

Experiment 1

Equilibrium Constants



Experiment Inventory

Materials

0.5 mL 4.5% Acetic Acid, CH_3COOH ✓

2 mL Turmeric Indicator ✓

15 mL Sodium Hydroxide, NaOH ✓

Graph Paper ✓

90 mL Distilled Water

Camera / Smart Phone

Computer / Internet Access

Labware

100 mL Beaker ✓

100 mL Graduated Cylinder ✓

3 Pipettes ✓

30 mL Syringe ✓

Syringe Stopcock ✓

pH Meter ✓

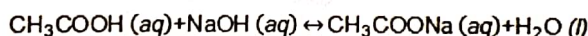
Ring Clamp ✓

Ring Stand ✓

Note: You must provide the materials listed in red.

EXPERIMENT 1: EQUILIBRIUM CONSTANTS

In this experiment, you will determine the equilibrium constant (K_a) of a weak monoprotic acid. The reaction between acetic acid and 0.1 M sodium hydroxide to produce sodium acetate and water will be monitored using a pH meter.



Creation of 0.1 M NaOH

- ☐ 1. Put on your safety glasses and gloves (provided in your safety box).

LAB SAFETY: Sodium hydroxide is very damaging to the eyes. Be sure to wear proper eye protection.

- ☒ 2. If you have not created 0.1 M NaOH, do so by following the procedures below. If you have already created this solution, skip ahead to the rest of the experiment.
- ☒ 3. Use the 100 mL graduated cylinder to measure 30 mL of distilled water.
- ☒ 4. Pour the water directly into the chemical bottle labeled "30 mL 0.2 M Sodium Hydroxide, NaOH." Be careful to avoid any splash-back.
- ☒ 5. Use a permanent marker to cross out the "0.2 M" on the label of the bottle and write "0.1 M NaOH."

PROCEDURE

- ☒ 1. Put on your safety glasses and gloves (provided in your safety box).

LAB SAFETY: Sodium hydroxide is very damaging to the eyes. Be sure to wear proper eye protection.

- ☒ 2. Set up the titration apparatus by first attaching the clamp to the ring stand (Figure 4).
- ☒ 3. Screw on the stopcock to the syringe by threading it onto the bottom of the syringe. Make sure the stopcock is closed by rotating the handle on the stopcock to a position that is perpendicular to the syringe.
- ☒ 4. Remove the plunger from the syringe, and secure the syringe in the clamp. This set should be positioned high enough on the ring stand to fit a beaker beneath it (Figure 4).
- ☒ 5. Use a pipette to fill the syringe with 15 mL of 0.1 M sodium hydroxide. Record the initial volume of NaOH in Table 2.
- ☒ 6. Add 80 mL of distilled water to the 100 mL beaker.
- ☒ 7. Use a pipette to measure and add 0.5 mL of acetic acid to the water in the 100 mL beaker.
- ☒ 8. Remove the dropper and lid, and use a clean pipette to add 15 drops of turmeric indicator to the 100 mL beaker and gently swirl. The solution will turn clear yellow.
- ☒ 9. Place the 100 mL beaker under the syringe.
- ☒ 10. If this is your first lab using the pH meter, read the instructions that came with it on how to calibrate it. If you do not properly calibrate the meter prior to using it, your results will be inaccurate. If you have used it before, check the calibration using distilled water. It should read a pH close to 7.
- ☒ 11. Remove the cap from the pH meter, and turn the pH meter on by moving the switch at the top to the right. Rinse the pH meter probe with 10 mL of distilled water.
- ☒ 12. Place the pH meter in the beaker with the solution and record the initial pH of the solution in Table 2. The pH meter reading may take a while to stabilize.
- ☒ 13. Slowly open the stopcock by rotating the handle to a position that is parallel to the syringe and slowly add 1 mL sodium hydroxide to the beaker in 0.5 mL increments. 0.5 mL is equal to approximately 8 drops.
- ☒ 14. Carefully swirl the contents of the beaker and allow the pH to stabilize (approximately 30 seconds). Once the pH has stabilized, record the pH, remove the pH meter and note the color. The end point will be indicated when the yellow color of the turmeric starts to change. When you near the end point, slightly close the stopcock to slow down the flow of the sodium hydroxide. Add the sodium hydroxide in a drop-wise manner.

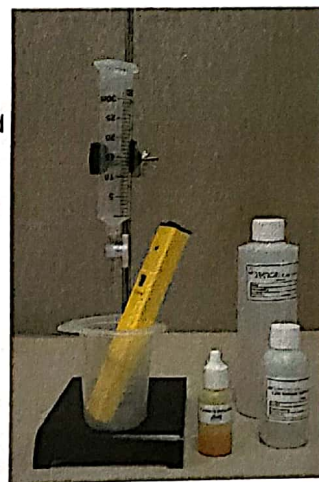


Figure 4: Titration apparatus.

Note: Be observant. The end point comes quickly as you progress through the titration.

- ☒ 15. The turmeric indicator will turn dark pink/orange when the end point is reached. Record the volume on the syringe to the nearest 0.5 mL.
- ☒ 16. Use your camera (or smart phone) to take a picture of the results. Be sure to correctly label the picture and send it to your instructor along with the answers to the lab questions.



☞ TAKE PICTURE

Data Sheet

Experiment 1 Data Sheet

9/17/2021

Table 2: Equilibrium Constants Data

Syringe Reading	pH After Each 0.5 mL Increment	Color Observations
15 mL	3.7	yellow
14.5 mL	4.0	yellow
14 mL	4.3	yellow
13.5 mL	4.6	yellow
13 mL	4.8	yellow
12.5 mL	5.1	yellow
12 mL	5.5	yellow
11.5 mL	5.8	yellow
11 mL	6.2	yellow
10.5 mL	7.6	yellow
10 mL	10.1	ORANGE
9.5 mL	10.7	ORANGE
9 mL	10.9	ORANGE
8.5 mL	11.1	ORANGE
8 mL	11.3	ORANGE



EXPERIMENT 1: EQUILIBRIUM CONSTANTS

Data Sheet

Table 2: Equilibrium Constants Data

Syringe Reading	pH After Each 0.5 mL Increment	Color Observations
8.5 mL	11	ORANGE
8 mL	11.3	ORANGE
7.5 mL		
7 mL		
6.5 mL		
6 mL		

Post-Lab Questions

1. Use the graph paper to prepare a titration graph by plotting the pH vs. volume (mL) of sodium hydroxide added. Don't forget to label the axes and title the graph. Take a picture of your graph and send it to your instructor with the post-lab questions.

Equilibrium Constants



2. From your graph, determine the volume of sodium hydroxide needed to reach the equivalence point in the titration.
3. Calculate the volume needed to reach the half-equivalence point in the titration.
4. Find this half-equivalence point on the graph and determine its corresponding pH.
5. Use the half-equivalence point pH value to find the experimental pKa. To solve, recall that:

$$pH = pK_a + \log \frac{[base]}{[acid]}$$

6. Determine the Ka of acetic acid. Recall that:

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

7. Look up the actual value for the equilibrium constant (Ka; acid ionization constant) for acetic acid (use a website like the Lab Rat as a reliable resource). Compare your answer to the value in the literature. Do you notice any variation? If so, why?