SAMPLE PROBLEM B

*For more help, go to the **Math Tutor** at the end of this chapter.*

Calculate the enthalpy of reaction for the combustion of nitrogen monoxide gas, NO, to form nitrogen dioxide gas, NO_2, as given in the following thermochemical equation.

$$\mathbf{NO}(g) + \tfrac{1}{2}\mathbf{O_2}(g) \longrightarrow \mathbf{NO_2}(g)$$

Use the enthalpy-of-formation data in Appendix Table A-14. Solve by combining the known thermochemical equations. Verify the result by using the general equation for finding enthalpies of reaction from enthalpies of formation.

SOLUTION

1 ANALYZE

Given: $\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \longrightarrow NO(g) \qquad \Delta H_f^0 = +90.29 \text{ kJ}$

$\frac{1}{2}N_2(g) + O_2(g) \longrightarrow NO_2(g) \qquad \Delta H_f^0 = +33.2 \text{ kJ}$

Unknown: ΔH^0 for $NO(g) + \frac{1}{2}O_2(g) \longrightarrow NO_2(g)$

2 PLAN

ΔH can be found by adding the ΔHs of the component reactions as specified in Hess's law. The desired equation has $NO(g)$ and $\frac{1}{2}O_2(g)$ as reactants and $NO_2(g)$ as the product.

$$NO(g) + \tfrac{1}{2}O_2(g) \longrightarrow NO_2(g)$$

We need an equation with NO as a reactant. Reversing the first reaction for the formation of NO from its elements and the sign of ΔH yields the following thermochemical equation.

$$NO(g) \longrightarrow \tfrac{1}{2}N_2(g) + \tfrac{1}{2}O_2(g) \qquad \Delta H^0 = -90.29 \text{ kJ}$$

The other equation should have NO_2 as a product, so we can retain the second equation for the formation of NO_2 from its elements as it stands.

$$\tfrac{1}{2}N_2(g) + O_2(g) \longrightarrow NO_2(g) \qquad \Delta H_f^0 = +33.2 \text{ kJ}$$

3 COMPUTE

$$\begin{array}{ll} NO(g) \longrightarrow \cancel{\tfrac{1}{2}N_2(g)} + \cancel{\tfrac{1}{2}O_2(g)} & \Delta H^0 = -90.29 \text{ kJ} \\ \cancel{\tfrac{1}{2}N_2(g)} + O_2(g) \longrightarrow NO_2(g) & \Delta H_f^0 = +33.2 \text{ kJ} \\ \hline NO(g) + \tfrac{1}{2}O_2(g) \longrightarrow NO_2(g) & \Delta H^0 = -57.1 \text{ kJ} \end{array}$$

Note the cancellation of the $\frac{1}{2}N_2(g)$ and the partial cancellation of the $O_2(g)$.

4 EVALUATE

The unnecessary reactants and products cancel to give the desired equation.

The general relationship between the enthalpy of a reaction and the enthalpies of formation of the reactants and products is described in the following word equation.

$$\Delta H^0 = \text{sum of } [(\Delta H_f^0 \text{ of products}) \times (\text{mol of products})] - \text{sum of } [(\Delta H_f^0 \text{ of reactants}) \times (\text{mol of reactants})]$$