Unit 3.5 Energy Calculations

Teacher: Dr. Van Der Sluys

Objectives

• Heat of Fusion (H_f)
• Heat of Vaporization (H_v)
• Specific heat capacity (C) of a liquid
  – Joules
  – Calories and Kilocalories
  – Nutritional Calories

Heat of Fusion (H_f)

Heat + H_2O (s) \xrightarrow{\text{Melting}} H_2O (l) \xrightarrow{\text{Fusion}}

• For a given mass of water, the heat that must be added to completely melt the solid is equal to the amount of heat that must be removed for fusion.
• Melting is an endothermic process
• Fusion is an exothermic process.
Why does the person’s hand get cold?

- Heat flows from an area of high average kinetic energy to a region of low kinetic energy

Heat of Fusion ($H_f$)

\[ q = H_f \cdot m \]

- \( q \) = heat in joules
- \( m \) = mass in grams
- \( H_f \) = heat of fusion
- For water \( H_f = 334 \text{ J/g} \)

Check your understanding.

- How much heat, in Joules, must be added to melt 500. g of ice at 0°C to produce an equivalent amount of water at 0°C? \( H_f = 334 \text{ J/g} \)
Check your understanding.

• How many kilojoules of energy must be removed from a 10. L bucket of water at 0°C to produce an equivalent amount of ice? \( D_{H_2O} = 1 \text{ g/mL, } H_f = 334 \text{ J/g} \)

Heat of Vaporization (H_v)

\[
\text{vaporization: } \text{Heat} + H_2O (l) \rightarrow H_2O (g)
\]

\[
\text{condensation: }
\]

• For a given mass of water, the heat that must be added to completely vaporize the liquid is equal to the amount of heat that must be removed for condensation.

• Vaporization is an endothermic process
• Condensation is an exothermic process.

Heat of Vaporization (H_v)

\[
q = H_v \cdot m
\]

\( q = \text{heat in joules} \)

\( m = \text{mass in grams} \)

\( H_v = \text{heat of vaporization} \)

For water \( H_v = 2260 \text{ J/g} \)
Check your understanding

• How many joules of heat must be added to 2.0 kg of liquid water at its boiling point to produce an equivalent amount of steam? $H_v = 2260 \text{ J/g}$

Check your understanding

• For an unknown liquid, 6.5 kJ of energy must be removed from 3000 g of the compound in the vapor phase at its boiling point to produce an equivalent amount of liquid. What is the heat of vaporization of the unknown compound in Joules per gram?

Heat Capacity (C) of a Liquid

$$q = mC\Delta T$$

$q =$ heat in Joules
$m =$ mass in grams
$\Delta T =$ $T_f - T_i$ or temperature change in degrees Celsius or Kelvin
$C =$ heat capacity of the liquid
$4.18 \text{ J/g}^{\circ}\text{C}$ for water
Check your understanding

• How much heat must be added to 50. g of liquid water at 25°C to increase the temperature to 75°C? C = 4.18 J/g°C

Check your understanding

• If 2000. J of heat are removed from a beaker of water and the temperature changes from 25°C to 0°C, how many grams of water are in the beaker? C = 4.18 J/g°C

Which equation do I use?
Check your understanding challenge

• How many joules of heat must be added to 100. g of ice at 0°C to produce an equivalent amount of liquid water at 75°C? **Hint:** Figure out the beginning and ending points on the heating curve, then determine the equations that are required.