Hess's Law and Heats of Formation

Using ΔH_f Values to Calculate Heats of Reaction

One interpretation of Hess's law is that the heat of reaction for any given reaction is equal to the sum of the heats of formation values for the reactants subtracted from the sum of the heats of formation values for the products. This is expressed in the equation below.

\[ \Delta H_{\text{rxn}} = \text{Sum of } \Delta H^\circ_f \text{ products} - \text{Sum of } \Delta H^\circ_f \text{ reactants} \]

Utilize this equation and the given heat of formation values to determine the heat of reaction for the following reactions. NOTE: the ΔH^\circ_f value for an element in its natural state is 0 kJ/mol.

<table>
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<tr>
<th>Reaction</th>
<th>ΔH_f (kJ/mol)</th>
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<tbody>
<tr>
<td>Al_2O_3(s) + 3 NH_4CLO_4(s) -----&gt; Al_2O_3(s) + AlCl_3(s) + 3 NO(g) + 6 H_2O(g)</td>
<td>-1676 + 3(-295) - 242 = -2253</td>
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</table>
4. Wine is produced by the fermentation of glucose (C\textsubscript{6}H\textsubscript{12}O\textsubscript{6}) to produce ethyl alcohol (C\textsubscript{2}H\textsubscript{5}OH) and carbon dioxide. The fermentation reaction proceeds according to the equation below. Determine the heat of reaction. \textbf{PSAYW}

\[ \text{C}_6\text{H}_{12}\text{O}_6(\text{s}) \rightarrow 2 \text{C}_2\text{H}_5\text{OH}(\text{l}) + 2 \text{CO}_2(\text{g}) \]

5. Photosynthetic plants use the following reaction to produce glucose:

\[ 6 \text{CO}_2(\text{g}) + 6 \text{H}_2\text{O}(\text{l}) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(\text{s}) + 6\text{O}_2(\text{g}) \]

The plants absorb energy from the sun in order to make this reaction possible. Determine the heat of reaction. \textbf{PSAYW}

6. Two of the oxides of nitrogen are major contributors to the production of photochemical smog (also known as "urban ozone pollution"). The major source of the oxides of nitrogen is the combustion of gasoline in automobiles and their subsequent release into the environment through automobile exhaust. Determine the heat of reaction for the following reaction. \textbf{PSAYW}

\[ 2 \text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{NO}_2(\text{g}) \]

7. A public utility engineer wants to know how much heat is liberated by burning natural gas (methane, CH\textsubscript{4}) at standard conditions. The reaction that occurs in your gas stove is

\[ \text{CH}_4(\text{g}) + 2 \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{g}) \]

Determine the heat of reaction. \textbf{PSAYW}

8. Oxyacetylene torches are used by metal workers to cut through iron and steel. The heat released by the burning of acetylene (C\textsubscript{2}H\textsubscript{2}) is capable of melting metal. Write a balanced chemical equation for the combustion of acetylene and determine the heat of reaction. \textbf{PSYW}
(4) The bombardier beetle stores two chemicals in two separate bladders. When attacked, the beetle mixes the chemicals. The chemicals react by means of the following exothermic reaction:

\[ C_6H_4(OH)_2(aq) + H_2O_2(aq) \rightarrow C_6H_4O_2(aq) + 2H_2O(l) \]

The heat released by the reaction is sufficient to raise water to near its boiling point. The beetle then sprays the boiling hot mixture at the predator as a highly potent defensive mechanism. Using the following data and Hess’s Law, calculate \( \Delta H \) for the above reaction.

\[ C_6H_4(OH)_2(aq) \rightarrow C_6H_4O_2(aq) + H_2(g) \quad \Delta H = +177.4 \text{ kJ} \]

\[ H_2(g) + O_2(g) \rightarrow H_2O_2(aq) \quad \Delta H = -191.2 \text{ kJ} \]

\[ H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(l) \quad \Delta H = -285.6 \text{ KJ} \]