7 • Thermochemistry

7.3 Notes - Enthalpies of Reaction

Enthalpies of Formation (ΔHf)

Enthalpy (or heat) of formation (ΔHf) –

- Units: \( \frac{\text{kJ}}{\text{mol substance}} \).
- The ΔHf is different from the ΔHrxn in that it describes the energy of a substance whereas the ΔHrxn describes the energy change of a reaction.
- The ΔHf for elements at standard state (e.g. Na (s), O2 (g), Br2 (l)) is 0 kJ/mol. ΔHf values for compounds will usually be given by a problem, or can be found on a table of ΔHf.
- [Formally, ΔHf is the energy released when 1 mole of a substance is formed from its elements at standard state. For example, the ΔHf for H2O (l) is −286 kJ/mol and represents the ΔHrxn for

\[
\text{H}_2(g) + \frac{1}{2}\text{O}_2(g) \rightarrow \frac{1}{2}\text{H}_2\text{O}(l).
\]

- The difference between the enthalpies of formation (ΔHf) of the products and reactants in a chemical reaction is the enthalpy of reaction (ΔHrxn).

\[
\Delta H_{\text{rxn}} = \sum \text{ products } \Delta H_f - \sum \text{ reactants } \Delta H_f
\]

Example: Find the ΔHrxn for the following reaction:

\[
4 \text{ FeS (s)} + 7 \text{ O}_2 (g) \rightarrow 2 \text{ Fe}_2\text{O}_3 (s) + 4 \text{ SO}_2 (g)
\]

<table>
<thead>
<tr>
<th>Substance</th>
<th>ΔHf</th>
</tr>
</thead>
<tbody>
<tr>
<td>FeS (s)</td>
<td>−95 kJ/mol</td>
</tr>
<tr>
<td>Fe2O3 (s)</td>
<td>−826 kJ/mol</td>
</tr>
<tr>
<td>SO2 (g)</td>
<td>−297 kJ/mol</td>
</tr>
</tbody>
</table>

Bond Energies

Bond Dissociation Energy or Bond Energy –

Breaking Bonds:  
Forming Bonds:

Example: Approximate the ΔHrxn for the following reaction:

\[
2 \text{ H}_2 + \text{ O}_2 \rightarrow 2 \text{ H}_2\text{O}
\]

<table>
<thead>
<tr>
<th>Bond</th>
<th>Bond Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>H–H</td>
<td>432 kJ/mol</td>
</tr>
<tr>
<td>H–O</td>
<td>467 kJ/mol</td>
</tr>
<tr>
<td>O=O</td>
<td>495 kJ/mol</td>
</tr>
</tbody>
</table>