Pearson

8.8: Gas-Evolution Reactions

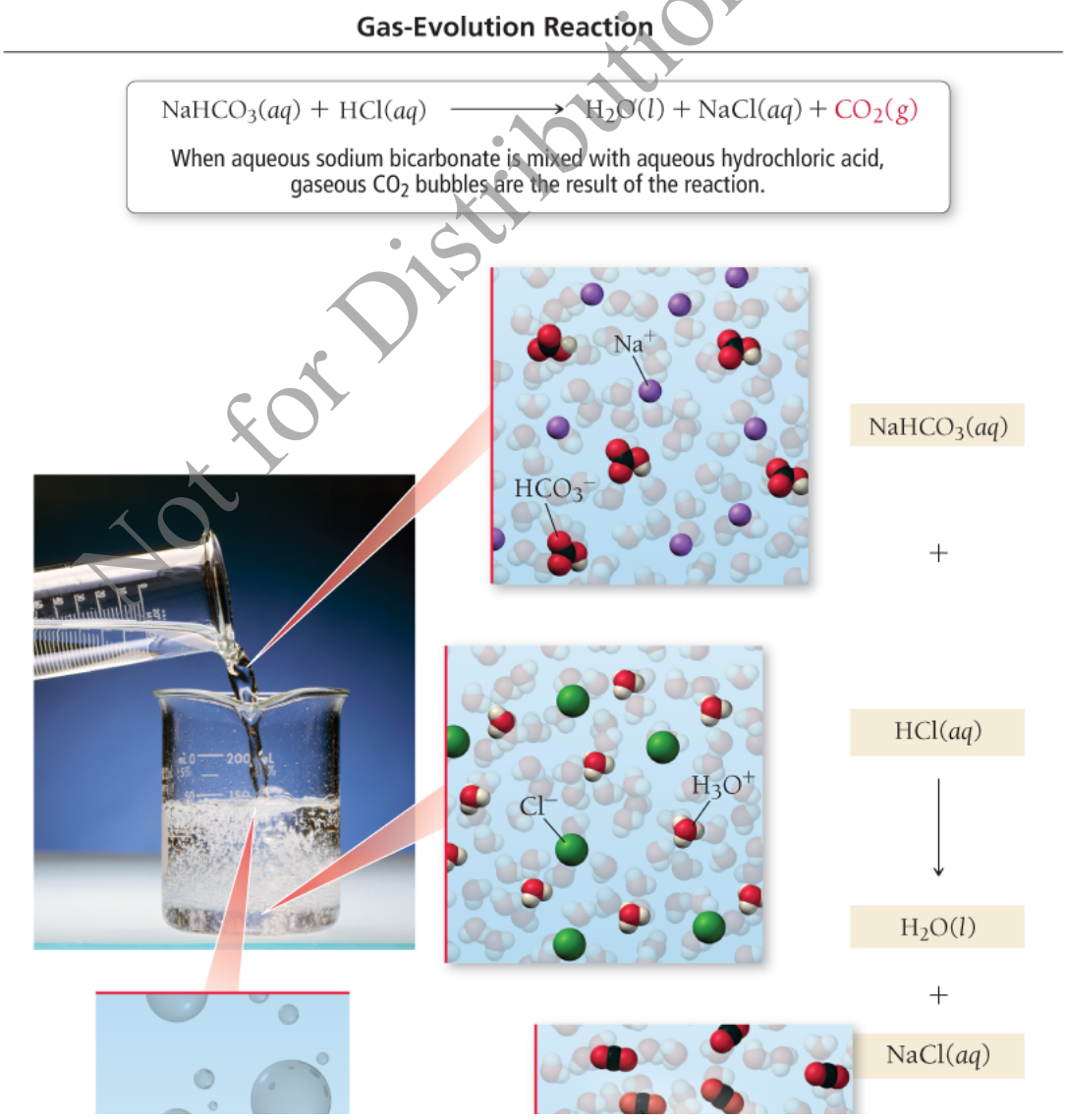
In a **gas-evolution reaction**, a gas forms, resulting in bubbling. As in precipitation reactions (see Section 8.5), the reactions occur when the anion from one reactant combines with the cation of the other. Many gas-evolution reactions are also acid–base reactions. Some gas-evolution reactions form a gaseous product directly when the cation of one reactant combines with the anion of the other. For example, when sulfuric acid reacts with lithium sulfide, dihydrogen sulfide gas forms:

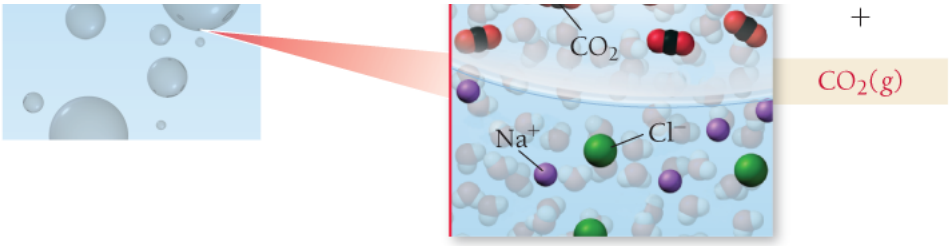
$$H_2SO_4\,(aq) + Li_2S\,(aq) \rightarrow \underset{\text{gas}}{H_2S\,(g)} + Li_2SO_4\,(aq)$$

Other gas-evolution reactions form an intermediate product that then decomposes (breaks down into simpler substances) to form a gas. For example, when aqueous hydrochloric acid is mixed with aqueous sodium bicarbonate, the following reaction occurs (Figure 8.20):

$$HCl\,(aq) + NaHCO_3\,(aq) \rightarrow \underset{\text{intermediate product}}{H_2CO_3\,(aq)} + NaCl\,(aq) \rightarrow H_2O\,(l) + \underset{\text{gas}}{CO_2\,(g)} + NaCl\,(aq)$$

Figure 8.20 Gas-Evolution Reaction





Gas-evolution reactions, such as the reaction of hydrochloric acid with limestone ($CaCO_3$), often produce CO_2; bubbling occurs as the gas is released.

The intermediate product, H_2CO_3, is not stable and decomposes into H_2O and gaseous CO_2. Other important gas-evolution reactions form either H_2SO_3 or NH_4OH as intermediate products:

$$HCl\,(aq) + NaHSO_3\,(aq) \rightarrow \underset{\text{intermediate product}}{H_2SO_3\,(aq)} + NaCl\,(aq) \rightarrow H_2O\,(l) + \underset{\text{gas}}{SO_2\,(g)} + NaCl\,(aq)$$

$$NH_4Cl\,(aq) + NaOH\,(aq) \rightarrow \underset{\text{intermediate product}}{NH_4OH\,(aq)} + NaCl\,(aq) \rightarrow H_2O\,(l) + \underset{\text{gas}}{NH_3\,(g)} + NaCl\,(aq)$$

> The intermediate product NH_4OH provides a convenient way to think about this reaction, but the extent to which it actually forms is debatable.

Table 8.3 lists the main types of compounds that form gases in aqueous reactions, as well as the gases that form.

Table 8.3 Types of Compounds That Undergo Gas-Evolution Reactions

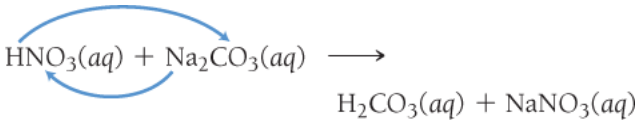
Reactant Type	Intermediate Product	Gas Evolved	Example
Sulfides	None	H_2S	$2\,HCl(aq) + K_2S(aq) \longrightarrow H_2S(g$
Carbonates and bicarbonates	H_2CO_3	CO_2	$2\,HCl(aq) + K_2CO_3(aq) \longrightarrow H_2($
Sulfites and bisulfites	H_2SO_3	SO_2	$2\,HCl(aq) + K_2SO_3(aq) \longrightarrow H_2($
Ammonium	NH_4OH	NH_3	$NH_4Cl(aq) + KOH(aq) \longrightarrow H_2C$

Example 8.14 Writing Equations for Gas-Evolution Reactions

Write a molecular equation for the gas-evolution reaction that occurs when you mix aqueous nitric acid

and aqueous sodium carbonate.

Begin by writing an unbalanced equation in which the cation of each reactant combines with the anion of the other.



$$HNO_3(aq) + Na_2CO_3(aq) \longrightarrow H_2CO_3(aq) + NaNO_3(aq)$$

You must then recognize that $H_2CO_3\,(aq)$ decomposes into $H_2O\,(l)$ and $CO_2\,(g)$ and write these products into the equation.

$$HNO_3\,(aq) + Na_2CO_3\,(aq) \rightarrow H_2O\,(l) + CO_2\,(g) + NaNO_3\,(aq)$$

Finally, balance the equation.

$$2\,HNO_3\,(aq) + Na_2CO_3\,(aq) \rightarrow H_2O\,(l) + CO_2\,(g) + 2\,NaNO_3\,(aq)$$

FOR PRACTICE 8.14 Write a molecular equation for the gas-evolution reaction that occurs when you mix aqueous hydrobromic acid and aqueous potassium sulfite.

FOR MORE PRACTICE 8.14 Write a net ionic equation for the reaction that occurs when you mix hydroiodic acid with calcium sulfide.