EXPERIMENT 21

Titration of Acids and Bases—II

Performance Goals

21–1 Determine the concentration of an acid by titrating a known volume with a standardized base.

CHEMICAL OVERVIEW

In this experiment you will use the standardized NaOH from Experiment 20 to determine the molar concentration of either hydrochloric acid (Option 1) or vinegar (Option 2), the latter being an acetic acid solution. The reactions for the two options are:

$$HCl(aq) + NaOH(aq) \rightarrow H_2O(\ell) + NaCl(aq) \qquad \text{(Option 1)} \qquad (21.1)$$

$$HC_2H_3O_2(aq) + NaOH(aq) \rightarrow H_2O(\ell) + NaC_2H_3O_2(aq) \qquad \text{(Option 2)} \qquad (21.2)$$

You will titrate a carefully measured volume of the acid with the NaOH solution. The product of the volume of NaOH times its molarity is the number of moles of base in the reaction. This is converted to moles of acid from the stoichiometry of the reaction. The number of moles of acid divided by the volume containing that number of moles (the volume of the acid sample) yields the molarity of the acid. These ideas were presented more fully in the general overview to Experiments 20 and 21.

To be acceptable, your reported molarity for the unknown must be within 0.015 of the molarity determined previously. Your results must also show good precision, that is, good reproducibility. In this experiment all sample sizes are the same. Therefore, all titration volumes should be alike. The requirement for precision will be satisfied if you have duplicate titrations within 0.2 mL (about 6 drops) of each other.

If your results are unsatisfactory from the standpoint of either precision or accuracy, your instructor may ask you to make repeat runs until acceptable results are reached. If precision is good but accuracy is bad, it is quite likely that the error lies in your results from Experiment 20. In this case your standardization runs against oxalic acid as a primary standard must be repeated. Keep all titration results, because they are helpful in locating errors if they do appear.

SAFETY PRECAUTIONS AND DISPOSAL METHODS

The same safety precautions identified for Experiment 20 apply to Experiment 21—plus one more. In taking your samples of unknown acid, you will use a volumetric pipet. *Always* use a pipet bulb to draw liquid chemicals into a pipet; never use mouth suction.

After you have finished your titrations and checked your results with the instructor, the dilute NaOH can be poured down the drain and rinsed with plenty of cold water or use the disposal method specified by your instructor.

PROCEDURE

NOTE: Record all volume measurements in milliliters to the nearest 0.1 mL.

A. Clean and prepare your buret for use as in Experiment 20, Step 3A. Be sure to shake the NaOH solution before you start using it, especially if the solution was stored for a period of time. This will ensure that the water condensed on the walls of your storage bottle is reabsorbed into the solution. Fill the buret with the standardized NaOH solution from Experiment 20.

B. Pipet a 10.0-mL sample of your unknown acid—hydrochloric acid (Option 1) or vinegar (Option 2)—into each of three 250-mL Erlenmeyer flasks. Add about 50 mL of deionized water and 3 to 5 drops of phenolphthalein to each flask.

C. Titrate each acid sample, using the same procedure that you used in Step 3C of Experiment 20. If the three runs do not yield at least two volumes that are within 0.2 mL of each other, run three additional samples. Record and retain all data.

D. Calculate the molarity of your unknown acid and submit it for approval if your instructor so requests. If it is not approved, complete any additional titrations, either standardizations of the NaOH or analyses of the unknown, as required.

E. On receiving approval of your final result (if required by your instructor), thoroughly clean and rinse all glassware before putting it away or returning it to the stockroom.

Name _____ Date _____ Section _____

Experiment 21

Advance Study Assignment

1. Why must you use a pipet bulb to draw a liquid into a pipet?

2. Why must you swirl the contents of the flask during the titration?

3. Why is it important that you shake the NaOH solution before using it in this experiment?

4. Calculate the molarity of an acetic acid solution, $HC_2H_3O_2(aq)$, if a 25.0-mL sample requires 27.2 mL of 0.138 M NaOH in a titration.

Name ______________________ Date __________ Section __________

Experiment 21

Work Page

TABLE OF DATA AND RESULTS
(Beneath the table show the full calculation setup for at least one valid titration run)

Unknown number ________ Average molarity of NaOH from Experiment 20 ________

Sample	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Initial buret reading (mL)								
Final buret reading (mL)								
Volume of NaOH (mL)								
Molarity of HCl (Option 1)								
Molarity of acetic acid (Option 2)								

Calculation setup for at least one valid titration run:

Name ______________________ Date ____________ Section ____________

Experiment 21

Report Sheet

TABLE OF DATA AND RESULTS
(Beneath the table show the full calculation setup for at least one valid titration run)

Unknown number ____________ Average molarity of NaOH from Experiment 20 ____________

Sample	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Initial buret reading (mL)								
Final buret reading (mL)								
Volume of NaOH (mL)								
Molarity of HCl (Option 1)								
Molarity of acetic acid (Option 2)								

Calculation setup for at least one valid titration run: