Lesson 33 Acids and Bases

Key Words

indicator:	substance used to detect the presence of an acid or a base; acids and bases cause indicators to change color
Arrhenius acid:	substance that produces hydrogen ions when it is in water solution
Arrhenius base:	substance that produces hydroxide ions when it is in water solution
Bronsted-Lowry acid:	a proton donor
Bronsted-Lowry base:	a proton acceptor
hydronium ion:	a hydrated proton or H_3O^+

KEY IDEAS

Observing the properties of acids and bases has led to two main theories. One is the Arrhenius theory, which states that acids produce hydrogen ions and bases produce hydroxide ions. The other is the Bronsted-Lowry theory, which states that acids are proton donors and bases are proton acceptors.

In recent years, acid rain has become a serious environmental problem. Some technicians are working on ways to prevent acid rain from forming. Other workers are trying to cope with the effects of acid rain pollution that have already occurred.

Properties of Acids and Bases. Acids have the following observed properties:

- Acids dissolved in water are electrolytes, which conduct an electric current.
- Acids have a sour taste. Examples are the acids in vinegar and lemon juice.
- Acids react with many metals to produce hydrogen gas.
- Acids change the color of some indicators. An **indicator** (IN-duh-KAYT-uhr) is a substance used to detect the presence of an acid or a base. In the presence of an acid, blue litmus turns red, and red phenolphthalein becomes colorless.
- Acids neutralize bases to produce a salt and water.

Bases have the following observed properties:

- Bases dissolved in water are electrolytes.
- Bases feel slippery.

- Bases change the colors of some indicators. In the presence of a base, red litmus turns blue, and colorless phenolphthalein turns red.
- Bases neutralize acids to produce a salt and water.

1. **What color is litmus in the presence of an acid?** _____

2. **What color is phenolphthalein in the presence of a base?** _____

Arrhenius Theory. Arrhenius proposed a theory to explain the behavior of acids and bases. An **Arrhenius acid** (uh-RAY-nee-uhs) is a substance that produces hydrogen ions (H^+) as the only positive ions in water solution. Here is an example:

Equation 1 $\quad HCl\ (in\ H_2O) \longrightarrow H^+ + Cl^-$

An **Arrhenius base** is a substance that produces hydroxide ions (OH^-) as the only negative ions in water solution. Here is an example:

Equation 2 $\quad NaOH\ (in\ H_2O) \longrightarrow Na^+ + OH^-$

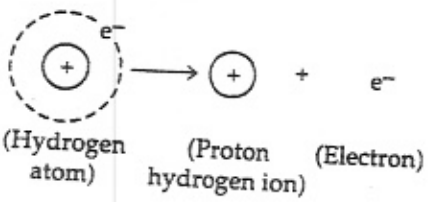
3. **Which symbol represents the hydrogen ion? The hydroxide ion?**

_____

Bronsted-Lowry Theory. Bronsted and Lowry proposed another theory to explain acid and base reactions that take place in either a water or a nonwater medium. According to this theory, a **Bronsted-Lowry acid** (BRAHN-stehd LOW-ree) is a proton donor. A **Bronsted-Lowry base** is a proton acceptor.

Recall that the hydrogen atom consists of one proton and one electron. As shown in Fig. 33-1, when a hydrogen atom loses an electron, only a proton remains. Thus, a hydrogen ion is a proton.

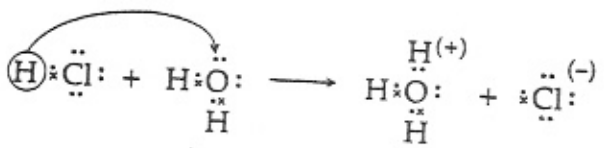
Fig. 33-1



Equation 3 shows HCl reacting with H_2O to produce hydronium ion (H_3O^+).

Equation 3 $\quad HCl + H_2O \longrightarrow H_3O^+ + Cl^-$

Fig. 33-2



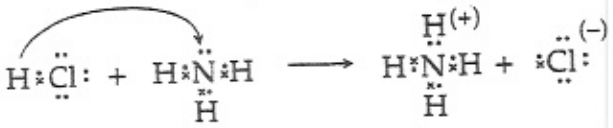
In the electron-dot diagrams shown in Fig. 33-2, you can see that a proton moves from the HCl to the H_2O. A hydronium ion—H_3O^+—is formed. The **hydronium ion** (hy-DROH-nee-uhm) is also called a hydrated proton because the proton is attached to a water molecule.

4. What is the formula for the hydronium ion? _____

An acid can give its proton to other substances besides water. In the reaction below, HCl loses its proton to ammonia, NH_3, forming an ammonium ion NH_4^+. This example shows that it is not necessary for the base to contain hydroxide OH^-. See Equation 4 and Fig. 33-3.

Equation 4 $$HCl + NH_3 \longrightarrow NH_4^+ + Cl^-$$

Fig. 33-3



A base, such as NaOH, accepts a proton from an acid, such as HCl.

Equation 5 $$NaOH + HCl \longrightarrow HOH + Na^+ + Cl^-$$

It is not necessary for a base to contain OH^-. For example, in Equation 4 in the reaction between HCl and NH_3, the base is NH_3.

TAKE ANOTHER LOOK

You've seen how electron-dot diagrams represent water molecules, hydroxide ions, and hydronium ions. Fig. 33-4 shows how these particles can be pictured as models made of spheres.

Fig. 33-4

Water molecule H_2O | Hydroxide ion OH^- | Hydronium ion H_3O^+

Indicators appear as different colors in acids and bases. The chart in Fig. 33-5 compares colors of various indicators.

Fig. 33-5

Table of Indicator Colors

Indicator	Color	
	Acid	Base
alizarin yellow	yellow	violet
bromthymol blue	yellow	blue
litmus	red	blue
methyl red	red	yellow
phenolphthalein	colorless	red
phenol red	yellow	red

Check Yo Understandi

Fill in the blanks.

5. According to Arrhenius, an acid produces _____ ions and a base produces _____ ions.
6. The Bronsted-Lowry theory states that an acid is a(n) _____ and a base is a(n) _____.
7. A hydrated proton is called a(n) _____ ion and has the formula _____.

On the lines under the following equations, write the word *acid* or *base* to identify the substance as either a proton donor or a proton acceptor.

8. $HCl + H_2O \longrightarrow H_3O^+ + Cl^-$

   _____ _____

9. $H_2O + NH_3 \longrightarrow NH_4^+ + OH^-$

   _____ _____

Write the correct term in each blank.

10. One property of acids is their _____ taste.
11. In an acid solution, the color of litmus is _____.
12. Compounds that produce hydrogen ions in a water solution are _____.
13. In a base solution, the color of phenolphthalein is _____.
14. One property of bases is their _____ feel.
15. A(n) _____ is any substance used to detect the presence of an acid or a base.

If the statement is correct, write the word *True*. If the statement is incorrect, write the word *False*.

16. _____ Acids and bases are both electrolytes.
17. _____ A base is a proton acceptor.
18. _____ The formula for the hydronium ion is OH^-.
19. _____ A hydrated proton is called a hydroxide.
20. _____ An acid must always give its proton to water.