TITRATION CURVES

How does the shape of a titration curve differ for a strong and a weak acid?

Objectives

- Distinguish between titration curves produced by strong and weak acid solutions.
- Determine the pH at the equivalence point for a strong acid and a weak acid.

Materials and Equipment

- Data collection system
- pH sensor
- Drop counter
- Syringe with holder
- Stopcock valves (2), with drop tip
- Magnetic stirrer with magnetic stir bar
- Ring stand
- Graduated cylinder, 10-mL
- Beakers (4), 250-mL
- Rinse bottle filled with distilled water
- Phenolphthalein (dropper bottle)
- 0.10 M Hydrochloric acid (HCl), 10 mL
- 0.10 M Acetic acid (CH_3COOH), 10 mL
- 0.10 M Sodium hydroxide (NaOH), 100 mL
- Distilled water, 200 mL

Safety

Follow these important safety precautions in addition to your regular classroom procedures:

- Wear safety goggles at all times.
- Immediately notify your teacher of any spills.

Procedure

1. Select Sensor Data in SPARKvue. Connect the pH sensor and drop counter to your device.
2. Choose the Titration (drop counter) experiment from the Quick Start menu.
3. Remove the cap and storage bottle from the pH probe and rinse it with distilled water. Label the beakers as follows: 0.10 M NaOH, 0.10 M HCl, 0.10 M CH_3COOH, and Waste.
4. Fill the NaOH beaker with about 120 mL of 0.10 M NaOH.
5. Remove the plunger from the syringe. Attach both stopcock valves to the syringe. Add the drop tip to the outer valve as shown in Figure 1.
6. Close both valves as shown in Figure 1. Pour about 20 mL of NaOH into the syringe. Hold the syringe over the waste beaker. Open both valves to flush all of the NaOH through the syringe into the waste beaker.

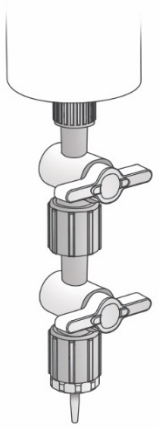


Figure 1: Syringe setup

7. Close both valves. Add about 4 mL of NaOH to the syringe. Hold the syringe over the waste beaker. Fully open the top valve. Slowly open the bottom valve until NaOH comes out in regular, distinct drops. Wait for all the NaOH to drain out of the syringe and close the top valve. Once the drop pattern is set, use only the top valve to open and close the syringe for the remainder of the investigation.

8. Slide the syringe holder up to the top of the syringe and set up the equipment as shown in Figure 2.

9. Place the magnet in the HCl beaker. Add enough distilled water to cover the magnet, then add 10 mL of 0.10 M HCl and 2-3 drops of phenolphthalein.

10. Place the beaker on the magnetic stirrer. The magnet inside the beaker must not contact the pH probe. Add enough distilled water to the beaker to cover the glass bulb at the end of the pH probe.

11. Fill the syringe with 0.10 M NaOH up to the 60 mL mark. Position the drop tip so drops will fall through the drop counter window into the HCl beaker as shown in Figure 2.

12. Turn on the magnetic stirrer to a medium speed.

13. Select Start to begin collecting data. Record the initial pH in Table 1.

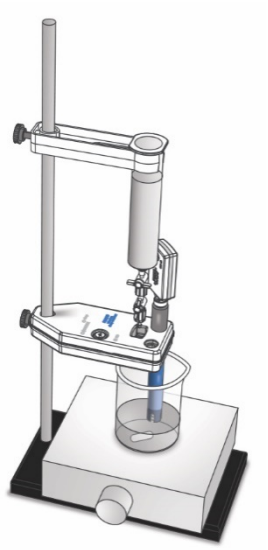


Figure 2: Titration setup

14. Open the top valve on the syringe to begin the titration.

15. Record observations of the solution inside the beaker throughout the titration in Table 1. Scale the graph and continue collecting data until the pH has leveled off in the basic pH region.

16. Close the top valve. Stop collecting data. Record the ending pH in Table 1. Use the Slope tool to determine the pH at the equivalence point. The equivalence point is found in the most vertical portion of the graph where slope (m) is smallest. Record the equivalence point pH in Table 1.

17. Remove the HCl beaker from the setup. Thoroughly rinse the pH probe into the waste beaker with distilled water. Retrieve the bar magnet and rinse it thoroughly with distilled water.

18. Repeat Steps 9 -17 with CH_3COOH instead of HCl. Use the CH_3COOH beaker and a clean graduated cylinder.

19. Dispose of solutions and clean your work area according to your teacher's directions.

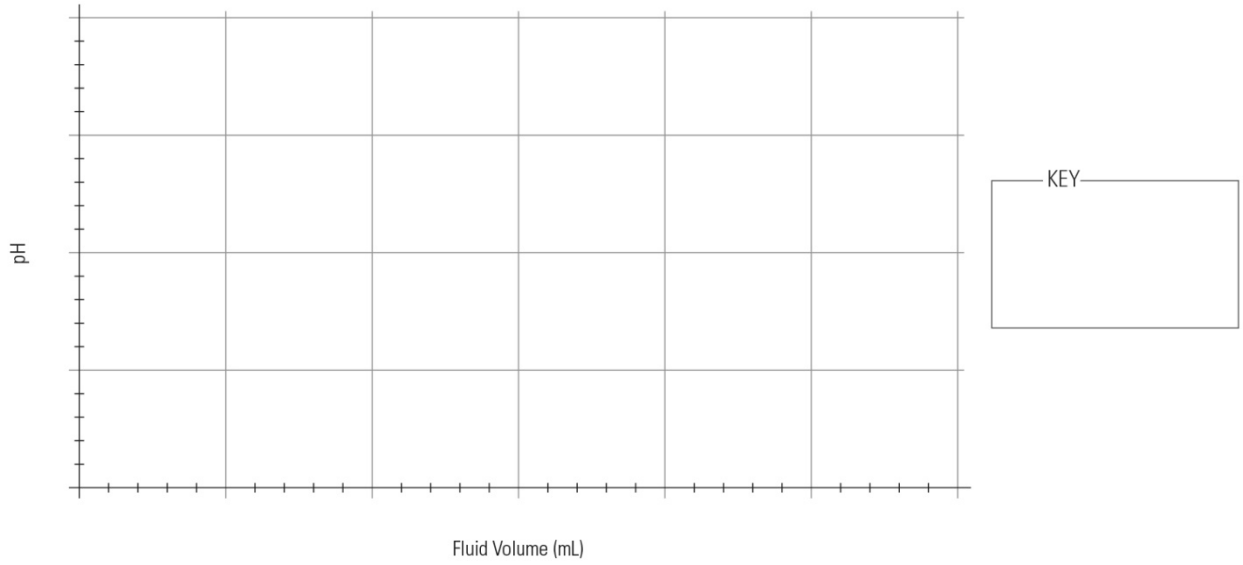
20. Show both data runs and scale the graph. Sketch both runs in Graph 1. Add numbers to the x- and y-axes and include a key. Mark the equivalence point for each run.

Data Collection

Table 1: Observations of acid solutions during titration

Acid	Observations During Titration
0.10 M Hydrochloric acid, HCl Initial pH: _____ pH at equivalence point: _____ Final pH: _____	
0.10 M Acetic acid, CH_3COOH Initial pH: _____ pH at equivalence point: _____ Final pH: _____	

Graph 1: Titration of 0.10 M HCl and 0.10 M CH_3COOH with 0.10 M sodium hydroxide, NaOH



Questions and Analysis

1. Which of the two acids is a strong acid, and which is a weak acid? What does the acid strength indicate about the behavior of ions in the acid solution?

2. Compare the starting and ending pH of a strong 0.10 M acid with the starting and ending pH of a weak 0.10 M acid. Support your answer with data.

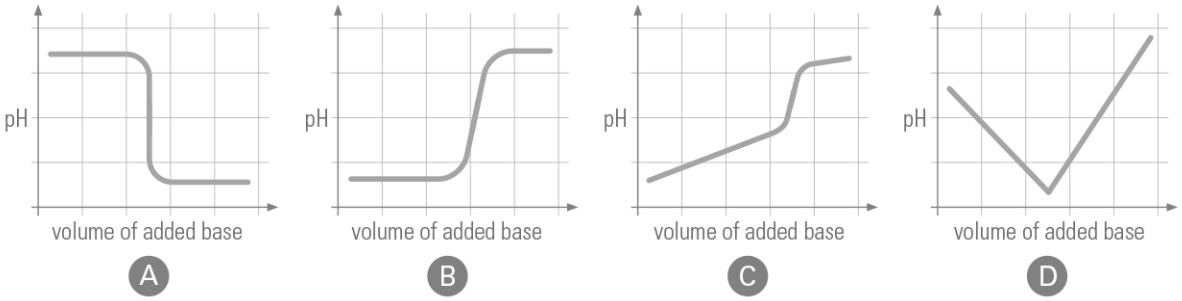
3. Compare the shape of a strong acid-strong base titration curve to the shape of a weak acid-strong base titration curve.

4. Explain how the acid:base mole ratio changes in the beaker before the equivalence point is reached, at the equivalence point, and after the equivalence point is surpassed.

5. Compare the pH at the equivalence point of a strong acid-strong base titration to the pH at the equivalence point of a strong acid-strong base titration.

6. Your friend says that when a solution is neutralized, the pH equals 7. Do you agree or disagree with your friend? Support your answer with data.

7. Circle the graph that represents a strong acid-strong base titration curve.



8. Circle the graph that represents a weak acid-strong base titration curve.