

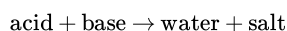
10.5.2: Acid–Base and Gas Evolution Reactions

Learning Objectives

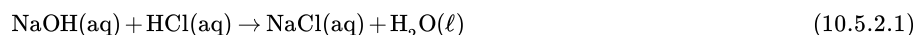
- Identify when a reaction will evolve a gas.

Neutralization Reactions

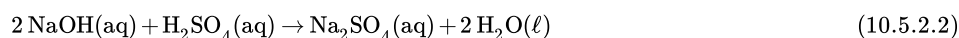
Acids and bases react chemically with each other to form *salts*. A salt is a general chemical term for any ionic compound formed from an acid and a base. In reactions where the acid is a hydrogen-ion-containing compound and the base is a hydroxide-ion-containing compound, water is also a product. The 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 10.5.2.1: Neutralizing Nitric Acid

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

Solution

Solutions to Example 7.8.1

Steps	Explanation	Equation
Write the unbalanced equation.	This is a double displacement reaction, so the cations and anions swap to create new products.	$\text{Ca(OH)}_2\text{(aq)} + \text{HNO}_3\text{(aq)} \rightarrow \text{Ca(NO}_3)_2\text{(aq)} + \text{H}_2\text{O(l)}$
Balance the equation.	Because there are two OH^- ions in the formula for Ca(OH)_2 , we need two moles of HNO_3 to provide H^+ ions	$\text{Ca(OH)}_2\text{(aq)} + 2\text{HNO}_3\text{(aq)} \rightarrow \text{Ca(NO}_3)_2\text{(aq)} + 2\text{H}_2\text{O(l)}$
Additional step: identify the salt.		The salt formed is calcium nitrate.

? Exercise 10.5.2.1

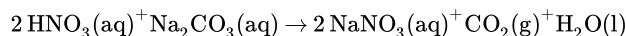
Hydrocyanic acid (HCN(aq)) can be neutralized by potassium hydroxide (KOH(aq)). Write a balanced chemical equation for the reaction between these two compounds and identify the salt that it produces.

Answer

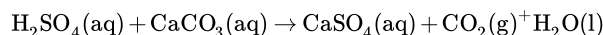


Gas Evolving Reactions

A gas evolution reaction is a chemical process that produces a gas, such as oxygen 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 10.5.2.1):



Sulfuric acid reacts with calcium carbonate to form calcium sulfate, carbon dioxide, and water:



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



Figure 10.5.2.1 demonstrates this type of reaction:

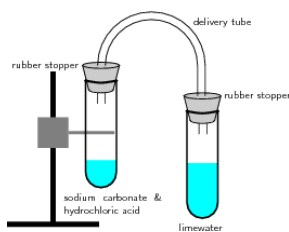


Figure 10.5.2.1: Reaction of acids with carbonates. In this reaction setup, lime water (water + calcium hydroxide) is poured into one of the test tubes and sealed with a stopper. A small amount of hydrochloric acid is carefully poured into the remaining test tube. A small amount of sodium carbonate is added to the acid, and the tube is sealed with a rubber stopper. The two tubes are connected. As a result of the acid-carbonate reaction, carbon dioxide is produced and the lime water turns milky.

In this reaction setup, lime water, a dilute calcium hydroxide ($\text{Ca}(\text{OH})_2$) solution, is poured into one of the test tubes and sealed with a stopper. A small amount of hydrochloric acid is carefully poured into the remaining test tube. A small amount of sodium carbonate is added to the acid, and the tube is sealed with a rubber stopper. The two tubes are connected. As a result of the acid-carbonate reaction, carbon dioxide is produced and the lime water turns milky.

Table 10.5.2.1: Types of Compounds That Undergo Gas-Evolution Reactions

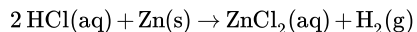
Reactant Type	Intermediate Product	Gas Evolved	Example
sulfide	none	H_2S	$2\text{HCl}(\text{aq}) + \text{K}_2\text{S} \rightarrow \text{H}_2\text{S}(\text{g}) + 2\text{KCl}(\text{aq})$
carbonates and bicarbonates	H_2CO_3	CO_2	$2\text{HCl}(\text{aq}) + \text{K}_2\text{CO}_3 \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g}) + 2\text{KCl}(\text{aq})$
sulfites and bisulfites	H_2SO_3	SO_2	$2\text{HCl}(\text{aq}) + \text{K}_2\text{SO}_3 \rightarrow \text{H}_2\text{O}(\text{l}) + \text{SO}_2(\text{g}) + 2\text{KCl}(\text{aq})$
ammonia	NH_4OH	NH_3	$\text{NH}_4\text{Cl}(\text{aq}) + \text{KOH}(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{NH}_3(\text{g}) + \text{KCl}(\text{aq})$

The gas-evolving experiment lime water is illustrated in the following video:



Video 10.5.2.1: Carbon Dioxide (CO_2) & Limewater (Chemical Reaction). As the reaction proceeds, the limewater turns from clear to milky; this is due to the $\text{CO}_2(\text{g})$ reacting with the aqueous calcium hydroxide to form calcium carbonate, which is only slightly soluble in water.

When this experiment is repeated with nitric or sulfuric acid instead of HCl , it yields the same results: the clear limewater turns milky, indicating the production of carbon dioxide. Another method to chemically generate gas is the oxidation of metals in acidic solutions. 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. Recall that oxidation refers to a loss of electrons, and reduction refers to the gain of electrons. In the above redox reaction, neutral zinc is oxidized to Zn^{2+} , and the acid, H^+ , is reduced to $\text{H}_2(\text{g})$. The oxidation of metals by strong acids is another common example of a gas evolution reaction.

Contributors & Affiliations

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