15.3 Thermochemical Equations

A **thermochemical equation** is a balanced chemical equation that includes the physical states of the reactants and products and the change in enthalpy. For example, the thermochemical equation for the combustion of ethanol is as follows.

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l) \quad \Delta H_{comb} = -1367 \text{ kJ}$$

The enthalpy change for the complete burning of one mole of a substance is the **enthalpy (heat) of combustion** (ΔH_{comb}) for that substance. Heat is also absorbed or released during changes of state. The heat required to vaporize one mole of a liquid is called its **molar enthalpy (heat) of vaporization** (ΔH_{vap}). The heat required to melt one mole of a solid is its molar enthalpy (heat) of fusion (ΔH_{fus}).

Example Problem 15-3

Calculating Enthalpy of Reaction

The enthalpy of combustion for methanol (CH_3OH) is −726 kJ/mol. How much heat is released when 82.1 g of methanol is burned?

The enthalpy of combustion is negative, so the reaction is exothermic and heat is released. The molar mass of methanol is 32.05 g/mol. First, calculate the number of moles of methanol that is burned.

$$82.1 \text{ g } \cancel{CH_3OH} \times \frac{1 \text{ mol } CH_3OH}{32.05 \text{ g } \cancel{CH_3OH}} = 2.56 \text{ mol } CH_3OH$$

Now find the enthalpy of reaction for the combustion of 82.1 g (2.56 mol) of methanol.

$$2.56 \text{ } \cancel{\text{mol } CH_3OH} \times \frac{(-726 \text{ kJ})}{1 \text{ } \cancel{\text{mol } CH_3OH}} = -1860 \text{ kJ}$$

Practice Problems

7. Calculate the heat required for the following two processes, and compare the results.

a. A 100.0-g sample of solid ethanol melts at its melting point. $\Delta H_{fus} = 4.94$ kJ/mol

b. A 100.0-g sample of liquid ethanol vaporizes at its boiling point. $\Delta H_{vap} = 38.6$ kJ/mol

8. How much heat is evolved when 24.9 g of propanol (C_3H_7OH) is burned? $\Delta H_{comb} = -2010$ kJ/mol

9. What mass of benzene (C_6H_6) must be burned in order to liberate 1.00×10^4 kJ of heat? $\Delta H_{comb} = -3268$ kJ/mol

10. Is the following reaction Endo- or Exothermic? $O_{2\,(g)} \rightarrow 2O_{(g)}$ $\Delta H^\circ = +495$ kJ/mol

11. How much energy is absorbed when 2.5 mol of $O_{(g)}$ is produced in the following reaction?

    $O_{2\,(g)} \rightarrow 2O_{(g)}$ $\Delta H^\circ = +495$ kJ/mol

12. How much energy is absorbed when 300.0g of $O_{(g)}$ is produced in the following reaction?

    $O_{2\,(g)} \rightarrow 2O_{(g)}$ $\Delta H^\circ = +495$ kJ/mol

13. Is the following reaction Endo- or Exothermic? $2O_{3\,(g)} \rightarrow 3O_{2\,(g)}$ $\Delta H^\circ = -427$ kJ/mol

14. How much energy is released when 10.2 mol of $O_{2\,(g)}$ is produced in the following reaction?

    $2O_{3\,(g)} \rightarrow 3O_{2\,(g)}$ $\Delta H^\circ = -427$ kJ/mol

15. How much energy is released when 115 g of $O_{2\,(g)}$ is produced in the following reaction?

    $2O_{3\,(g)} \rightarrow 3O_{2\,(g)}$ $\Delta H^\circ = -427$ kJ/mol

16. How much energy is released when 75.0 g of $O_{2\,(g)}$ is produced in the following reaction?

    $2O_{3\,(g)} \rightarrow 3O_{2\,(g)}$ $\Delta H^\circ = -427$ kJ/mol