7.6: Combustion Reactions

Learning Objectives

- Recognize a reaction as a combustion reaction.
- Complete and balance chemical equations for combustion reactions.

A **combustion reaction** is a reaction in which a substance reacts with oxygen gas, releasing energy in the form of light and heat. Combustion reactions involve O_2 as one reactant. The combustion of hydrogen gas producing water vapor qualifies as a combustion reaction:

$$2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (g)$$

The *Hindenberg* was a hydrogen-filled airship that suffered an accident upon its attempted landing in New Jersey in 1937. The hydrogen immediately combusted in a huge fireball, destroying the airship and killing 36 people. The chemical reaction was a simple one: hydrogen combining with oxygen to produce water.

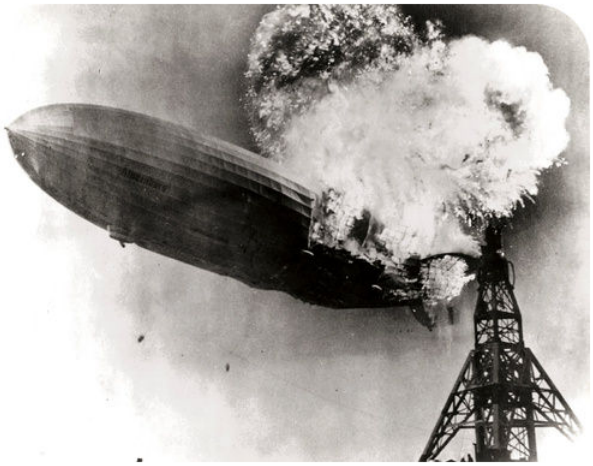

Figure 7.6.1: Explosion of the Hindenberg.

Many combustion reactions occur with a hydrocarbon, a compound comprised solely of carbon and hydrogen. The products of the complete combustion of hydrocarbons are carbon dioxide and water. Many hydrocarbons are used as fuel because their combustion releases very large amounts of heat energy. Propane, C_3H_8, is a gaseous hydrocarbon that is commonly used as the fuel source in gas grills.

$$C_3H_8\ (g) + 5\ O_2\ (g) \rightarrow 3\ CO_2\ (g) + 4\ H_2O\ (g)$$

As a general rule, combustion of a reactant that contains:

- carbon will yield carbon dioxide, CO_2, as one of the products.
- hydrogen will yield water, H_2O, as one of the products.
- sulfur will yield sulfur dioxide, SO_2, as one of the products.

When the supply of oxygen becomes limited, incomplete combustion typically occurs. The incomplete combustion carbon or carbon-containing compounds leads to the production of carbon monoxide, CO, in addition to carbon dioxide. In this text, however, complete combustion will always be assumed to occur unless otherwise specified.

✅ Example 7.6.1: Combustion of Ethanol

Ethanol (C_2H_5OH) may be used as a fuel source in an alcohol lamp. Write the balanced chemical equation that shows the combustion of ethanol.

Solution

Combustion is a reaction in which a substance reacts with oxygen gas.

$$C_2H_5OH\ (l) + O_2\ (g) \rightarrow$$

Since C_2H_5OH contains carbon, CO_2 will be one of the products. Since it also contains hydrogen, H_2O will be another product. H_2O is produced in the gaseous phase due to the high temperatures that accompany combustion reactions.

$$C_2H_5OH\ (l) + O_2\ (g) \rightarrow CO_2\ (g) + H_2O\ (g)$$

Carbon atoms are balanced by placing a coefficient of "2" in front of CO_2 (g). Hydrogen atoms are balanced by placing a "3" in front of H_2O (g).

$$C_2H_5OH\ (l) + O_2\ (g) \rightarrow 2\ CO_2\ (g) + 3\ H_2O\ (g)$$

The simplest formula, O_2 (g), is balanced last using a coefficient of "3".

$$C_2H_5OH\ (l) + 3\ O_2\ (g) \rightarrow 2\ CO_2\ (g) + 3\ H_2O\ (g)$$

Exercise 7.6.1: Combustion of Hexane

Write the balanced equation for the combustion of hexane, C_6H_{14}, which is a liquid at room temperature.

Answer

$2\ C_6H_{14}\ (l) + 19\ O_2\ (g) \rightarrow 12\ CO_2\ (g) + 14\ H_2O\ (g)$