Heat Changes of State

Heats of Fusion and Solidification

What happens if you place an ice cube on a table in a warm room? Use what you know so far about thermochemistry to describe what happens.

The ice absorbs heat from the surroundings and begins to melt. The temperature of the ice and the water produced remain at 0 °C until all of the ice has melted. The temperature of the water begins to increase only after all of the ice has melted.

Like ice cubes, all solids absorb heat as they melt to become liquids. *The gain of heat causes a change of state rather than a temperature change.*

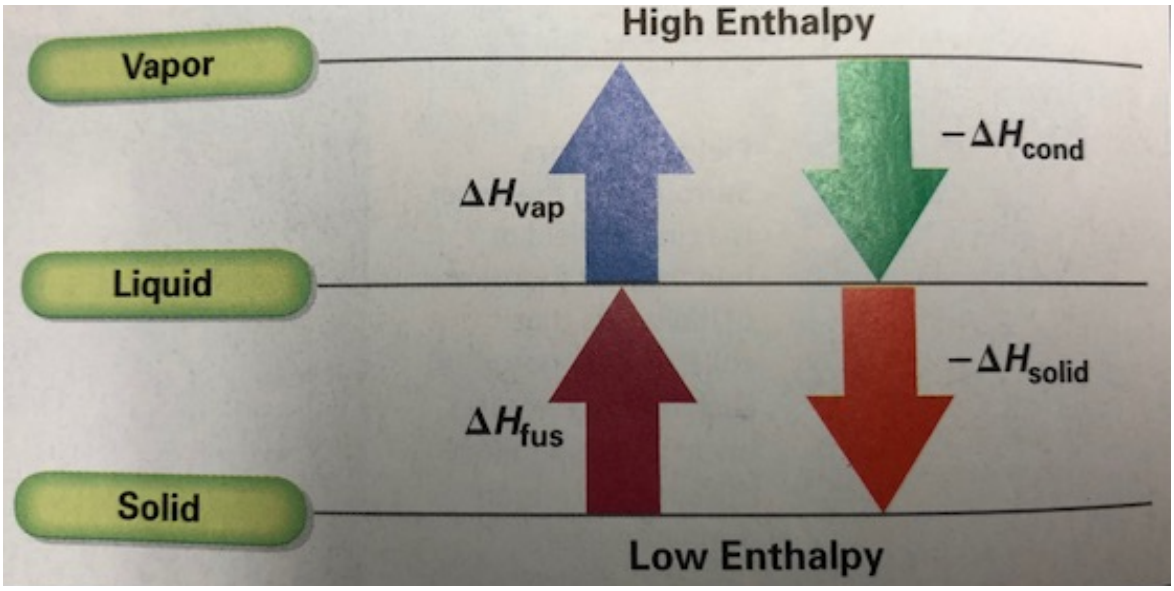
Whenever a state change occurs by a gain or loss of heat, the temperature of the system remains constant.

The heat absorbed by one mole of a solid substance as it melts to a liquid at a constant temperature is the **molar heat of fusion (H_{fus})**.

The **molar heat of solidification (H_{solid})** is the heat lost when one mole of a liquid solidifies at constant temperature.

The quantity of heat absorbed by a melting solid is exactly the same as the quantity of heat released when the liquid solidifies; so $H_{fus} = -H_{solid}$

In general:


High Enthalpy
Vapor
$-\Delta H_{cond}$
ΔH_{vap}
Liquid
$-\Delta H_{solid}$
ΔH_{fus}
Solid
Low Enthalpy

The melting of 1 mol of ice at 0 °C requires the absorption of 6.01 kJ of heat.

$$H_{fus} = 6.01 \text{ kJ/mol}$$

So the conversion of 1 mol of water at 0 °C to 1 mol of ice at 0 °C releases 6.01 kJ.

$$H_{solid} = -6.01 \text{ kJ/mol}$$

Example:

How many grams of ice at 0 °C will melt if 2.25 kJ of heat are added.

Heats of Vaporization and Condensation

When liquids absorb heat at their boiling point, they become vapors. The amount of heat necessary to vaporize one mole of a liquid is called its **molar heat of vaporization (H_{vap})**.

The molar heat of the vaporization of water is 40.7 kJ/mol. This means it takes 40.7 kJ of energy to convert 1 mol of water molecules in a liquid state to 1 mol in a vapor state.

$$H_2O(l) \longrightarrow H_2O(g) \quad H_{vap} = 40.7 \text{ kJ/mol}$$

Condensation is the exact opposite of vaporization. When a vapor condenses, heat is released.

The amount of heat released when 1 mol of vapor condenses at the normal boiling point is called the **molar heat of condensation (H_{cond})**

The quantity of heat being absorbed and released through vaporizing and condensing must be the same.

$$H_{vap} = -H_{cond}$$

Take a look at page figure 17.10 on page 523.

- Look at the graph and answer the three questions under 'Interpreting Graphs'

Example

How much heat (in kJ) is absorbed when 24.8 g $H_2O_{(l)}$ at 100°C and constant pressure is converted to steam at 100°C?

Heat of Solution

During the formation of a solution, heat is either released or absorbed.

The enthalpy change caused by making a solution of one mole of substance is the molar heat of solution (H_{soln})

Practical applications of this would be hot and cold packs.

A hot pack mixes $CaCl_2$ and water which produces heat characteristics of an exothermic reaction.

When ammonium nitrate $(NH_4NO_3)_{(s)}$ dissolves in water, endothermic dissolving occurs. Once the solute dissolves in the solvent, the pack becomes cold.

Example

How much heat (in kJ) is released when 2.500 mol $NaOH_{(s)}$ is dissolved in water? (H_{soln} = -445.1 kJ/mol)

Try questions 23-31 on pages 524 - 526