Name ________________________________

Date ______________ Pd ___

Chemistry – Unit 11 – Acid-Base Titration Lab

A study of acid/base neutralization

INTRODUCTION

A titration is a laboratory process used to determine the volume of a solution needed to react with a given amount of another substance. In this procedure, a solution of known concentration, called the **standard solution (or titrant)**, is used to react with a precisely measured volume of the solution of unknown concentration, **the analyte**. In this experiment, you will titrate hydrochloric acid solution (HCl) with a basic sodium hydroxide solution (NaOH). In this lab, your team will prepare an NaOH solution that you can calculate the concentration of (standard solution). Then your team will be asked to determine the concentration (molarity) of acid in your unknown sample. In doing so, you will become familiar with the lab techniques of solution preparation, pipette and burette use, and titration.

When performing an acid-base titration, you must be able to recognize when to stop adding the standard solution, that is, when the reaction is complete. A few drops of an appropriate acid-base indicator are added to the unknown solution. A sudden change in color of the indicator signals that complete reaction has occurred. At this point, the indicator changes color due to the changing acid/base conditions in the beaker. The point at which this occurs is called the **endpoint** of the titration. When the endpoint is reached, the volume of the standard solution used is carefully measured. Then the measured volumes of the two solutions and the known concentration of the standard solution can be used to calculate the concentration of the unknown solution.

When an HCl solution is titrated with an NaOH solution, measuring the pH of the acidic solution can allow us to understand what is happening in the reaction. A secondary goal of this investigation is to plot and describe the relationship between the volume of NaOH solution added and the pH of the resulting solution.

For the first part of this experiment, you will be determining the molarity of an HCl solution by titration with NaOH, using phenolphthalein as the indicator. In the second part of the experiment, you will use a pH electrode to monitor pH as you titrate. Results from parts 1 and 2 of this experiment should yield data for the equivalence point or endpoint. Using this data and your knowledge of reactions and stoichiometry, you should be able to achieve the following goals:

GOALS

As you complete this investigation you will:

1. Prepare a standard NaOH(aq) solution.
2. Titrate a strong acid with a strong base to its endpoint, using an indicator.
3. Titrate a strong acid with a strong base to its equivalence point, using a pH electrode.
4. Graphically determine the relationship between pH and NaOH(aq) added to the unkown acid.
5. Determine the molarity of the unknown solution of a strong acid.
6. Report your results in the usual scientific manner.

MATERIALS

NaOH	50-mL buret	250-mL beakers (2)
HCl solution (unknown concentrations)	ring stand	500-mL volumetric flask
phenolphthalein	buret clamp	stirring rod
distilled water	utility clamp	LabQuest system
balance	10-mL pipet	Vernier pH probe
weighing boat	pipet bulb	

PROCEDURE (Remember to record ALL RELEVANT data)

A. PREPARATION OF THE STANDARD SOLUTION (0.100 M NaOH)

1. Calculate the mass of NaOH necessary to make 500 mL of a 0.100 M NaOH solution.
2. Use the balance to obtain ___________ g of NaOH
3. Add the NaOH to a 500-mL volumetric flask
4. Add distilled water to fill about ¾ of the flask
5. Swirl the mixture gently until all of the NaOH has dissolved
6. Add water to the 500 mL line (**DO NOT** go past the line!)
   - Add water with a beaker until just before the line
   - Continue adding water with a pipet until it reaches the line
7. Cover the top with Parafilm or a stopper and mix
   - Place your hand on top of the Parafilm
   - Slowly and carefully tip up and down over a sink
8. Transfer the standard solution to a storage container with the solution name and your group number and class period clearly labeled.

ANALYSIS FOR PART A: (Left Side work)

1. Using your measurements, determine the *precise* molarity of your NaOH solution.

B. TITRATION OF THE UNKNOWN ACID USING PHENOLPHTHALEIN INDICATOR

1. Clamp the buret to a ring stand and place a "waste" beaker under it
2. Run water through the buret and completely empty it
3. Add about 5 mL of the 0.1 M NaOH to the buret and pour this into the waste beaker. Rinsing with the titrant prevents further dilution when you fill the buret.
4. Now add the 0.1 M NaOH solution to the buret and fill, slightly above the 0.0 line
5. Release some of the NaOH into the waste beaker until the amount in the buret is reading **EXACTLY** 50.0 mL (meniscus on 0.0)
6. With a **pipet**, measure exactly 10.0 mL of the HCl solution into a clean **dry** beaker
7. Add 2-3 drops of phenolphthalein
8. Slowly add 0.1 M NaOH solution while swirling the acid mixture until it changes from a colorless solution to a magenta color that remains for about 30 seconds. When it gets close, you should add the solution drop by drop.
9. Note and record the exact final volume reading on the buret. (Remember to estimate between the lines)
10. **Use the data and proceed to "Titration analysis for Part B"**
11. Repeat this method of titration three more times, **WHILE** doing the titration with the LabQuest.
12. If the three volumes are close to each other (precise), determine the average

TITRATION ANALYSIS FOR PART B: (Left Side work)

1. The end of the titration in Part B was signaled by the color change of an indicator. This is referred to as the "endpoint" of the titration.
2. Using the volume of NaOH required to reach the endpoint, determine the number of moles of NaOH required to reach the endpoint of the titration.
3. Using your model of chemical reactions and *stoichiometry*, determine how many moles of HCl were in the original acid sample.
4. Calculate the molarity of the unknown HCl solution you tested.

C. TITRATION OF THE UNKNOWN ACID USING THE LabQuest

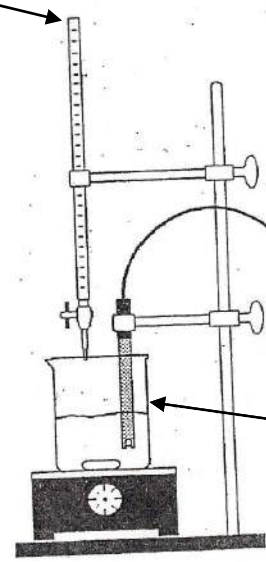

Figure 1

1. Prepare the buret as in steps 1-4 in previous procedure.
2. Measure exactly 10.0 mL of HCl solution into a clean dry beaker with a pipet
3. Add 2-3 drops of phenolphthalein
4. Prepare the pH system for data collection
   - Plug the pH probe into Channel 1 of the LabQuest system.
   - Plug the LabQuest into the electrical outlet and turn the LabQuest on.
   - The LabQuest should recognize the pH probe and display a reading.
     If not, get help from the instructor.
5. Set up the LabQuest for data collection
   - From the Sensor Menu, tap the "Mode" box with the stylus
     (or Select DATA COLLECTION from the "Sensors" menu)
   - Tap on the "Mode" box to bring up the drop down menu.
   - Choose mode "Events with Entry"; leave "Number of Columns" as 1.
   - For "Name" type **Volume 0.1 M NaOH**; for units, type **mL**. Click on OK.

   Call over the instructor if you have any questions!
6. The pH values will show in the red box if in the Sensor window or in the top right if in the Graph window. Remove the pH probe from its storage bottle and rinse it with distilled water into the waste beaker. Using the pH probe, check the pH of either the buffers pH 4, pH 7, or pH 10. If they are close (within +/- 0.8) to the correct pH value of the buffer, proceed to the next step. If they are not close, see your teacher for calibration instructions. Rinse the probe with distilled water into the waste beaker.
7. Use a utility clamp to suspend the pH probe on the ring stand as shown in Figure 1.
8. Place your beaker containing HCl **and phenolphthalein** under the buret and immerse the pH probe as in Figure 1. The bottom of the probe must be in the solution, but it should not be touching the bottom of the beaker.
9. Before adding NaOH titrant, take a reading of just the HCl solution. Tap the green triangle "Play" button to start data collection. Monitor the pH value on the screen. Once the pH has stabilized, tap the blue "KEEP" button at the bottom left of the screen. Enter "0" for the volume (the buret volume, in mL). You have now saved the first data points for this experiment.
10. You are now ready to begin the titration. This process goes faster if one person manipulates and reads the buret while another person operates the computer and enters volumes.
    - Add the next increment of NaOH titrant (enough to raise the pH about 0.15 units). Gently swirl the mixture in the beaker to stir the contents. When the pH stabilizes, press "KEEP"

and enter the current buret reading. It is vital that you read the buret precisely, estimating between lines.

- Continue adding NaOH solution in increments and entering the buret readings for each. When you are about a milliliter away from your endpoint determined in Part B, change to a one or two drop increment. Enter a new buret reading (in mL) after each increment.
- Be sure to record the *endpoint* of the titration when the phenolphthalein indicator changes color. This may or may not be the same as the equivalence point you will determine later, but will be helpful for comparison.
- After a pH value of approximately 10 is reached, again add larger increments that raise the pH by about 0.15 pH units, entering the buret reading after each increment.
- Continue adding NaOH solution until the pH value remains relatively constant (the graph levels out)

11. Tap the red, square STOP button when you have finished collecting data. If you have a thumb/flash drive, you may save this file. The graph and data table may later be transferred into your laboratory report. (Tables and Graphs may be copied and pasted into Microsoft Word for later manipulation.) If not, be sure you have your data copied into your lab notebook.
12. Repeat this procedure for a total of three trials.
13. Dispose of the beaker contents in the waste beaker. Rinse the pH electrode with distilled water and return it to the storage solution container. Rinse the buret several times with water, a final rinse with distilled water, then clamp it upside down with the valve open

TITRATION ANALYSIS FOR PART C: (Left side work)

1. Print and tape in or draw a sketch of your graph in your notebook. (You will need a computer generated graph for your report). Divide the graph into regions.
2. Write the balanced chemical equation for the reaction occurring in the titration.
3. Describe what has happened or what is present in the beaker during each region (think *chemistry*: "what is in the solution?"):
    a. Consider the point in the graph when only a few mL of NaOH titrant have been added. Considering that a base has been added, why is the pH of the solution still so low? What chemical species are present in the solution at this point?
    b. Consider the point towards the end of the graph when the pH begins to level off. Why is the pH of the solution so high at this point? What chemical species are present in the solution at this point? Do you think the curve will ever stop rising? If not, why? If so, at what point or pH?
    c. Now consider what happens during the middle section of your graph.. What is happening in this region? Which specific part of this region is of greatest significance? What chemical species are in the solution at this point?
4. Examine the data points along the displayed graph of pH vs NaOH volume. The midpoint of this region is usually referred to as the "equivalence point." To determine the equivalence point, go to the region of the graph with the large increase in pH. You can use the stylus pen to tap the data points in this region and see their coordinates. Estimate the equivalence point of the titration and describe how you came up with this estimate (the equivalence point should <u>NOT</u> be one of your data points).
5. How does the equivalence point determined in this way compare to the endpoint in Part B? Why might the "endpoint" of the titration not be the exact same as the "equivalence point"?
6. Determine the volume of NaOH and then the moles of NaOH needed to reach the equivalence point.
7. Using your model of chemical reactions and *stoichiometry*, determine how many moles of HCl were in the original acid sample.
8. Calculate the molarity of the unknown HCl solution.