

7.9: Acid-Base and Gas Evolution Reactions

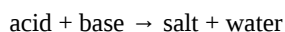


Learning Objectives

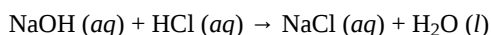
- Identify when a reaction will evolve a gas.

Neutralization Reactions

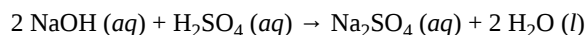
Acids and bases react chemically with each other to form **salts**. A salt is a general chemical term for any ionic compound formed from an acid and a base. In reactions where the acid is a hydrogen-ion-containing compound and the base is a hydroxide-ion-containing compound, water is also a product. The general reaction is as follows:



The reaction of acid and base to make water and a salt is called **neutralization**. Like any chemical equation, a neutralization chemical equation must be properly balanced. For example, the neutralization reaction between sodium hydroxide and hydrochloric acid is as follows:



with coefficients all understood to be one. The neutralization reaction between sodium hydroxide and sulfuric acid is as follows:

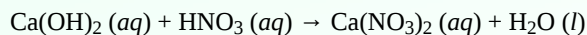


Example 7.9.1: Neutralizing Nitric Acid

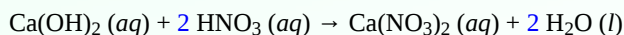
Nitric acid, $\text{HNO}_3 (aq)$, can be neutralized by calcium hydroxide, $\text{Ca(OH)}_2 (aq)$. Write a balanced chemical equation for the reaction between these two compounds and identify the salt that it produces.

Solution

Write the unbalanced equation. This is a double replacement reaction, so the cations and anions swap to create new products. Referring to the [solubility rules](#), $\text{Ca(NO}_3)_2$ is soluble in water resulting in a phase label of (aq) . Water, H_2O , is a liquid at room temperature resulting in a phase label of (l) .



At this point, the equation may be balanced by placing a coefficient of "2" in front of $\text{HNO}_3 (aq)$ and $\text{H}_2\text{O} (l)$.



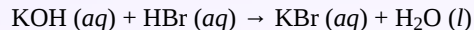
The salt formed is calcium nitrate, $\text{Ca(NO}_3)_2 (aq)$.



Exercise 7.9.1

Hydrobromic acid, $\text{HBr} (aq)$, may be neutralized with potassium hydroxide, $\text{KOH} (aq)$. Write a balanced chemical equation for the reaction between these two compounds and identify the salt that it produces.

Answer



The salt is potassium bromide, $\text{KBr} (aq)$.

Gas Evolving Reactions

Figure 7.9.1 shows an apparatus that may be used for collecting gases in the laboratory.

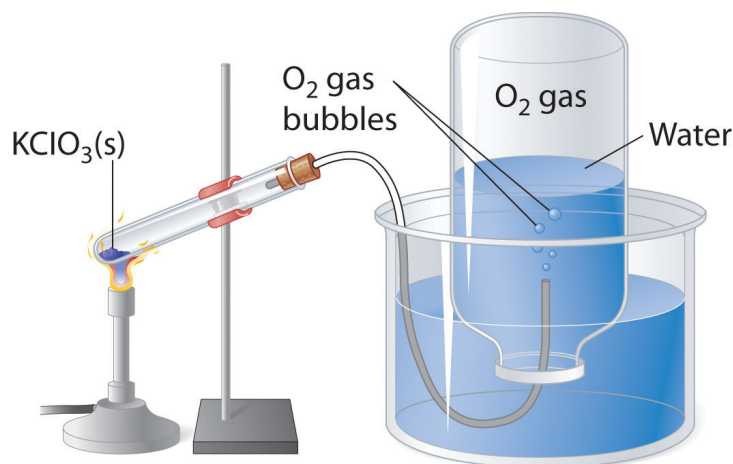
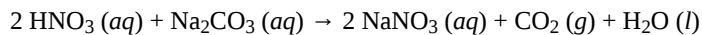


Figure 7.9.1: An apparatus for collecting gases by the displacement of water.

A gas evolution reaction is a chemical process that produces a gas, such as hydrogen or carbon dioxide. In the following examples, an acid reacts with a carbonate, producing salt, carbon dioxide, and water, respectively. For example, nitric acid reacts with sodium carbonate to form sodium nitrate, carbon dioxide, and water (Table 7.9.1):



Hydrochloric acid reacts with calcium carbonate to form calcium chloride, carbon dioxide, and water:

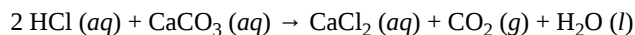
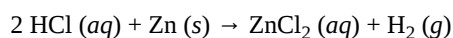


Table 7.9.1: Types of Compounds That Undergo Gas-Evolution Reactions

Reactant Type	Intermediate Product	Gas Evolved	Example
sulfide	none	H_2S	$2 \text{HCl} (aq) + \text{K}_2\text{S} (aq) \rightarrow \text{H}_2\text{S} (g) + 2 \text{KCl} (aq)$
carbonates and bicarbonates	H_2CO_3	CO_2	$2 \text{HCl} (aq) + \text{K}_2\text{CO}_3 (aq) \rightarrow \text{H}_2\text{CO}_3 (aq) + 2 \text{KCl} (aq)$ Final Equation: $2 \text{HCl} (aq) + \text{K}_2\text{CO}_3 (aq) \rightarrow \text{H}_2\text{O} (l) + \text{CO}_2 (g) + 2 \text{KCl} (aq)$

Reactant Type	Intermediate Product	Gas Evolved	Example
sulfites and bisulfites	H_2SO_3	SO_2	$2 \text{HCl (aq)} + \text{K}_2\text{SO}_3 \text{ (aq)} \rightarrow \text{H}_2\text{SO}_3 \text{ (aq)} + 2 \text{KCl (aq)}$ <p>Final Equation:</p> $2 \text{HCl (aq)} + \text{K}_2\text{SO}_3 \text{ (aq)} \rightarrow \text{H}_2\text{O (l)} + \text{SO}_2 \text{ (g)} + 2 \text{KCl (aq)}$
ammonia	NH_4OH	NH_3	$\text{NH}_4\text{Cl (aq)} + \text{KOH (aq)} \rightarrow \text{NH}_4\text{OH (aq)} + 2 \text{KCl (aq)}$ <p>Final Equation:</p> $\text{NH}_4\text{Cl (aq)} + \text{KOH (aq)} \rightarrow \text{H}_2\text{O (l)} + \text{NH}_3 \text{ (g)} + 2 \text{KCl (aq)}$

The oxidation of metals by strong acids is another common example of a gas evolution reaction. This reaction will yield a metal salt and hydrogen gas.



Here, hydrochloric acid oxidizes zinc to produce an aqueous metal salt and hydrogen gas bubbles.

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