Predicting ΔH Using Standard Enthalpies of Formation, Extra Exercises

1. Laboratory quantities of ethylene can be prepared by an elimination reaction of ethanol using an acid catalyst. Calculate the enthalpy change for the conversion of ethanol into ethylene and water using standard enthalpies of formation.

2. Calculate the enthalpy of combustion for acetic acid using standard enthalpies of formation.

3. An initial step in the production of iron in a blast furnace involves the conversion of iron(III) oxide and carbon monoxide into iron(II, III) oxide and carbon dioxide. Calculate the enthalpy of this reaction using standard enthalpies of formation.

(continued)

4. The fertilizer urea is produced along with liquid water by the reaction of ammonia and carbon dioxide. Calculate the enthalpy of this reaction using standard enthalpies of formation.

Predicting ΔH Using Standard Enthalpies of Formation, Extra Exercises, Solution

1. Laboratory quantities of ethylene can be prepared by an elimination reaction of ethanol using an acid catalyst. Calculate the enthalpy change for the conversion of ethanol into ethylene and water using standard enthalpies of formation.

$$\mathbf{C_2H_5OH_{(l)} \rightarrow C_2H_{4(g)} + H_2O_{(l)}}$$

$$\begin{aligned}\Delta H &= \sum nH^\circ_{\mathbf{f(products)}} - \sum nH^\circ_{\mathbf{f(reactants)}} \\ &= \left(\mathbf{1\ mol} \times \frac{\mathbf{+52.5\ kJ}}{\mathbf{1\ mol}} + \mathbf{1\ mol} \times \frac{\mathbf{-285.8\ kJ}}{\mathbf{1\ mol}}\right) - \left(\mathbf{1\ mol} \times \frac{\mathbf{-235.2\ kJ}}{\mathbf{1\ mol}}\right) \\ &= \mathbf{-233.3\ kJ - (-235.2\ kJ)} \\ &= \mathbf{+1.9\ kJ}\end{aligned}$$

2. Calculate the enthalpy of combustion for acetic acid using standard enthalpies of formation.

$$\mathbf{CH_3COOH_{(l)} + 2\,O_{2(g)} \rightarrow 2\,CO_{2(g)} + 2\,H_2O_{(g)}}$$

$$\begin{aligned}\Delta H &= \sum nH^\circ_{\mathbf{f(products)}} - \sum nH^\circ_{\mathbf{f(reactants)}} \\ &= \left(\mathbf{2\ mol} \times \frac{\mathbf{-393.5\ kJ}}{\mathbf{1\ mol}} + \mathbf{2\ mol} \times \frac{\mathbf{-241.8\ kJ}}{\mathbf{1\ mol}}\right) \\ &\quad - \left(\mathbf{1\ mol} \times \frac{\mathbf{-432.8\ kJ}}{\mathbf{1\ mol}} + \mathbf{2\ mol} \times \frac{\mathbf{0\ kJ}}{\mathbf{1\ mol}}\right) \\ &= \mathbf{-1270.6\ kJ - (-432.8\ kJ)} \\ &= \mathbf{-837.8\ kJ}\end{aligned}$$

3. An initial step in the production of iron in a blast furnace involves the conversion of iron(III) oxide and carbon monoxide into iron(II, III) oxide and carbon dioxide. Calculate the enthalpy of this reaction using standard enthalpies of formation.

$$\mathbf{3\,Fe_2O_{3(s)} + CO_{(g)} \rightarrow 2\,Fe_3O_{4(s)} + CO_{2(g)}}$$

$$\begin{aligned}\Delta H &= \sum nH^\circ_{\mathbf{f(products)}} - \sum nH^\circ_{\mathbf{f(reactants)}} \\ &= \left(\mathbf{2\ mol} \times \frac{\mathbf{-1118.4\ kJ}}{\mathbf{1\ mol}} + \mathbf{1\ mol} \times \frac{\mathbf{-393.5\ kJ}}{\mathbf{1\ mol}}\right) \\ &\quad - \left(\mathbf{3\ mol} \times \frac{\mathbf{-824.2\ kJ}}{\mathbf{1\ mol}} + \mathbf{1\ mol} \times \frac{\mathbf{-110.5\ kJ}}{\mathbf{1\ mol}}\right) \\ &= \mathbf{-2630.3\ kJ - (-2583.1\ kJ)} \\ &= \mathbf{-47.2\ kJ}\end{aligned}$$

4. The fertilizer urea is produced along with liquid water by the reaction of ammonia and carbon dioxide. Calculate the enthalpy of this reaction using standard enthalpies of formation.

$$2\,NH_{3(g)} + CO_{2(g)} \rightarrow CO(NH_2)_{2(s)} + H_2O_{(l)}$$

$$\Delta H = \sum nH^\circ_{f(products)} - \sum nH^\circ_{f(reactants)}$$

$$= \left(1\text{ mol} \times \frac{-333.5\text{ kJ}}{1\text{ mol}} + 1\text{ mol} \times \frac{-285.8\text{ kJ}}{1\text{ mol}}\right) - \left(2\text{ mol} \times \frac{-45.9\text{ kJ}}{1\text{ mol}} + 1\text{ mol} \times \frac{-393.5\text{ kJ}}{1\text{ mol}}\right)$$

$$= -619.3\text{ kJ} - (-485.3\text{ kJ})$$

$$= -134.0\text{ kJ}$$