Lesson 35 Acid-Base Reactions

Key Words

neutralization: reaction between an acid and a base to make a salt and water

salt: compound of a positive ion other than H^+ and a negative ion other than OH^-

titration: process of finding the concentration of an unknown solution by reacting it with a standard solution

standard solution: solution of known concentration

end point: point in titration at which chemically equivalent amounts of acid and base are present

phenolphthalein: indicator that is colorless in the presence of an acid and red in the presence of a base

KEY IDEAS

Acids and bases neutralize each other. If the strength of one of two solutions that neutralize each other is known, titration can be used to find the strength of the second solution.

Technicians in medical and in environmental laboratories use titration to analyze solutions. These workers need to be skilled in titration techniques and must be able to interpret the results.

Neutralization. The reaction that takes place when an acid and a base react to form a salt and water is **neutralization** (noo-truhl-ih-ZAY-shun). Look at these reactions:

Equation 1

$$\underset{\text{hydrochloric acid}}{HCl} + \underset{\text{sodium hydroxide}}{NaOH} \longrightarrow \underset{\text{sodium chloride}}{NaCl} + \underset{\text{water}}{H_2O}$$

Equation 2

$$\underset{\text{nitric acid}}{HNO_3} + \underset{\text{potassium hydroxide}}{KOH} \longrightarrow \underset{\text{potassium nitrate}}{KNO_3} + \underset{\text{water}}{H_2O}$$

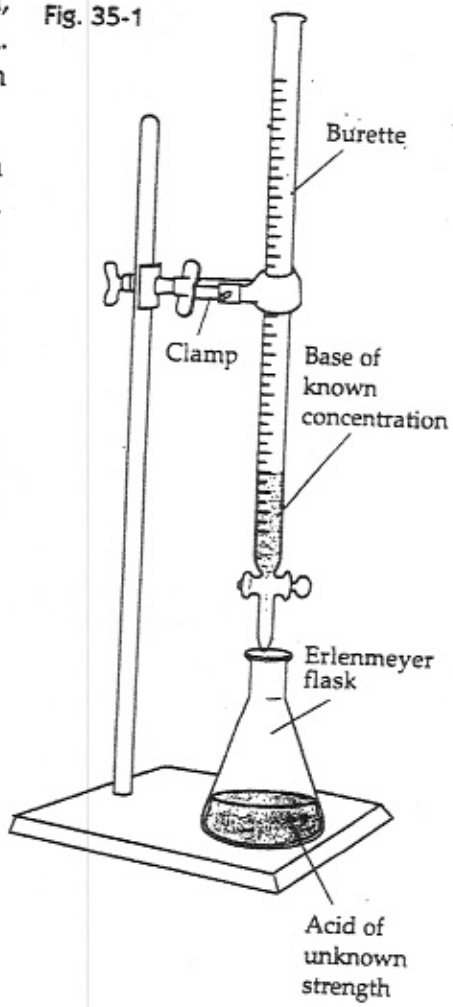
In each reaction, an acid and a base neutralize each other. In each reaction, water and a **salt** are formed. A salt is a compound with a positive ion other than the hydrogen ion—H^+—and a negative ion other than the hydroxide ion—OH^-.

The salt NaCl was formed in the first reaction. The salt KNO_3 was formed in the second reaction. In each case, the salt is the result of the combination of the positive ion from the base with the negative ion of the acid.

1. What salt would form if HCl neutralized KOH? _____

Titration. If the strength of only the acid or the base is known, the strength of the other solution can be measured by titration. **Titration** (ty-TRAY-shuhn) measures the concentration of an unknown solution by reacting it with a standard solution.

Fig. 35-1



To find the concentration of an acid, such as HCl, a burette such as the one in Fig. 35-1 is filled with a standard solution of a base, such as NaOH. The NaOH solution is titrated, or added in small amounts, into the HCl until the end point is reached. A **standard solution** is a solution of known concentration. The **end point** is that point in titration at which chemically equivalent amounts of acid and base are present.

The burette is a tool that can be used to measure the exact amount of a base of known concentration that will react with an acid of unknown strength. If phenolphthalein is present in the acid, a red color will appear at the end point. **Phenolphthalein** (fee-nohl-THAYL-een) is an indicator that is colorless in the presence of an acid and red in the presence of a base.

Sample Problem: Suppose 10 m*l* of a solution of HCl is titrated to the end point with 25.0 m*l* of 1.00 *M* NaOH. What is the molarity of the HCl solution?

$$\text{molarity} = \text{moles/liters}$$
$$1.00\ M = \text{moles of NaOH}/0.0250 \text{ liters of NaOH}$$
$$\text{moles of NaOH} = 0.0250$$

The equation for the neutralization in this problem is

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

In this equation, the moles of acid, HCl, neutralized is also 0.0250.

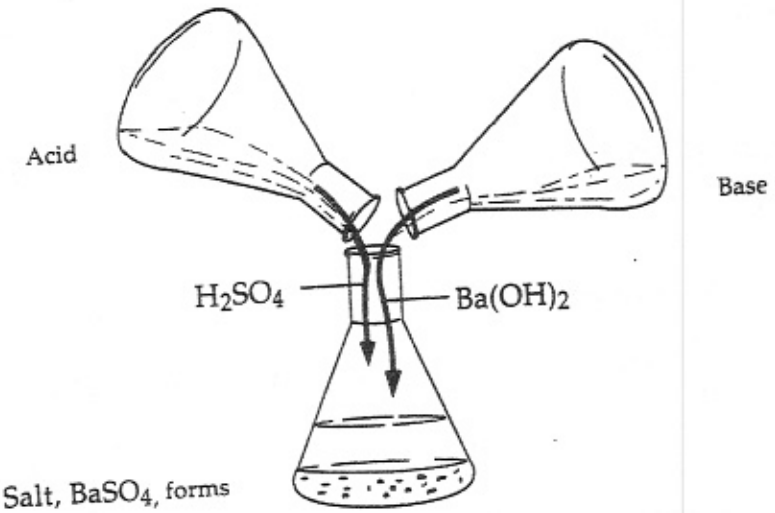
$$\text{molarity} = \text{moles/liters}$$
$$\text{molarity} = 0.0250 \text{ moles of HCl}/0.0100 \text{ liters of HCl}$$
$$\text{molarity} = 2.50\ M$$

2. What is the molarity of 25.0 m*l* of HCl solution if it is neutralized by 30.0 mL of 5.00 *M* NaOH? _____

TAKE ANOTHER LOOK

An acid and a base neutralize each other to make a salt and water. An example is the reaction of sulfuric acid—H_2SO_4—and barium hydroxide $Ba(OH)_2$. Fig. 35-2 shows $Ba(OH)_2$ neutralizing H_2SO_4. The salt barium sulfate—$BaSO_4$—is forming as a solid at the bottom of the flask.

Fig. 35-2



$$H_2SO_4 + Ba(OH)_2 \longrightarrow BaSO_4 + 2H_2O$$

Fig. 35-3

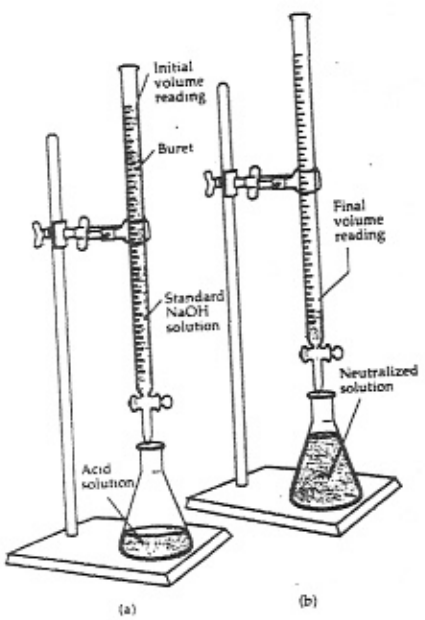


Fig. 35-3 shows the procedure for titrating HCl with a standard NaOH solution. A known volume of HCl and phenolphthalein is placed in the flask. A standard NaOH solution is poured into the burette. The volumes of the NaOH solution at the beginning and at the end of the titration are recorded. The volume of NaOH used is found by subtraction.

Check Your Understanding

Use the Key Words from the beginning of this lesson to fill in the blanks.

3. An acid and a base react to form a salt and water in a reaction called _____.

4. A compound made of a positive ion other than H^+ and a negative ion other than OH^- is a(n) _____.

5. The process used to measure the concentration of an unknown solution by reacting it with a standard solution is _____.

6. A solution of known concentration is a(n) _____.

7. The point of titration when chemically equivalent amounts of acid and base are present is the _____.

Fill in the blanks with the correct word or answer to the problem.

8. When hydrobromic acid—HBr—neutralizes NaOH, the formula of the salt is _____.

9. If the salt formed during neutralization is calcium sulfate—$CaSO_4$, the formula of the acid used is _____. The formula of the base used is _____.

10. What is the molarity of 40 m*l* of NaOH if it is completely neutralized by 10 m*l* of 6.0 *M* HCl? _____

11. How many m*l* of 2.0 *M* KOH will be needed to neutralize 30 m*l* of 0.50 *M* HNO_3? _____

12. How many liters of 2.5 *M* H_2SO_4 are needed to neutralize 2.5 liters of 5.0 *M* $Ca(OH)_2$? _____

13. A 30-m*l* sample of HCl is neutralized by 10 m*l* of 1.5 *M* KOH. What is the molarity of the HCl? _____

14. If 30 m*l* of water is added to the HCl in question 13, how much more KOH will be needed for complete neutralization? _____

Unit 6 Review

Summary

- A solution is a mixture of substances whose particles are molecular or ionic in size and are evenly spread throughout the mixture.
- Three types of solutions are gas solutions, liquid solutions, and solid solutions. In each type of solution, the solvent is present in a greater amount than the solute or solutes.
- Substances whose water solutions conduct electricity are electrolytes.
- Solubility is the amount of solute dissolved in a specific amount of solvent at a given temperature.
- Molarity is the concentration of a solution in moles per liter of solution. The concentration of a solution in moles per kilogram of solvent is molality.
- The boiling point of a water solution increases by 0.52°C. per molal solution of nonelectrolyte. The freezing point of a solution decreases by 1.86°C per molal solution of a nonelectrolyte.
- The movement of a solvent through a membrane is osmosis. The solvent flows from areas of low concentration to areas of high concentration. The pressure needed to stop osmosis is osmotic pressure.
- Arrhenius defined acids as substances that produce hydrogen ions and bases as substances that produce hydroxide ions in water solution. Bronsted-Lowry acids are defined as proton donors. Bronsted-Lowry bases are proton acceptors. An acid and a base neutralize each other to form a salt and water.
- Related acid-base pairs differ by one proton. Some substances can act as either an acid or a base.