**Acid Base Titration Lab**

**Introduction:**

*Titration* is a method of volumetric analysis—the use of volume measurements to analyze an unknown. In acid-base chemistry, titration is most often used to analyze the amount of acid or base in a sample or solution. A substance in a solution of known concentration (the **titrant**, usually in a buret) is reacted with another substance in a solution of unknown concentration (the **analyte**). The goal of titration is to use the stoichiometric ratio between the titrant and analyte to determine the unknown concentration of the analyte.

*Indicators* are usually added to acid-base titrations to detect the equivalence point. The *endpoint* of the titration is the point at which the indicator changes color and signals that the equivalence point has indeed been reached. For the titration of a strong acid with a strong base (or vice versa), the pH of the solution would be acidic (< 7) before the equivalence point and basic (> 7) after the equivalence point. The pH at the equivalence point should be exactly 7, corresponding to the neutral products. An indicator that changes color around pH 7 is therefore a suitable indicator for the titration of a strong acid with a strong base.

**Experimental Method:**

We will be performing a titration using a strong base, NaOH, to determine the concentration of an unknown solution of HCl. During the first stages of the titration, the NaOH will be completely neutralized, and an excess of acid will remain. However, at the theoretical endpoint, the acid and the base will have neutralized one another exactly, and the phenolphthalein indicator will turn pink when the acid is completely neutralized and a slight excess of base is present. **In this titration, a successful endpoint is achieved if one drop of base turns the solution in the flask from colorless to a very faint pink**, and at this point, the number of moles of NaOH used will be equal to the number of moles of HCl in the unknown solution.

The progress of an acid-base titration can also be followed by measuring the pH of the solution being analyzed as a function of the volume of titrant added. A plot of the resulting data is called a pH curve or titration curve. Titration curves allow a precise determination of the equivalence point of the titration without the use of an indicator. In this experiment, the pH of the titration solution will be monitored using a pH meter; the obtained titration plot will then be used to confirm the equivalence point that was determined with an indicator.

**Materials:**

*Chemicals*

indicator solution, 1.0%, 1 mL

Sodium hydroxide solution, NaOH, 0.100 M

Hydrochloric acid solution, HCl, *unknown concentration*

*Equipment*

pH probe

Wash Bottle

Beaker (250 mL), Buret (50 mL)

Data Collection Device

**Procedure:**

***IT IS IMPORTANT THAT YOU ARE CAREFUL WITH THE TIP OF THE pH PROBE! THEY EASILY BREAK!!*** Carefully unscrew the container of storage solution at the tip of the pH probe and set the container in a safe place where it will not tip over. When you are not using the pH probe, gently rest it in a beaker of tap water.

 **Be sure to rinse the pH probe with distilled water EACH TIME before using!**

**Part 1: Prepare for Data Collection**

**Part 2: Determination of the Concentration of HCl**



1. Your buret has been pre-filled with 0.100 M NaOH solution. If needed, open the buret stopcock to allow any air bubbles to escape from the tip. Close the stopcock when the liquid level is between the 0 and 10 mL marks.
2. Measure the precise volume in the buret and record this value in the appropriate Data Table as “initial volume.” Note: volumes are read from the top down in a buret. Always read from the bottom of the meniscus remembering to include the appropriate number of significant figures. 
3. Carefully measure 50 mL of the unknown concentration HCl solution and add it a 250 mL beaker. **Add three drops of indicator to the solution in the beaker.**
4. Use a utility clamp position the pH sensor on a ring stand as shown. Clamp the pH electrode so it is submerged in the acid solution (see figure to the right).
5. When the pH reading has stabilized, record the initial pH of your unknown acid solution in the appropriate Data Table.
6. Begin the titration by adding 3 mL of the NaOH solution to the beaker. Record the ***exact volume added to the hundredths place*** in the appropriate Data Table. When the pH reading has stabilized, record the pH value.
7. Continue adding NaOH in 3 mL increments. Be sure to swirl the solution thoroughly and record the pH value and the exact volume of NaOH added after EACH addition.
8. When the pH begins to increase by more than 0.3 pH units after 3 mL of NaOH is added, decrease the amount of NaOH added to about 0.5 mL. Continue adding NaOH in about 0.5 mL increments. Be sure to swirl the solution thoroughly and record the pH value and the exact volume of NaOH added after EACH addition.
9. When the indicator shows you have almost reached equivalence point, add NaOH drop by drop.
10. Record the exact volume of NaOH added at equivalence point. **The pink color should remain for at least 15 seconds at the equivalence point.**
11. After the equivalence point, add NaOH in increments of 0.5 mL until the pH change is again about 0.3 pH units, resume adding the NaOH in 3 mL increments. Be sure to stir the solution thoroughly and record the exact volume of NaOH added after EACH addition.
12. Stop titrating when adding NaOH causes your pH to increase by 0.1 pH units or less.
13. Dispose of the solution in your beaker into the “Waste” container provided by your teacher.

**Data:** You only need to include Data Table 2 in your lab report. *However*, you will need to include your graph for the data in Data Table 1!

**Data Table 1:** Determination of the Concentration of HCl

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Volume NaOH Added(mL) | pH | Volume NaOH Added Continued(mL) | pH | Volume NaOH Added Continued(mL) | pH |
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**Data Table 2:** Volume of Titrant Added at Equivalence Point

|  |  |  |
| --- | --- | --- |
| Volume NaOH Added at Equivalence Point(mL) | pH | indicator color |
|  |  |  |

**Graphical Analysis:** Use graph paper to graph your data (or, if you prefer, use Excel or a similar program).

* For Data Table 1, place pH on the vertical axis and volume of NaOH added on the horizontal axis. (Be sure to include a title and correctly labeled axes!)

**Insert a graph of both titration curves into your final lab report in the Data section.**

**Calculations:** (You will need to complete analysis question #1 first!)

For the titration of unknown HCl (data table 1), calculate:

1. The moles of NaOH used to reach equivalence point.
2. The moles of HCl present in your initial solution.
3. The concentration of HCl, [HCl], in your initial solution.
4. The pH of your initial 0.100 M NaOH solution.
5. What is the accepted (true) value of [HCl]? (ask your teacher) \_\_\_\_\_\_\_\_\_ Calculate your percent error!

$$\left[\frac{accepted value-experimental value}{accepted value}\right]x100=Percent Error$$

**Analysis:**

1. Write the balanced reaction for the neutralization reaction performed in this lab (including states of matter).
2. Write the **net ionic** reaction for the neutralization reaction performed in this lab (including states of matter).
3. Would the addition of several milliliters of distilled water to the **beaker** during the titration affect the results of the titration? Explain your answer.
4. Would the addition of several milliliters of distilled water to the **buret** during the titration affect the results of the titration? Explain your answer.
5. Suppose you instead titrated an ***unknown*** concentration of NaOH in your beaker with a ***known*** concentration of HCl in your buret.
	1. Identify at least **two** things about your data that would be different from the data you collected in lab, and explain why they would be different.
	2. Identify at least **one** thing about your data that would be the same as the data you collected in lab, and explain why it would be the same.

**Error Analysis: STATE YOUR CALCULATED PERCENT ERROR.** Describe the errors that may have occurred during your titrations. Identify **at least 2** specific and likely sources of error, and explain the probable effect of these errors on your data and final results.

**\*Note about over- and under-titrating:** if you believe that your group over-titrated (added too much from the buret) or under-titrated (added too little much from the buret), GIVE EVIDENCE to support your conclusion. Hint: what happened to the color of your indicator?

* 1. Lab Error #1
		1. What was the lab error? Describe its effect on your **data**.
		2. What affect did the lab error have on your calculations and final results? **Be specific.**
	2. Lab Error #2
		1. What was the lab error? Describe its effect on your **data**.
		2. What affect did the lab error have on your calculations and final results? **Be specific.**

**Pre-AP Formal Lab Report Requirements**

**Title of Lab**

**Date** (lab was performed)

**Your name, Lab partner(s) name(s)**

**Objectives** :  ***In your own words,*** describe the purpose of the lab. DO NOT SIMPLY COPY THE OBJECTIVES FROM THE BOOKLET.

*“The purpose of this lab was to…*

*The necessary materials were \_\_\_\_\_ which was used to \_\_\_\_\_, \_\_\_\_\_ which was used to \_\_\_\_\_, …”*

**Data/Graph:** Only data table 2 needs to be included, but you **must** include your titration curve.

**Calculations** : You do not need to show your work, just your answers. Answers should have units and should be clearly labeled so that it is clear what each calculation represents.

**Analysis / Error Analysis:**

Answer all analysis and error analysis questions from the lab procedure: **these should be two separate sections**. Number each question so they are easy to locate and **DO NOT copy the question** into your lab report before answering it! (The system will flag you for “copying” someone else’s work.)

**Conclusion:** This section is the most important part of your lab report, and should include ALL of the following:

* Thesis statement: intro to your paragraph that reminds the reader about the goal of the lab. (Hint: if you’re stuck, you can choose to summarize your objectives here. Do not just copy them down again.)

*The purpose of this lab was to…*

* Brief recap of lab procedure and data collection method. (DO NOT explain how to math. Just explain lab procedures.) NOT step-by-step: summarize in 2-4 sentences.

*This was accomplished by…*

* Explanation of your results. (Be specific: include data! But not all data. Summarize the highlights.) **Be sure to identify if you achieved the objectives you outlined in section 1.**

*We found that…*

* Identify how your results compare to the accepted value (**cite your calculated percent error**).

*The concentration of HCl was…*

*The experimental concentration of HCl was…*

*This led to a percent error of…*

* Reflection: identify what you learned from this lab, and how it connects to current Pre-AP chemistry content. How was the content you learned in this unit essential for understanding the lab?

*In order to complete this report, it was necessary to understand that…*

Concluding statement: wrap up your conclusion! This is **different** from your reflection. Tell me the most important points of the lab.

**References:**  If you’ve used any outside sources, create a reference list here. Follow formatting from your English class.

**Grading Hints:**

* Include the full heading (as shown at the top).
* Label all sections (objectives, analysis, etc).
* Write the **objectives** and **conclusions** sections in complete sentences.
* Use paragraphs (aka more than one) for the **conclusion** section.
* Do not capitalize chemicals names – they are NOT proper nouns (i.e. write “copper” not “Copper”).
* Use subscripts and superscripts when needed (i.e. write “Cr2O72-“ not “Cr2O7 2-“)
* Do not double-space: 1.5 or 1.15 spacing!

**Warning about Plagiarizing**:Just because you worked in the same lab group as someone else does NOT mean you are allowed to have identical (or similarly-worded) sections of your lab report. The ONLY sections that are allowed to be the same across a lab group are data/calculations tables. **YOU WILL RECEIVE A ZERO FOR YOUR LAB REPORT IF YOUR REPORT COMES UP AS A SUSPICIOUSLY HIGH MATCH WITH ANOTHER STUDENT (even if you completed the lab first).** Any work that is truly your own will show up as statistically different from all other students, and turnitin.com will show that!