Solids can be heated to the point where the molecules holding their bonds together break apart and form a liquid. The most common example is solid ice turning into liquid water. This process is better known as melting, or heat of fusion, and results in the molecules within the substance becoming less organized. When a substance converts from a solid state to a liquid state, the change in enthalpy ($\Delta H$) is positive. However, if the substance is transforming from a liquid state to a solid state the change in enthalpy ($\Delta H$) is negative. This process is commonly known as the freezing, and results in the molecules within the substance becoming more ordered.

Introduction

Determining the heat of fusion is fairly straightforward. When a solid undergoes melting or freezing, the temperature stays at a constant rate until the entire phase change is complete. One can visualize this process by examining the heating/cooling chart. By drawing this chart before conducting a heat of fusion analysis, one can easily map out the required steps in completing the analysis. The equation for determining the enthalpy of fusion ($\Delta H_{fus}$) is listed below.

$$\Delta H = n \Delta H_{fus}$$

with

- $n$ = number of moles
- $\Delta H_{fus}$ = the molar heat of the substance

Example

Calculate the heat when 36.0 grams of water at 113 °C is cooled to 0 °C.

Given

- Heat of fusion = 6.0 kJ/mol
- Heat of vaporization = 40.7 kJ/mol
- $C_{sp}(s)$ = 2.10 J/gK
- $C_{sp}(l)$ = 4.18 J/gK
- $C_{sp}(g)$ = 1.97 J/gK

Answer

$q = -110.6 \text{ kJ}$

Sublimation

In some cases, the solid will bypass the liquid state and transition into the gaseous state. This direct transformation from solid to gas is called sublimation. The opposite reaction, when a gas directly transforms into a solid, is known as deposition. Therefore, these two processes can be summarized in the following equation:
\[ \Delta H_{\text{sub}} = \Delta H_{\text{fus}} + \Delta H_{\text{vap}} \]

with

- \( \Delta H_{\text{sub}} \) is the change in heat in sublimation
- \( \Delta H_{\text{fus}} \) is the change in heat in fusion
- \( \Delta H_{\text{vap}} \) is the change in heat in vaporization

Applications

The heat of fusion process can be seen in countless applications and evidenced in the creation of many common household items. As mentioned in the opening paragraph, the most common application of the heat of fusion is the melting of ice to water. The vast majority of examples where heat of fusion is commonplace can be seen in the manufacturing industry. The following examples have been used for hundreds of years and are still perfected to this day. The processes of coin making, glassblowing, forging metal objects, and transforming blow molded plastics into household products all require heat of fusion to become final product. The change in your wallet, the glass vase on your fireplace mantel, and the plastic soda bottle from the vending machine all went through a heat of fusion manufacturing process.

In coin making, solid zinc and copper (metals in American pennies) are placed into a casting furnace and heated by the heat of fusion process until they reach the liquid phase. Once in the liquid phase, the molten zinc and copper are poured into a mold, and cast into long bars. In the casting process, the molten metal transforms from the liquid phase to the solid phase, becoming a solid bar. The long bars are flattened by heavy machinery and stamped into thousands of coins. Without the heat of fusion process, a monetary system would not exist in the United States.

References


Contributors

- Maxim Hnojewyj (UCD)