Enthalpy (H) ~ heat content (q) @ constant pressure
\[ \Delta H = \text{thermal (heat) energy change} = q \]

Physical process

\[ H_2O (l) + \text{energy} \rightarrow H_2O (g) \]
\[ \Delta H_{\text{vap}} = 44 \text{ kJ/mole} \]
heat of vaporization

What happens for the reverse process?
\[ \Delta H = -44 \text{ kJ/mole and exothermic} \]

What does the sign of the enthalpy tell you?

Endothermic process or reaction
\[ \Delta H > 0 \text{ or positive} \]

Exothermic process or reaction
\[ \Delta H < 0 \text{ or negative} \]

Endothermic or exothermic?

\[ H_2O (l) \rightarrow H_2O (s) \]

Standard State Conditions

- Temperature - 25°C or 298K
- Pressure - 1.00 atm
- Element in its stable state

\[ \begin{align*} 
& \text{O (g)} \\
& \text{O}_2 (g) \\
& \text{Br}_2 (g) \\
& \text{Br}_2 (l) \\
& \text{O}_3 (g) \\
& \text{C (diamond)} \\
& \text{C (graphite)} 
\end{align*} \]

Chemical process

\[ C \text{ (graphite)} + O_2 (g) \rightarrow CO_2 (g) + 394 \text{ kJ} \]
\[ \Delta H_f = -394 \text{ kJ/mole} \]

This is the standard molar enthalpy of formation for the formation of one mole substance from its elements in their standard states.

\[ \Delta H_f = 0 \text{ kJ/mole for free elements} \]

Combustion of methanol

\[ 2\text{CH}_3\text{OH (l)} + 3\text{O}_2 (g) \rightarrow 2\text{CO}_2 (g) + 4\text{H}_2\text{O (g)} \]
\[ \Delta H_f: -239 \text{ kJ/mol} \quad 0 \quad -394 \quad -242 \]

\[ \Delta H_{\text{rxn}} = \sum n\Delta H_f \text{products} - \sum n\Delta H_f \text{reactants} \]
where \( n \) is the number of moles

How about just vaporizing the methanol?

\[ \text{CH}_3\text{OH (l)} \rightarrow \text{CH}_3\text{OH (g)} \]
\[ \Delta H_f: -239 \text{ kJ/mol} \quad -201 \text{ kJ/mole} \]
Describe all processes for the following:

\[ \text{I}_2 (s) \rightarrow 2\text{I} (g) \]

\[ \Delta H_{\text{subl}} = \]

\[ \text{I}_2 (s) \rightarrow \text{I}_2 (g) \]

\[ \Delta H_{\text{diss}} = \]

\[ \text{I}_2 (g) \rightarrow 2\text{I} (g) \]

\[ \Delta H_{\text{rxn}} = \]

overall: \[ \text{I}_2 (s) \rightarrow 2\text{I} (g) \]

From an energetics point of view, what is happening in each case for the water? Is the reaction endothermic or exothermic?

\[ 2\text{H} + \text{O} \rightarrow \text{H}^+ + \text{OH}^- + \text{H}_2 + 0.5\text{O}_2 \]

Compare the \( \Delta H \) for this reaction calculated by \( \Delta H_f \) data with that calculated from bond energies.

\[ 2\text{H}_2\text{O} \rightarrow 12\text{CO}_2(g) + 6\text{H}_2\text{O} \]

\[ \Delta H = \text{(-2.9 kJ/mol)} \]

Write the reaction used for the measurement of the standard molar enthalpy of formation of benzene.

Do you think this reaction is possible?