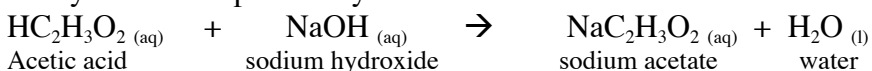


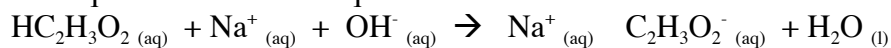
Experiment 25 - Titration of Vinegar

Vinegar tastes sour because it has a pH less than 7. This low pH is caused by the presence of the weak acid acetic acid, CH_3COOH (or $\text{HC}_2\text{H}_3\text{O}_2$). Like any acid, acetic acid can be neutralized by allowing it to react with a base. You will use the base sodium hydroxide (NaOH), in the form of an aqueous solution. By measuring how much $\text{NaOH}_{(\text{aq})}$ is needed for the neutralization you can calculate how much acetic acid must be present in the vinegar. You will add the NaOH solution slowly from a buret until enough has been added to neutralize all of the acetic acid in the vinegar. You know when that point has been reached because before starting, you have added a few drops of the indicator phenolphthalein. This remains colorless until you have reached the “endpoint,” whereupon it turns pink, signaling or “indicating” that you have added enough NaOH ; then you must stop instantly. The neutralization reaction follows this equation:



Note the 1:1 ratio of the two reactants to each other.

Because sodium hydroxide and sodium acetate are soluble ionic compounds, we often write the equation as an ionic equation:



Finally, a net ionic equation may be written, by omitting the “spectator ions,” those which are not taking part in the reaction. (Write the net ionic reaction for the above reaction.)

Regardless of how the equation is written, one mole of acetic acid in the vinegar requires one mole of sodium hydroxide to get neutralized. When all of the acetic acid in the vinegar has been neutralized, any further sodium hydroxide added (even just one tiny drop) will not find anything to react with except phenolphthalein (the indicator). When that happens, the pH is about 8, and the phenolphthalein is converted to its red form. The “color change” of the phenolphthalein indicates the endpoint.

Safety Precautions:

- Wear your safety goggles.
- If acid or base splashes on you, rinse it off with plenty of water.

Waste Disposal:

- The neutralized samples can be poured down the drain.
- Any excess acid or base may also be poured down the drain with lots of water.

Procedure

1. Clean a buret and rinse it with deionized water. (The instructor will explain this procedure.)
2. Rinse the buret with about 5 mL of the standard NaOH solution that will be used for the titration. Make sure the entire inner wall of the buret gets rinsed with the NaOH. (Tilt and rotate the buret while rinsing.) Discard the rinse liquid by allowing it to drain out the tip of the buret. Repeat this rinsing with a new 5 mL portion of NaOH solution.
3. Fill the buret with the standard NaOH solution. To make sure that the buret contains solution all the way to the bottom of the tip, allow some of the solution to drain out the tip into the sink. Write down the concentration of the NaOH (written on the bottle).
4. Clamp the buret onto the ring stand with a buret clamp.
5. Weigh a clean, dry 250-mL Erlenmeyer flask to the nearest 0.1 gram.
6. Using a 10-mL graduated cylinder, measure 10 mL of commercial vinegar (to the nearest 0.1 mL) and pour it into the weighed flask. (Do not put anything else into the flask at this point.)
7. Weigh the flask and its contents. Subtract to obtain the mass of the vinegar sample.
8. If the vinegar is colored, add about 20 mL of deionized water to the flask. (The amount of water added does not have to be measured.)
9. Put 2 drops of phenolphthalein indicator into the sample in the flask.
10. Record the initial buret reading to the nearest 0.1 mL.
11. Begin adding NaOH slowly from the buret, while constantly swirling the flask to mix the solutions.
12. When the pink color of the indicator seems to persist for a longer time before disappearing, you are approaching the endpoint. Add NaOH more slowly near the endpoint until you are adding it one drop at a time. Make sure to swirl the flask well between drops, and periodically rinse down the inner walls of the flask with a jet of water from a wash bottle. When one drop of NaOH causes a permanent color change from colorless to pink that persists for at least 20 seconds, you have reached the endpoint. Stop adding NaOH.
13. Record the final buret reading. Determine the volume of NaOH used by subtraction. Pour the neutralized sample down the sink.
14. Rinse the titration flask with tap water and then with deionized water. Wipe off the outside of the flask with a paper towel.
15. Add more NaOH solution to the buret, and repeat steps 5-13. This time, however, you can add the NaOH more quickly at first, because now you will know the approximate volume of NaOH needed. You only need to slow down when you get close to the endpoint.
16. Do two more trials of the titration: repeat steps 5-15. You should have data for four trials.

Calculations (do these separately for each trial)

1. From the volume of NaOH used and the concentration of the NaOH, determine the moles of NaOH used in the titration.
2. Use the balanced equation to determine the number of moles of acetic acid that must have been present in the titration flask to react with the amount of NaOH found in #1.
3. Determine the molarity of acetic acid in the vinegar using the number of moles of acetic acid found in #2 and the known volume of the vinegar sample used.
4. Report the average molarity of acetic acid from the two trials.
5. Determine the mass of acetic acid present in the vinegar sample: use the number of moles of acetic acid found in #2 and the molar mass of acetic acid.
6. Determine the mass percent of acetic acid in the vinegar sample from the mass of acetic acid found in #5 and the mass of the vinegar sample. Remember:

Here, X is the acetic acid and the total mass of the sample is the mass of the

$$\text{mass percent X} = \left(\frac{\text{mass X}}{\text{total mass sample}} \right) \times 100$$

vinegar.

7. Report the average mass percent found from the four trials. Compare this with the mass percent of acetic acid found on the label of the vinegar bottle.

Questions

1. How many milliliters of a 0.100 M NaOH solution are needed to neutralize 15.0 mL of 0.200 M H₃PO₄?
2. If 24.7 mL of 0.250 M NaOH solution is needed to neutralize 19.8 mL of H₂SO₄ solution, what is the molarity of the H₂SO₄?
3. 25.0 g of 5.0 % (by mass) acetic acid solution is titrated with 0.300 M NaOH. What volume of NaOH will be needed to neutralize this sample?