Acids, Bases, and Neutralization

Use with Section 19.4

Neutralization is a chemical reaction between an acid and a base that produces a salt and water.

$$\text{acid} + \text{base} \longrightarrow \text{salt} + \text{water}$$

In an acid-base neutralization reaction, the hydronium (hydrogen) ions of the acidic solution react with the hydroxide ions in the basic solution. The reaction may be shown by this equation.

$$H_3O^+ (aq) + OH^- (aq) \longrightarrow H_2O(l)$$

Note that one mole of hydronium ions reacts with one mole of hydroxide ions. The solution is neutral when chemically equivalent amounts of acid and base are present.

Indicators are chemical dyes that change color with a change of pH. Litmus paper and phenolphthalein are two common indicators used in acid-base reactions. They are chosen because they change color at or very near solution neutrality. Litmus paper is red in acidic solutions and blue in basic solutions. Phenolphthalein is colorless in acidic solutions and turns red in basic solutions.

Problem: What substance is formed during a neutralization reaction?

Objectives

- **Compare** the color of an indicator in acidic solution to its color in a basic solution.
- **Classify** a solution as an acid or a base by observing the color of an indicator in that solution.
- **Observe** the change in color of an indicator when the solution changes from acidic to basic.
- **Draw a conclusion** about what substance is formed during the neutralization reaction of an acid and a base.

Materials

1-*M* hydrochloric acid (HCl)

1-*M* Sulfuric acid (H_2SO_4)

1-*M* acetic acid ($HC_2H_3O_2$)

1-*M* sodium hydroxide (NaOH)

1-*M* ammonium hydroxide (NH_4OH)

Limewater— saturated calcium hydroxide ($Ca(OH)_2$) solution

Phenolphthalein Indicator

Blue litmus papers (6)

Red litmus paper (6)

50-mL beakers (2)

10-mL graduated cylinder

Well Plate

Dropping pipette

Hot Plate

pH papers (6)

Tongs

Stirring rod

Filter paper

Evaporating dish

Safety Precautions

- **Always wear safety goggles, a lab apron, and gloves.**
- **Dispose of chemical wastes as directed by your teacher.**
- **Hydrochloric acid, sulfuric acid, and acetic acid are corrosive to skin and clothing.**
- **Hydrochloric acid, sulfuric acid, and acetic acid are toxic.**
- **Sodium hydroxide and ammonium hydroxide are caustic and toxic.**
- **Limewater is a tissue irritant.**

Pre-Lab

1. Define neutralization.
2. Compare the color of litmus paper in acidic and basic solutions.
3. Compare the color of phenolphthalein in acidic and basic solutions.
4. Read the entire laboratory activity. Form a hypothesis about how to know when an acid or a base has been neutralized. Record your hypothesis on page 147.
5. Summarize the procedures you will follow to test your hypothesis.

Procedure

Part A: Acids and Bases

1. Number the wells on a well plate 1 through 6.
2. Place about 20 drops of 1-*M* hydrochloric acid (HCl) into well number 1.
3. Place about 20 drops of 1-*M* sulfuric acid (H_2SO_4) into well number 2.
4. Place about 20 drops of 1-*M* acetic acid ($HC_2H_3O_2$) into well number 3.
5. Place about 20 drops of 1-*M* sodium hydroxide (NaOH) into well number 4.
6. Place about 20 drops of 1-*M* ammonium hydroxide (NH_4OH) into well number 5.
7. Place about 20 drops of limewater, saturated calcium hydroxide ($Ca(OH)_2$), into well 6.
8. Place six pieces of red litmus paper, six pieces of blue litmus paper, and six pieces of pH paper on a piece of filter paper.
9. Use a stirring rod to transfer 1 drop of hydrochloric acid to a piece of red litmus paper. Then transfer 1 drop of hydrochloric acid to a piece of blue litmus paper. Then transfer 1 drop of hydrochloric acid to a piece of pH paper
10. Record your observations in **Data Table 1.**
11. Rinse the stirring rod and repeat steps 9 and 10 for the remaining solutions. Be sure to rinse the stirring rod between solution tests.
12. Add 2 drops of phenolphthalein solution to each solution in each of the numbered test tubes.
13. Record your observations in the data table.

Part B: Neutralization

1. Label a 50-mL beaker "acid" and pour about 10-mL of 1.00-*M* hydrochloric acid (HCl) into the beaker.
2. Label another 50-mL beaker "base" and pour about 10-mL of 1.00-*M* sodium hydroxide (NaOH) into the beaker.
3. Using the 10-mL graduated cylinder, measure 7 mL of hydrochloric acid (HCl) and pour it into a clean evaporating dish.
4. Add 2 drops of phenolphthalein solution to the acid in the evaporating dish.
5. Stir the acid and gradually add about 6-mL of 1.00-*M* sodium hydroxide (NaOH).
6. Using a dropping pipette, add 1.00-*M* sodium hydroxide (NaOH) drop by drop to the acid solution, stirring after each drop, until 1 drop of base causes the solution to remain a permanent red color.

7. Add 1 drop of 1.00*M* hydrochloric acid (HCl). The red color should disappear. If the red color does not disappear, add another drop.
8. Place the evaporating dish on the hot plate on a medium setting.
9. Slowly heat the contents of the evaporating dish to near dryness.
10. When dry, use tongs to place the evaporating dish on the table to cool.
11. When the evaporating dish is cool, examine the contents of the dish and record your observation.

Cleanup and Disposal

1. Dispose of chemicals as instructed by your teacher.
2. Return all lab equipment to its proper place.
3. Report any broken or damaged equipment.
4. Wash your hands thoroughly before leaving the laboratory.

Data and Observations

Data Table 1

Well number	Name of substance	Color of blue litmus	Color of red litmus	Color of phenolphthalein	pH Acid or Base?
1	Hydrochloric acid				
2	Sulfuric acid				
3	Acetic acid				
4	Sodium hydroxide				
5	Ammonium hydroxide				
6	Calcium hydroxide				

Analyze and Conclude

1. **Applying Concepts:** Describe how litmus paper may be used to differentiate between an acid and a base.

2. **Classifying:** Complete the last column of **Data Table 1.**
3. **Applying Concepts:** Describe how phenolphthalein may be used to differentiate between an acid and a base.

4. **Observing and Inferring:** Explain why the phenolphthalein remained colorless when 10.0 mL of 1.00*M* hydrochloric acid and about 9 mL of 1.00*M* sodium hydroxide were mixed.

5. **Observing and Inferring:** What is the significance of the permanent red color change in step 6?

6. **Observing and Inferring:** Why was a drop of 1.00*M* hydrochloric acid added to make the red color disappear in step 7?

7. **Observing and Inferring:** Describe the solid residue remaining after heating the contents of the evaporating dish to near dryness.

8. **Drawing a Conclusion** Identify the solid residue remaining after heating the contents of the evaporating dish to near dryness.

9. **Measuring and Using Numbers** Write a balanced chemical equation for the reaction between hydrochloric acid and sodium hydroxide.

10. **Predicting** What quantity of 2.00*M* sodium hydroxide would be needed to neutralize 10.0 mL of 1.00*M* hydrochloric acid? Explain.

11. **Error Analysis** Compare your answers in **Data Table 1** to the answers of other students in your class. What are some reasons that the answers might be different?

Real-World Chemistry

1. Explain the difference between using antacids and acid inhibitors in the treatment of excess stomach acid.
2. Explain why neutralization of soil is important in the agricultural economy.