

Lab 6: Titration of an unknown acid

Objective: Determine the molarity of an unknown monoprotic acid by titration, the process that matches the number of moles of base with the number of moles of reactant.

Pre-lab: Read sections 10.5 and 10.6 in the textbook. Complete question 1 of the analysis section below.

Materials needed:

- 50 mL buret
- 125 mL Erlenmeyer flask
- buret clamp
- small beakers
- unknown acid sample
- buret valve (Teflon)
- 25 mL volumetric pipet
- funnel
- standardized NaOH solution

Safety issues: There will be acids and bases in this lab; please wear goggles and tie back long hair. In addition, there will be plenty of glassware so be aware of your surroundings while you are working and while you are transporting glassware.

Remember: Read the buret correctly: the graduations run from 0 mL at the top of the buret to 50 mL near the bottom (note this is backwards from how a graduated cylinder's scale runs). Read the buret to the nearest **hundreth** of a milliliter.

Procedure: Select one of the two available acids, record the **letter** for the acid you chose on the lab 6 data sheet, and assemble the titration setup.

Prepare two samples for titration by this procedure:

(1) Pour about 60 mL of the acid into a beaker and, using the 25.00 mL volumetric pipet, transfer 25.00 mL of acid to each of two Erlenmeyer flasks.

(2) Add 2 drops of phenolphthalein to each flask. Swirl the flask to mix the phenolphthalein in (you will do this to mix the base in as well, so get used to it). The solution should still be colorless.

Prepare the buret as follows:

(1) Pour about 60 mL of the base into another beaker and record the concentration of the standardized base solution. "Standardized" means that the solution concentration has been measured to a high degree of precision. In this case, record four significant figures for the base concentration.

(2) With the stopcock **closed**, place a funnel in the buret and add the base solution carefully until the buret is filled up to between the 0 and 10 mL marks.

(3) With yet another beaker below the buret, open the stopcock to fill the tip, closing it as soon as the tip is filled. It is important that there be no air bubbles in the tip, as such bubbles leaving during the titration will affect the volume of base, and thus the molarity of the acid. If you cannot get all the bubbles out, get help from me.

(4) Once the tip is free of air, add more base to the buret to fill it back up to between the 0 and 10 mL marks. Wait a few minutes to let all the liquid run down the

sides of the buret and record the **initial buret volume** for the first titration. **All buret volume measurements should be to the hundredths place.**

Perform the titrations as follows:

(1) Place one of the flasks of prepared acid below the tip of the buret.

(2) Add base relatively quickly, 0.5 or 1 mL at a time with swirling until a pink or magenta color persists for a few seconds after adding the base. This means you are getting close to the endpoint and should add base more slowly. You want to reduce the amount you add to a few drops at a time, swirling each time to mix. As the color persistence time lengthens you should reduce the amount of base you add each time until you are adding one drop at a time. Stop after the first drop where the color change persists for a couple of minutes and record the **final buret volume** for the titration. Subtract the initial buret volume from the final buret volume and record the volume of base added. If you believe you overshot the endpoint, make a note of that too.

(3) Now you have an idea of how much base is required. Looking at the buret, determine if you have enough base left in it to titrate the second sample, with a few extra mL leeway. If so, record the initial buret volume for the second sample. If not, add more base to the buret until you are sure there is enough for the second titration, let the liquid settle, and record the initial buret volume for the second sample.

(4) The second titration can go faster, because you know about how much base to add. Figure out what the new level would be if you added two mL less than the volume of base added on the previous trial. That is, take two mL from the volume of base added in the first trial, add that to the initial buret volume for the second trial and the result is the level of the buret to which you may safely go in adding base to the acid without risking passing the endpoint. After this addition, let the liquid settle, because you've added a lot of base. Swirl to mix, then begin adding a drop at a time with swirling until the color change persists for a couple of minutes. Record the final buret volume for the second trial.

(5) Calculate the volume of base added for the second trial.

Checking for **reproducibility**:

(1) Compare the base volumes for the two trials by taking their difference and dividing that by their average. Convert the decimal to a percent. If your percent is 0.5% or less, the agreement is good enough and another trial is not necessary. If the deviation is **more than 0.5%**, you should do another trial and compare the two closer values. Continue until you have two trials in agreement to 0.5%. Record the average volume of base for these two trials and the percent difference.

Calculating the molarity: The acid is monoprotic, so it will react one to one with NaOH; therefore, the number of moles of base equals the number of moles of acid. For each solution, the number of moles of the substance is equal to the molarity of the solution times the volume of solution.

$$M_a V_a = M_b V_b$$

Rearranged to solve for M_a :

$$M_a = M_b V_b / V_a$$

Use the averaged base volume in this calculation to get the best value of the acid molarity and record it. Be careful about units and sig figs.

Analysis and Questions (Please use your own paper for the answers of these questions, but number them the same way):

1. Fill in the blanks (both in the table and below the table):

Acid unknown letter X
Acid volume 25.00 mL
NaOH concentration 0.1028 M

Trial	1	2
Initial buret volume (mL)	0.01	0.05
Final buret volume (mL)	14.12	14.09
Volume of base added (mL)		

(Note that the part below will have different wording on the actual data sheet)

Average base volume between the trials _____

Percent deviation between the trials _____

Unknown acid concentration from trial 1 _____

Please show all of your calculation setups!

2. Suppose, in the example above, the acid were **diprotic**. Recalculate the concentration for the acid. Show your work. Hint: after you determine what “diprotic” means, this calculation should involve the inclusion of only one other factor.

3. How would the calculation of the unknown acid concentration be affected if the buret tip was **not** filled when reading the initial volume? Be specific: would the calculated concentration have been **lower**, **higher** or **the same**? Show your reasoning!