If a mixture of hydrogen and oxygen is ignited, water will form and energy will be released explosively. The energy that is released comes from the reactants as they form products. Because energy is released, the reaction is *exothermic,* and the energy of the product, water, must be less than the energy of the reactants. The following chemical equation for this reaction indicates that when 2 mol of hydrogen gas at room temperature are burned, 1 mol of oxygen gas is consumed and 2 mol of water vapor are formed.

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

The equation does not tell you that energy is evolved as heat during the reaction. Experiments have shown that 483.6 kJ of energy are evolved when 2 mol of gaseous water are formed from its elements at 298.15 K.

Modifying the chemical equation to show the amount of energy as heat released during the reaction gives the following expression.

$$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g) + 483.6 \text{ kJ}$$

This expression is an example of a **thermochemical equation,** *an equation that includes the quantity of energy released or absorbed as heat during the reaction as written.* In any thermochemical equation, we must always interpret the coefficients as *numbers of moles* and never as *numbers of molecules.* The quantity of energy released as heat in this or any other reaction depends on the amounts of reactants and products. The quantity of energy as heat released during the formation of water from H_2 and O_2 is proportional to the quantity of water formed. Producing twice as much water vapor would require twice as many moles of reactants and would release 2×483.6 kJ of energy as heat, as shown in the following thermochemical equation (which is simply the previous thermochemical equation, multiplied by two).

$$4H_2(g) + 2O_2(g) \longrightarrow 4H_2O(g) + 967.2 \text{ kJ}$$

Producing one-half as much water would require one-half as many moles of reactants and would release only one-half as much energy, or $\frac{1}{2} \times 483.6$ kJ. The thermochemical equation for this reaction would be as follows.

$$H_2(g) + \tfrac{1}{2}O_2(g) \longrightarrow H_2O(g) + 241.8 \text{ kJ}$$

The situation is reversed in an *endothermic* reaction because products have a larger enthalpy than reactants. The decomposition of water vapor is endothermic; it is the reverse of the reaction that forms water vapor. The amount of energy as heat absorbed by water molecules to form hydrogen and oxygen equals the amount of energy as heat released when the elements combine to form the water. This is to be expected because the difference between the energy of reactants and products is unchanged. Enthalpy now appears on the reactant side of the thermochemical equation that follows, indicating that it is an endothermic reaction.

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