

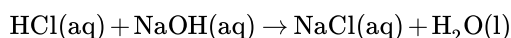
## 1.11.7: Reactions of Acids and Bases

### Learning Objectives

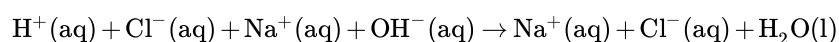
- Write acid-base neutralization reactions.
- Write reactions of acids with metals.
- Write reactions of bases with metals.

### Neutralization Reactions

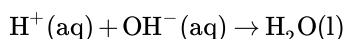
The reaction that happens when an acid, such as  $\text{HCl}$ , is mixed with a base, such as  $\text{NaOH}$ :



When an acid and a base are combined, water and a salt are the products. Salts are ionic compounds containing a positive ion other than  $\text{H}^+$  and a negative ion other than the hydroxide ion,  $\text{OH}^-$ . Double displacement reactions of this type are called **neutralization reactions**. We can write an expanded version of this equation, with aqueous substances written in their longer form:



After removing the spectator ions, we get the net ionic equation:



When a strong acid and a strong base are combined in the proper amounts—when  $[\text{H}^+]$  equals  $[\text{OH}^-]$ —a neutral solution results in which  $\text{pH} = 7$ . The acid and base have neutralized each other, and the acidic and basic properties are no longer present.

Salt solutions do not always have a  $\text{pH}$  of 7, however. Through a process known as **hydrolysis**, the ions produced when an acid and base combine may react with the water molecules to produce a solution that is slightly acidic or basic. As a general concept, if a strong acid is mixed with a weak base, the resulting solution will be slightly acidic. If a strong base is mixed with a weak acid, the solution will be slightly basic.



Video: Equimolar ( $\sim 0.01 \text{ M}$ ) and equivolume solutions of  $\text{HCl}$  and  $\text{NaOH}$  are combined to make salt water. <https://youtu.be/TS-I9KrUjB0>

### ✓ Example 1.11.7.1: Propionic Acid + Calcium Hydroxide

Calcium propionate is used to inhibit the growth of molds in foods, tobacco, and some medicines. Write a balanced chemical equation for the reaction of aqueous propionic acid ( $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$ ) with aqueous calcium hydroxide [ $\text{Ca}(\text{OH})_2$ ].

#### Solution

Solutions to Example 14.5.1

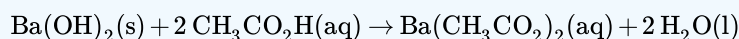
Steps	Reaction

Steps	Reaction
<p><i>Write the unbalanced equation.</i></p> <p>This is a double displacement reaction, so the cations and anions swap to create the water and the salt.</p>	$\text{CH}_3\text{CH}_2\text{CO}_2\text{H}(\text{aq}) + \text{Ca}(\text{OH})_2(\text{aq}) \rightarrow (\text{CH}_3\text{CH}_2\text{CO}_2)_2\text{Ca}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
<p><i>Balance the equation.</i></p> <p>Because there are two <math>\text{OH}^-</math> ions in the formula for <math>\text{Ca}(\text{OH})_2</math>, we need two moles of propionic acid, <math>\text{CH}_3\text{CH}_2\text{CO}_2\text{H}</math>, to provide <math>\text{H}^+</math> ions.</p>	$2\text{CH}_3\text{CH}_2\text{CO}_2\text{H}(\text{aq}) + \text{Ca}(\text{OH})_2(\text{aq}) \rightarrow (\text{CH}_3\text{CH}_2\text{CO}_2)_2\text{Ca}(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$

### ? Exercise 1.11.7.1

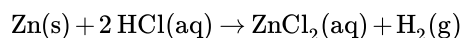
Write a balanced chemical equation for the reaction of solid barium hydroxide with dilute acetic acid.

**Answer**

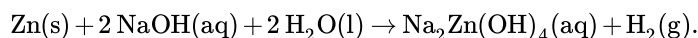


## Acids and Bases React with Metals

Acids react with most metals to form a salt and hydrogen gas. As discussed previously, metals that are more active than acids can undergo a **single displacement reaction**. For example, zinc metal reacts with hydrochloric acid, producing zinc chloride and hydrogen gas.



Bases also react with certain metals, like zinc or aluminum, to produce hydrogen gas. For example, sodium hydroxide reacts with zinc and water to form sodium zincate and hydrogen gas.



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