CONCEPT 3

Most combustion reactions release heat and light.

A **combustion reaction** is a chemical reaction in which a compound or element reacts with oxygen to form compounds called oxides. The oxides contain oxygen and the elements that make up the reactant compound. For example, sulfur (or compounds containing sulfur) will react with oxygen in a combustion reaction to produce sulfur dioxide, $SO_2(g)$.

$$S_8(s) + 8O_2(g) \rightarrow 8SO_2(g)$$

This reaction is one of the main sources of air pollution, as shown in Figure 2.34. The diagram also shows the impact of a similar reaction that involves nitrogen and oxygen. These products, sulfur dioxide and nitrogen dioxide, undergo a synthesis reaction with water to produce a type of compound called an acid. You will investigate acids and their impact on the environment in Concept 4.

Another feature of combustion reactions is that many produce heat and light. The burning of fuels such as natural gas and gasoline involves the combustion of a type of compound called a hydrocarbon. Hydrocarbons are compounds made up of just two elements: carbon and hydrogen. A general equation for the combustion of hydrocarbons is

$$C_xH_y + O_2 \rightarrow CO_2 + H_2O$$

In this general equation, C_xH_y is a general formula for hydrocarbons, with x representing the number of carbon atoms and y representing the number of hydrogen atoms that make up the compound. Figure 2.35 shows some examples of common combustion reactions.

combustion reaction a chemical reaction in which an element reacts with oxygen to produce an oxide of the element and heat; also refers to the burning of hydrocarbons to produce carbon dioxide and water

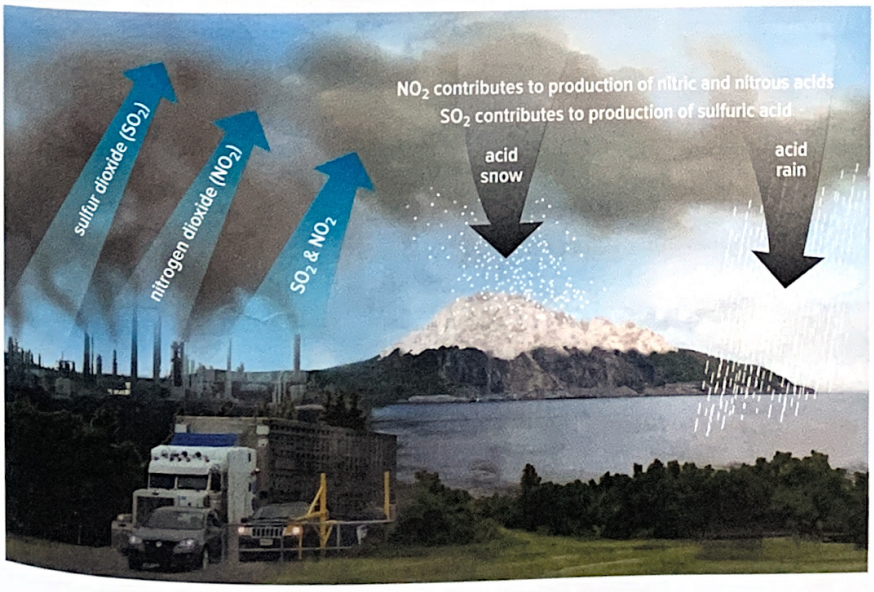


Figure 2.34 Key sources of SO_2 and NO_2. **Questioning: What sources of these pollutants are identified in this Figure? What effects do they have on human health and the environment?**

Methane Combustion

Methane, $CH_4(g)$, is a hydrocarbon that is the main component in natural gas. The flame and heat produced when using a gas stove is due to the combustion of methane. The balanced chemical equation for the complete combustion of methane is

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

Gasoline Combustion

Gasoline is a mixture of different hydrocarbons. Fuels are graded based on their octane rating. The greater the amount of octane present, the higher the quality of fuel. The combustion of octane is represented by the equation

$$2C_8H_{18}(\ell) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$$

Propane Combustion

Propane, $C_3H_8(g)$, is a common fuel with several applications. Small propane torches like this one are often used by professionals, such as plumbers, and many people have them in their homes. Propane is also used as a heating fuel, with both indoor and outdoor heaters available. You are probably most familiar with its use as fuel for barbecues. Regardless of what the combustion of propane is used for, its combustion is represented by the equation

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

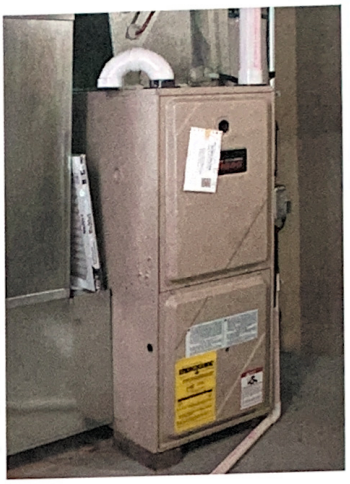
Figure 2.35 Our society depends on combustion reactions for transportation, cooking, and heating **Analyzing: Are these combustion reactions exothermic or endothermic? What evidence supports your answer?**

Extending the Connections

Combustion and Greenhouse Gases

The greenhouse effect is a natural part of Earth's climate system and helps to regulate Earth's temperature. Which greenhouse gases occur naturally, and which are the result of human activity? What role does combustion play in the greenhouse effect? Develop three questions that you have about this topic, and decide how you could investigate answers to them.

Figure 2.36 These are places where carbon monoxide produced from the incomplete combustion of fuels can occur. Accumulation of carbon monoxide in the air can be hazardous. **Applying: Identify sources in your home where carbon monoxide could be produced.**



Incomplete Combustion

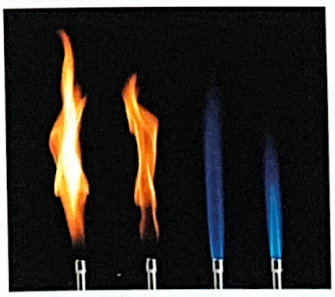
If the supply of oxygen is too low, incomplete combustion occurs. Like complete combustion, incomplete combustion produces carbon dioxide and water. But it also results in other products such as carbon (soot) and carbon monoxide. Carbon monoxide is a colourless, odourless, highly toxic gas. You have probably heard or read warnings about the dangers associated with using camp stoves or propane barbecues indoors, or ever letting a car run in a closed garage. A poorly ventilated fireplace can also be dangerous. In fact, the burning of any fuels, such as gasoline, natural gas, oil, or wood, within a home or garage is potentially dangerous (**Figure 2.36**). If there is not enough oxygen, incomplete combustion results and carbon monoxide is produced. That's why carbon monoxide detectors like the one shown in **Figure 2.37** are necessary.

Figure 2.37 Homes with appliances or other equipment that burn fossil fuels and/or wood should have carbon monoxide detectors.

Activity

Considering Combustion

Methane is the hydrocarbon in natural gas used for school Bunsen burners. The photo shows two sets of burner flames. One set shows complete combustion; the other shows incomplete combustion. Which is which? What could explain the differences you observe in the flames? Share your ideas and reasoning with your teacher, who will decide how they can be explored safely in the lab or with video demonstrations.



Before you leave this page . . .

1. What energy changes are associated with hydrocarbon combustion?
2. What are the products of the complete combustion of a hydrocarbon?