =

Calculated Value: pH =

% Error:

Show calculations below:

3. 0.0010 M NaOH

Measured Value: pH =

Calculated Value: pH =

% Error:

Show calculations below:

4. 0.010 M NH_3 (Kb = 1.77 x 10^{-5})

Measured Value: pH =

Calculated Value: pH =

% Error:

Show calculations below:

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5. 0.010 M $NaC_2H_3O_2$ (Ka of $HC_2H_3O_2$ = 1.75 x 10^{-5})

Measured Value: pH =

Calculated Value: pH =

% Error:

Show calculations below:

pH of Acid, Base and Salt Solutions

6. 0.010 M NH_4Cl (Kb of NH_3 = 1.77 x 10^{-5})

Measured Value: pH =

Calculated Value: pH = % Error:

Show calculations below: