Introduction to pH Meter Titrations of Acid – Base Reactions in Aqueous Solution

Objectives:
- Study a solution phase reaction via pH meter titration analysis
- Identify and understand the importance of the different segments of a pH titration curve in quantitative and qualitative terms.

BACKGROUND:
Addition of an Arrhenius base into an Arrhenius acid functions to neutralize the acid and produce a salt and weak electrolyte. That is:

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\text{BASE + ACID} \rightarrow \text{SALT + WEAK ELECTROLYTE}
\]

As the base is added to the acid solution, the acid concentration decreases with increasing amounts of base until the initial concentration of acid is completely converted (neutralized) to salt and (in this experiment) water. The change in concentration of the acid may be monitored using a pH-meter. As the base is added to the acid in incremental portions, the pH of the solution will change from acidic (pH < 7) to basic (pH > 7). The pH of the acid – base reaction can be measured directly using a pH meter. A plot of pH as a function of Volume of base added produces a reaction trend representing changes occurring in the chemistry of the solution. In this experiment, a computer generated plot known as a ‘Titration Curve’ will be generated and studied to understand both the qualitative and quantitative nature of a chemical reaction in a solution environment. A typical Titration Curve is as follows:

![Figure 1 - Strong Acid + Strong Base Titration Curve](image)
The equivalence point pH of a Strong Acid + Strong Base titration is always 7.0 with only salt ions remaining in solution. Below the equivalence point is the Limiting Reagent is the titrant being added from the burette into the acidic solution. Above the equivalent point no reactions are taking place and the pH values are due solely to excess titrant being added into the acidic solution. The equivalence point volume times the molarity of the titrant being added gives the moles of acid neutralized if the reaction ratio between acid and base is one to one. This is represented in the following equation:

$$\text{(Molarity} \times \text{Volume)}_{\text{Base Added}} = \text{(Molarity} \times \text{Volume)}_{\text{Acid Neutralized}} \quad \text{(Equation – 1)}$$

Knowing the Molarity of the Base and Volume of Base added along with the volume of acid solution used, the molar concentration of the acid solution can be determined.

EXPERIMENTAL
Your instructor will guide you through set-up of the Logger Pro – Vernier Lab ware and demonstrate its use. You will then follow the procedure given and generate an acid-base titration curve which is used to calculate the molar concentration of the acidic solution.

Set-up an acid – base titration with 0.05M NaOH added into the burette up to the 0.0 ml marker. If you are given a 0.10M NaOH solution, dilute 50:50, add 5 – 6 drops of bromothymol blue (BTB) indicator and then add into the burette. The solution should have a bright blue color. Add base solution up to the 0.00 ml marker of the burette with bottom of the meniscus of the liquid (i.e., the concaved shape) just touching the zero marker. The add 20-ml of 0.10-M HCl in a 100-ml Griffin beaker. Add to this solution 5 or 6 drops of bromothymol blue indicator ( BTB ) and a stir bar. The solution in the beaker should be bright yellow. Place beaker with acid solution on stir-plate centered below the burette. Insert the pH electrode into the beaker solution as instructed such that when the stir bar is turning it does not hit the electrode or the sides of the beaker. Adjust burette with the graduations in a position that is easy to view and determine volume values as the titration proceeds.

Using the titration equation (Eqn 1), assume the acid solution concentration is 0.10M and determine the theoretical amount of base solution needed to neutralize the 20 ml sample of acid solution. This gives an estimation of the equivalence point volume and where the base addition should be slowed to small quantities. This is very important in order to obtain several points in the titration curve's inflection region.

Get instructor to check your set-up and, if approved begin the titration.

To begin titration, first click the green box at the top of the data graph window of the Logger Pro program. The box will turn red indicating that the titration is in progress. Then to the right of the now red box, click on the ‘Keep’ icon and type ‘zero’ (number) and enter. The data dot on the graph will move to the y-axis just above the 0.0 ml mark on the horizontal axis. This is the pH of the acid solution. Then add 5 ml of base into the acid solution, click ‘Keep’ and record volume. Continue until you are 2 or 3 milliliters
from the equivalence point volume and slow base addition to 1 ml increments. As the data dot begins to approach the equivalence point volume, it will increase pH very rapidly. Decrease base volume to fractional additions to generate as many points in the inflection region as possible. After the pH changes begin to slow, increase base volume increments until the data dot is approximately at pH = 13. Stop additions of base and terminate the titration by clicking on the red box. It will then turn to green.

Your instructor will show you how to annotate (label) the graph and determine the equivalence point volume. Record the $V_{eq}$ and calculate the experimental concentration value of the acid using the titration equation. After calculation, record the value obtained on the class results table that will be drawn on the chalk board at the front of the lab. After all data values are in, your instructor will guide you through use of Microsoft Excel to determine average, standard deviation and confidence interval of all experimental results. The average, standard deviation and confidence interval will be reported in the conclusion section.

CONCLUSION ANALYSIS

Summarize the experimental work by briefly stating the class results. Your instructor will show you where to find the grammatical format for the experimental conclusions. If a discussion is required, this will also be in the grammatical format section.

- Your lab instructor will have a handout that will guide you through organization and protocol for keeping a laboratory notebook and experimental observations. All experimental write-ups are to be entered into a standard laboratory notebook for submission for grading.