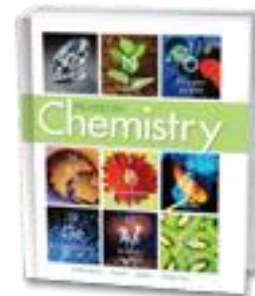
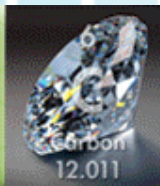




PEARSON
Chemistry



Chapter 19

Acids, Bases, and Salts

- 19.1 Acid-Base Theories
- 19.2 Hydrogen Ions and Acidity
- 19.3 Strengths of Acids and Bases

19.4 Neutralization Reactions

- 19.5 Salts in Solution

What could cause leaves to turn yellow during the growing season?

This condition is called *chlorosis* because the plant lacks a pigment called chlorophyll.



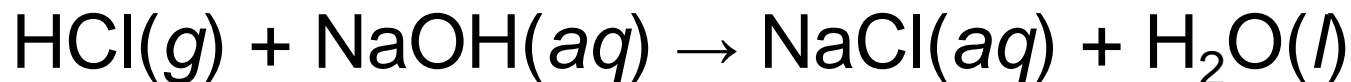
Acid-Base Reactions

 What products form when an acid and a base react?

19.4 Neutralization Reactions > Acid-Base Reactions

Suppose you mix a solution of a strong acid, such as HCl, with a solution of a strong base, such as NaOH.

- The products are sodium chloride and water.



19.4 Neutralization Reactions > Acid-Base Reactions



In general, acids and bases react to produce a salt and water.

- The complete reaction of a strong acid and a strong base produces a neutral solution.
- Thus, this type of reaction is called a **neutralization reaction**.

19.4 Neutralization Reactions > Acid-Base Reactions

When you hear the word *salt*, you may think of the substance that is used to flavor food.

- Table salt (NaCl) is only one example of a salt.
- Salts are ionic compounds consisting of an anion from an acid and a cation from a base.

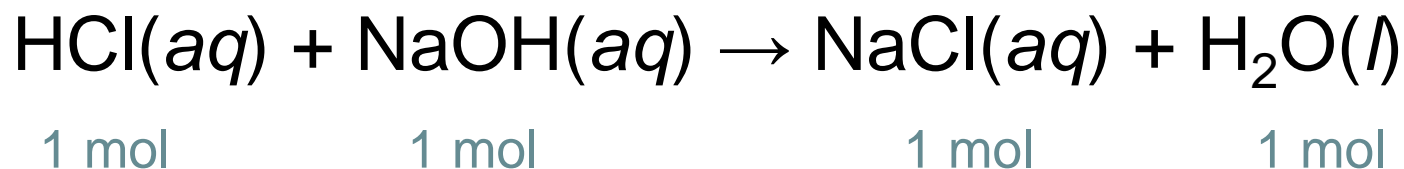
19.4 Neutralization Reactions > Acid-Base Reactions

A reaction between an acid and a base will go to completion when the solutions contain equal numbers of hydrogen ions and hydroxide ions.

- The balanced equation provides the correct ratio of acid to base.

19.4 Neutralization Reactions > Acid-Base Reactions

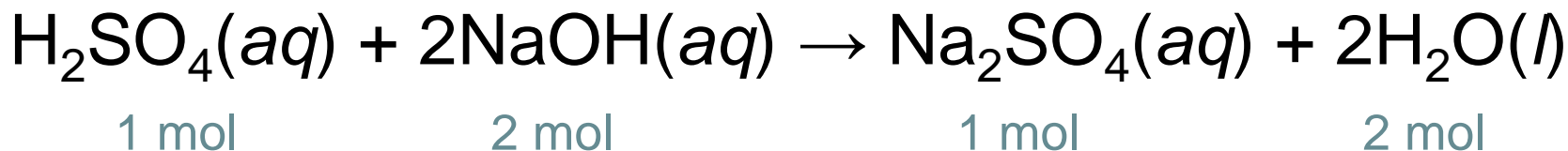
For hydrochloric acid and sodium hydroxide, the mole ratio is 1:1.



19.4 Neutralization Reactions > Acid-Base Reactions

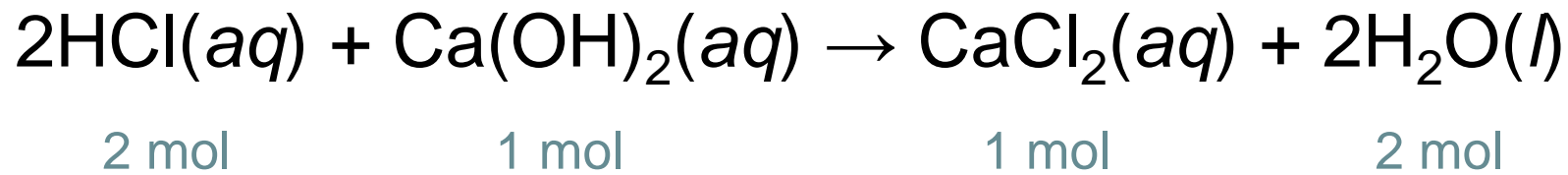
For sulfuric acid and sodium hydroxide, the ratio is 1:2.

- Two moles of the base are required to neutralize one mole of the acid.



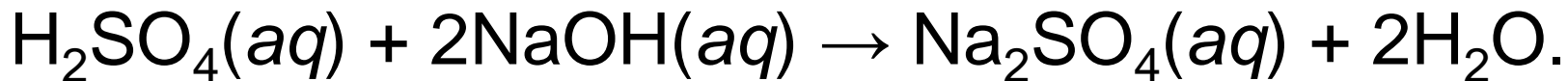
19.4 Neutralization Reactions > Acid-Base Reactions

Similarly, hydrochloric acid and calcium hydroxide react in a 2:1 ratio.



Finding the Moles Needed for Neutralization

The term *neutralization* is used to describe both the reaction and the point at which a neutralization reaction is complete. How many moles of sulfuric acid are required to neutralize 0.50 mol of sodium hydroxide? The equation for the reaction is



1 Analyze List the knowns and the unknown.

To determine the number of moles of acid, you need to know the number of moles of base and the mole ratio of acid to base.

KNOWNNS

mol NaOH = 0.50 mol

1 mol H₂SO₄/2 mol NaOH
(from balanced equation)

UNKNOWN

mol H₂SO₄ = ? mol

2 Calculate Solve for the unknown.

Use the mole ratio of acid to base to determine the number of moles of acid.

$$0.50 \text{ mol NaOH} \times \frac{1 \text{ mol H}_2\text{SO}_4}{2 \text{ mol NaOH}} = 0.25 \text{ mol H}_2\text{SO}_4$$

3 Evaluate Does the result make sense?

Because the mole ratio of H_2SO_4 to NaOH is 1:2, the number of moles of H_2SO_4 should be half the number of the moles of NaOH .



Why are acid-base reactions called neutralization reactions?



Why are acid-base reactions called neutralization reactions?

The complete reaction of an acid with a base creates a solution of a salt in water. This solution has a neutral pH. It is neither acidic nor basic.

Titration



At what point in a titration does neutralization occur?

19.4 Neutralization Reactions > Titration

You can use a neutralization reaction to determine the concentration of an acid or base.

- The process of adding a measured amount of a solution of known concentration to a solution of unknown concentration is called a **titration**.

The steps in an acid-base titration are as follows:

1. A measured volume of an acid solution of unknown concentration is added to a flask.
2. Several drops of an indicator are added to the solution while the flask is gently swirled.
3. Measured volumes of a base of known concentrations are mixed into the acid until the indicator just barely changes color.

19.4 Neutralization Reactions > Titration



A flask with a known volume of acids (and an indicator) is placed beneath a buret that is filled with a base of known concentration.



The base is slowly added from the buret to the acid.



A change in the color of the solution is the signal that neutralization has occurred.

The solution of known concentration is the **standard solution**.

- You can use a similar procedure to find the concentration of a base using a standard acid.

19.4 Neutralization Reactions > Titration



Neutralization occurs when the number of moles of hydrogen ions is equal to the number of moles of hydroxide ions.



Neutralization occurs when the number of moles of hydrogen ions is equal to the number of moles of hydroxide ions.

- The point at which neutralization occurs is called the **equivalence point**.

19.4 Neutralization Reactions > Titration

The indicator that is chosen for a titration must change color at or near the pH of the equivalence point.

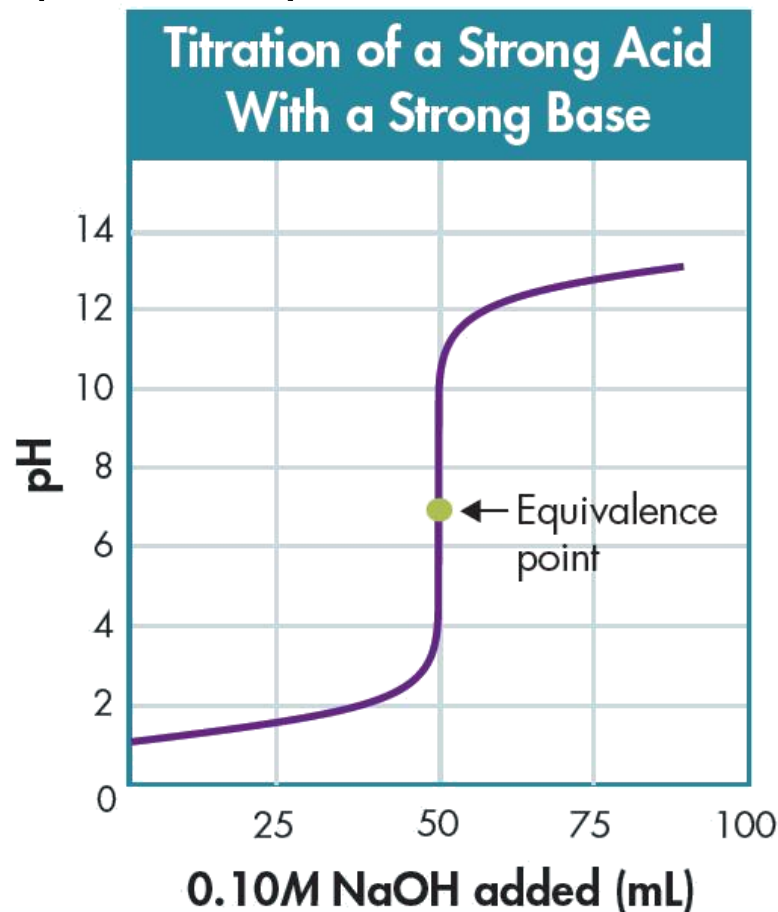
- The point at which the indicator changes color is the **end point** of the titration.



19.4 Neutralization Reactions > Interpret Graphs

This graph shows how the pH of a solution changes during the titration of a strong acid (HCl) with a strong base (NaOH).

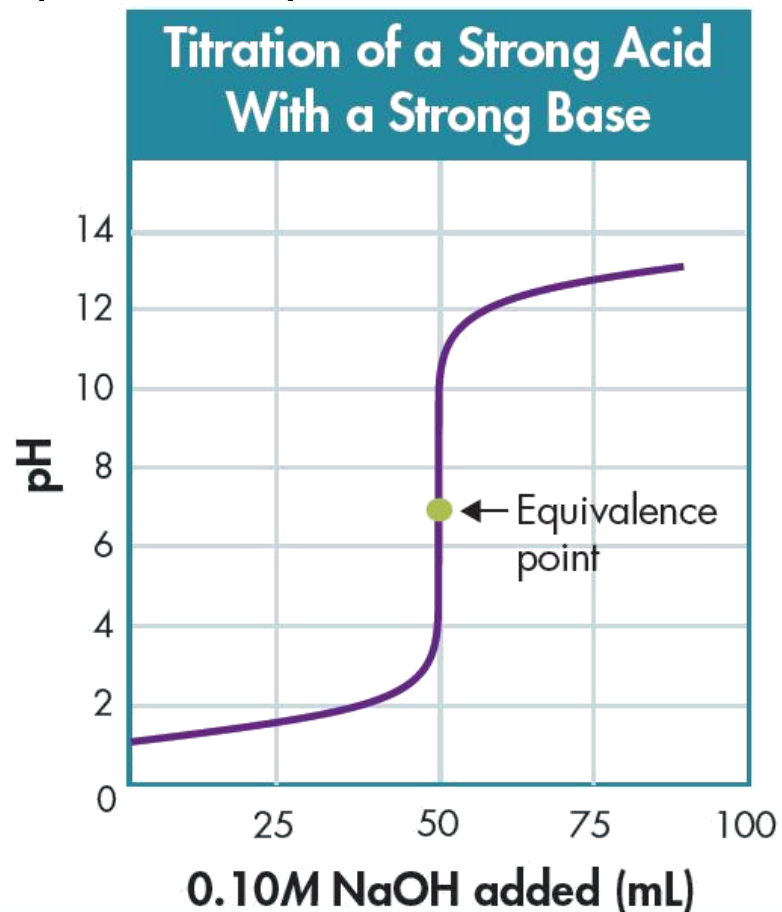
- The initial acid solution has a low pH (about 1).
- As NaOH is added, the pH increases because some of the acid reacts with the base.



19.4 Neutralization Reactions > Interpret Graphs

This graph shows how the pH of a solution changes during the titration of a strong acid (HCl) with a strong base (NaOH).

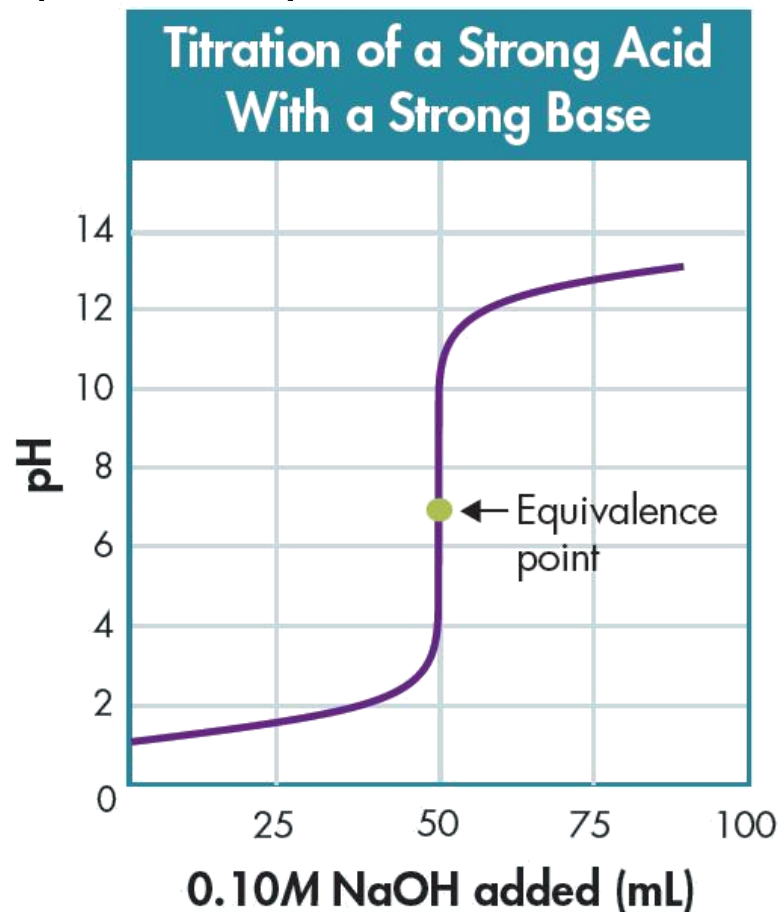
- The equivalence point for this reaction occurs at a pH of 7.
- As the titration nears the equivalence point, the pH rises dramatically because hydrogen ions are being used up.



19.4 Neutralization Reactions > Interpret Graphs

This graph shows how the pH of a solution changes during the titration of a strong acid (HCl) with a strong base (NaOH).

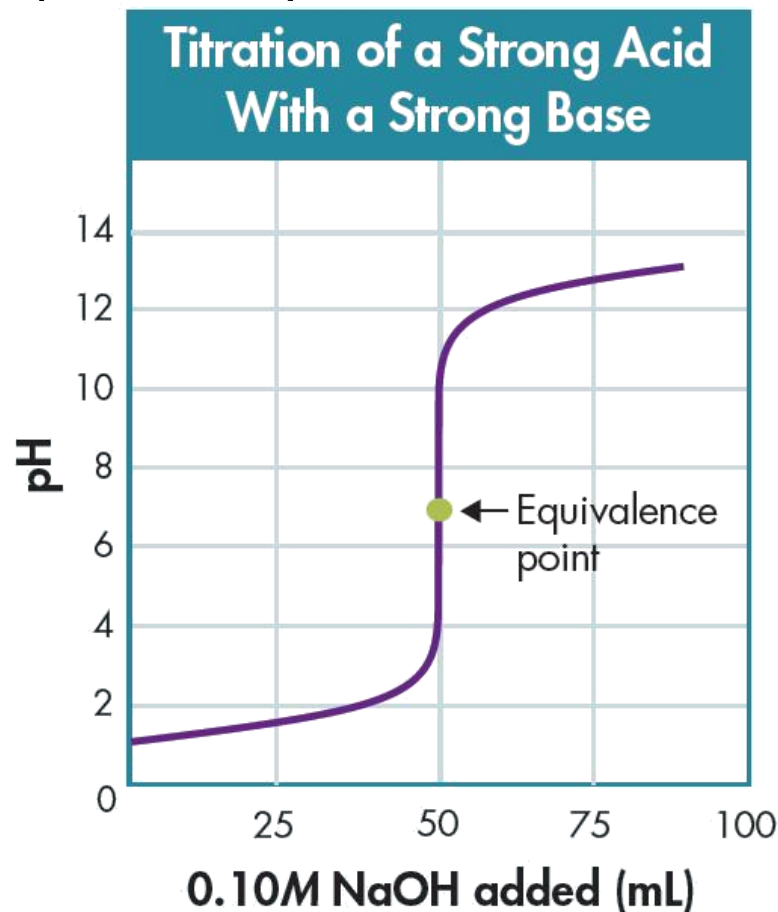
- Extending the titration beyond the point of neutralization produces a further increase of pH.



19.4 Neutralization Reactions > Interpret Graphs

This graph shows how the pH of a solution changes during the titration of a strong acid (HCl) with a strong base (NaOH).

- If the titration of HCl and NaOH could be stopped right at the equivalence point, the solution in the beaker would consist of only H_2O and NaCl, plus a small amount of indicator.



Iron compounds need to dissociate before the iron can be absorbed by plants. However, these compounds become less soluble as the pH rises. For most plants, a pH between 5.0 and 6.5 will provide enough usable iron. How could you change the pH of soil?



Iron compounds need to dissociate before the iron can be absorbed by plants. However, these compounds become less soluble as the pH rises. For most plants, a pH between 5.0 and 6.5 will provide enough usable iron. How could you change the pH of soil?

You can change the pH of basic soil by adding an acidic compound. To acidic soil you can add a basic compound.

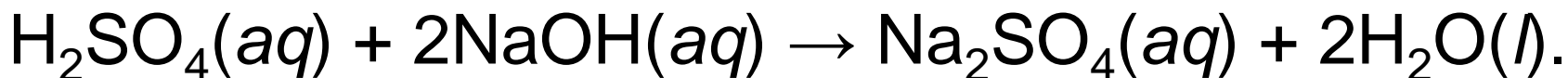


Determining Concentration by Titration

A 25-mL solution of H_2SO_4 is neutralized by 18 mL of 1.0M NaOH.

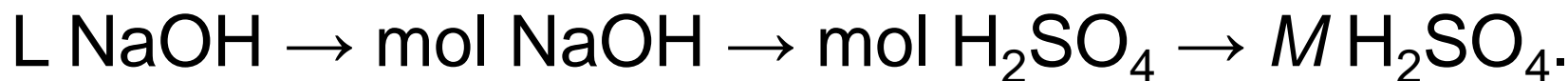
What is the concentration of the H_2SO_4 solution?

The equation for the reaction is



1 Analyze List the knowns and the unknown.

The conversion steps are as follows:

KNOWN

$$[\text{NaOH}] = 1.0M$$

$$V_{\text{NaOH}} = 18 \text{ mL} = 0.018 \text{ L}$$

$$V_{\text{H}_2\text{SO}_4} = 18 \text{ mL} = 0.018 \text{ L}$$

UNKNOWN

$$[\text{H}_2\text{SO}_4] = ?M$$

Convert volume to liters because molarity is in moles per liter.

2 Calculate Solve for the unknown.

Use the molarity to convert the volume of base to moles of base.

$$0.018 \text{ L NaOH} \times \frac{1.0 \text{ mol NaOH}}{1 \text{ L NaOH}} = 0.018 \text{ mol NaOH}$$

2 Calculate Solve for the unknown.

Use the mole ratio to find the moles of acid.

$$0.018 \text{ mol } \cancel{\text{NaOH}} \times \frac{1.0 \text{ mol H}_2\text{SO}_4}{2 \cancel{\text{ mol NaOH}}} = 0.0090 \text{ mol H}_2\text{SO}_4$$

2 Calculate Solve for the unknown.

Calculate the molarity by dividing moles of acid by liters of solution.

$$\begin{aligned}\text{molarity} &= \frac{\text{mol of solute}}{\text{L of solution}} = \frac{0.0090 \text{ mol}}{0.025 \text{ L}} \\ &= 0.36M \text{ H}_2\text{SO}_4\end{aligned}$$

3 Evaluate Does the result make sense?

- If the acid had the same molarity as the base ($1.0M$), 50 mL of base would neutralize 25 mL of acid.
- Because the volume of the base is much less than 50 mL, the molarity of the acid must be much less than $1.0M$.



In strong acids, are all ionizable hydrogens completely ionized? In weak acids?



In strong acids, are all ionizable hydrogens completely ionized? In weak acids?

In strong acids, all ionizable hydrogens are completely ionized. In weak acids, all ionizable hydrogens are partially ionized. Some hydrogens in these acids (those with larger K_a values) have a greater degree of ionization.

19.4 Neutralization Reactions > Key Concepts



In general, acids and bases react to produce a salt and water.



Neutralization occurs when the number of moles of hydrogen ions is equal to the number of moles of hydroxide ions.

19.4 Neutralization Reactions > Glossary Terms

- **neutralization reaction**: a reaction in which an acid and a base react in an aqueous solution to produce a salt and water
- **titration**: process used to determine the concentration of a solution (often an acid or base) in which a solution of known concentration (the standard) is added to a measured amount of the solution of unknown concentration until an indicator signals the end point

19.4 Neutralization Reactions > Glossary Terms

- **standard solution**: a solution of known concentration used in carrying out a titration
- **equivalence point**: the point in a titration where the number of moles of hydrogen ions equals the number of moles of hydroxide ions
- **end point**: the point in a titration at which the indicator changes color

Reactions

Chemists use acid-base reactions to determine the concentration of an acid or a base in solution.

19.4 Neutralization Reactions >

END OF 19.4