

8 The Titration of 8 An Acid and a Base

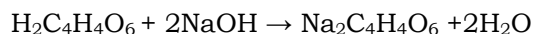
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- Prepare standard solutions.
- Use acid-base titration to analyze acid and base solutions of unknown concentration.

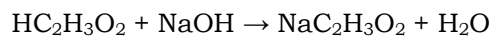
DISCUSSION

If you know the concentration of a solution accurately, then that solution is called a **standard solution**. **Titration** is the process by which you determine what volume of a standard solution is required to react with a specified amount of pure substance.

In this experiment you will make a standard solution of tartaric acid ($\text{H}_2\text{C}_4\text{H}_4\text{O}_6$) by dissolving a known amount of it in a known final volume. Then you will titrate a solution of sodium hydroxide with the standard tartaric acid. Using the reaction equation



you will calculate the concentration of the sodium hydroxide solution thus making *it* a standard solution. Then, you will titrate commercial vinegar (dilute aqueous acetic acid) with the sodium hydroxide



PROCEDURE

A. Preparation of a Standard Tartaric Acid Solution

1. Insert a small plastic funnel into a 50 mL volumetric flask and tare on the balance. Add about 0.9 grams ($\pm 0.1\text{g}$) of tartaric acid and record the actual mass of the sample. Rinse the funnel with distilled water to make sure that all the solid is transferred to the flask. Then fill the flask about 2/3 full with distilled water and swirl until the solid completely dissolves. **DO NOT PUT THE CAP ON AND INVERT THE FLASK.** Once the solid is dissolved, adjust the volume using a dropper until the bottom of the meniscus is **EXACTLY** on the calibration ring. If there are water drops on the inside of the neck above the calibration line, use a paper towel to carefully remove them. Be careful not to stick the towel into the solution! Stopper the flask and check to be sure that the cap is tight. It should not rotate easily. While holding the stopper, invert the flask completely and shake the contents. Repeat the inversion and shaking several times until the solution is uniform. Transfer the solution to a dry 60 mL plastic bottle.

2. Calculate the molarity of the tartaric acid solution.

B. Preparation of a Standard Sodium Hydroxide Solution

3. Pour approximately 5 mL of 6 M sodium hydroxide solution in a 125 mL plastic storage bottle. (This stock solution is *not* a standard solution; its concentration is known to only one significant figure.) Fill the bottle to the shoulder with purified water, and shake it to achieve a uniform concentration.

Assume the volume of the solution is about 125 mL. Calculate the approximate molarity of the diluted solution.

Empty the water from a 10 mL buret, and rinse it with several small portions of the diluted NaOH solution. Allow the rinse to drain through the stopcock into a waste beaker. Then fill the buret with the solution. Open the stopcock, and allow the buret tip to fill with solution. In the same manner, fill the other buret with the tartaric acid solution.

4. Record the initial buret reading of the tartaric acid solution to the nearest 0.01 mL. Drain about 8 mL of acid into a 50 mL erlenmeyer flask.

5. Record the final buret reading of the tartaric acid to the nearest 0.01 mL.

6. Determine the (accurately-measured) volume of tartaric acid solution by subtracting the initial buret reading from the final.

7. Record the initial buret reading of sodium hydroxide solution.

8. Add 1 drop of phenolphthalein indicator to the acid in the flask. With careful swirling, slowly add NaOH solution from the buret into the flask. Continue until the solution in the flask becomes *faintly* pink. Record the final buret reading.

9. Determine the volume of sodium hydroxide solution by subtracting the initial buret reading from the final.

10. Calculate the molarity of the sodium hydroxide solution to three significant figures.

Discard the contents of the flask, refill the burets, and repeat Steps 4 through 10 for two more titrations. Calculate the molarity of sodium hydroxide solution for each titration.

11. Determine the average NaOH molarity using your three titrations. You have now standardized the sodium hydroxide solution.

C. The Percentage of Acetic Acid in a Sample of Vinegar

12. Wash a 50 mL flask, and dry the outside. Measure its mass.

13. Transfer approximately 2 g of vinegar to the 50-mL flask. Record the mass of the flask and vinegar.

14. Add a drop of phenolphthalein to the flask. Refill the NaOH buret with your standardized solution, and record the initial volume to the nearest 0.01 mL.

15. Add NaOH solution from the buret until the solution in the flask becomes *faintly* pink. Record the final volume of NaOH solution to the nearest 0.01 mL.

16. Calculate the volume of NaOH solution used.

17. Using the chemical equation for the reaction between acetic acid and sodium hydroxide, calculate the mass of acetic acid in the vinegar.

18. Calculate the mass of the vinegar sample.

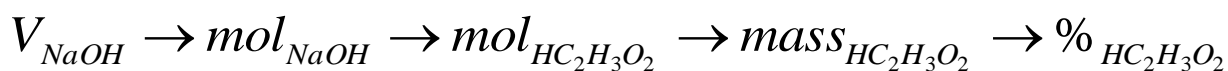
19. Calculate the weight percent of acetic acid in the vinegar.

$$\% = \frac{\text{mass of acetic acid}}{\text{mass of vinegar}} \times 100\%$$

Discard the solution, and repeat Steps 12 through 19 for two more samples of vinegar.

20. Calculate the average percent for your three titrations.

When you are finished, discard all the solutions. Rinse the plastic storage bottles with tap water. Without removing the buret from its stand, drain it and rinse it out with purified water from your wash bottle. Finally, fill the buret with purified water, and cap it with the small stopper provided.



8 The Titration of An Acid and a Base

Name _____
 Partner _____
 Section _____ Locker _____
 Instructor _____

Enter the data or answer the questions *according to the corresponding step in the procedure*

A. Preparation of a Standard Tartaric Acid Solution

1. Mass of tartaric acid	
2. Molarity of tartaric acid solution	

CALCULATIONS

B. Preparation of a Standard Sodium Hydroxide Solution

	Titration #1	Titration #2	Titration #3
3. Approximate molarity of NaOH(aq)			
4. Initial buret reading (tartaric acid)			
5. Final buret reading (tartaric acid)			
6. Volume of tartaric acid			
7. Initial buret reading (NaOH)			
8. Final buret reading (NaOH)			
9. Volume of NaOH(aq)			
10. Molarity of NaOH(aq)			
11. Average molarity			

CALCULATIONS

C. The Percentage of Acetic Acid in Vinegar

	Titration #1	Titration #2	Titration #3
12. Mass of flask			
13. Mass of flask and vinegar			
14. Initial buret reading			
15. Final buret reading			
16. Volume of sodium hydroxide			
17. Mass of acetic acid			
18. Mass of vinegar			
19. Percent acetic acid			
20. Average percent			

CALCULATIONS

APPLICATION OF PRINCIPLES

1. 32.30 mL of 0.220 M $\text{H}_2\text{SO}_4(aq)$ are titrated with 46.30 mL of a NaOH solution. What is the molarity of the $\text{NaOH}(aq)$? Show your work.

2. A 0.546 g sample of pure $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ crystals is dissolved in water and titrated with 22.40 mL of a potassium hydroxide solution. What is the molarity of the $\text{KOH}(aq)$? Show your work.

3. If 45 mL of a 0.5 M solution is diluted to 150 mL, what is the new concentration of the solution?

4. . An empty flask is found to have a mass of 97.34 grams. A sample of vinegar is added to the flask and the total mass is measured at 119.22 grams. A 5.023-gram sample of tartaric acid dihydrate is dissolved in water and diluted to 250.0 mL in a volumetric flask. A 34.2 mL portion of this tartaric acid solution reacts completely with 28.3 mL of a sodium hydroxide solution. The vinegar sample requires 40.1 mL of this same sodium hydroxide solution for complete reaction. Calculate the percent (w/w) of acetic acid in the vinegar.

