ENERGY CHANGES IN A SYSTEM

DRILL QUESTION:
A student performed an experiment in which she dissolved a salt in water. She took the initial temperature of the water, before dissolution of the salt, to be 23°C. After the salt was completely dissolved in the water the temperature of the solution dropped to 19°C. Was the dissolution of the salt an exothermic or endothermic process? Explain.

MY ANSWER
• The temperature of the WATER dropped during the process. The salt is the system water is the surroundings. If the water lost heat energy, than it must have given it to the salt (needed to complete the process). Therefore the process of dissolving was ENDOthermic. The salt absorbed energy from the water.

SPECIFIC HEAT ($C_p$)
• Amount of heat required to raise the temperature of one gram of a substance by one degree Celsius. (Every substance has its own specific heat.)
• Water has a very high specific heat: liquid water $C_p = 4.18 \text{ J/g} \cdot \text{°C}$.
• The higher the specific heat of a substance, the greater the energy change needed to change the temperature.

EXAMPLE 1:
• A student uses 225 grams of water in a lab procedure. Calculate the amount of heat needed to raise the temperature from 20° to 100°.
• $Q = C_p \cdot m \cdot \Delta T$
• $Q = 4.18 \text{ J/g°C} \cdot 225 \text{ g} \cdot 80°$
• $Q = 75240 \text{ J}$
EXAMPLE 2:

- A 40.0 g sample of ethanol releases 2952 J as it cools from 50°C to 20°C. Find the specific heat of ethanol.
- \( q = C_p \cdot m \cdot \Delta T \)
- \(-2952 \text{ J} = C_p \cdot 40.0 \text{ g} \cdot (-30°C)
- \( C_p = 2.46 \text{ J/g°C} \)

HEAT OF SOLUTION

The **Heat of Solution** is the amount of heat energy absorbed (endothermic) or released (exothermic) when a specific amount of solute dissolves in a solvent. Molar heat of solution is the amount of energy absorbed or released per one mole of the solute.

PROBLEM 1

In an experiment, a student added 1.01 grams of lithium bromide, LiBr, to 12.21 grams of water at 20.1°C. After stirring for awhile, the temperature of the mixture rose to 31.3°C. Calculate the molar heat of solution for lithium bromide.

SOLUTION

- The **WATER** absorbs the energy released by the solution process:
  - \( m = 12.21 \text{ g} \quad T_i = 20.1°C \quad T_f = 31.3°C \quad C_p = 4.184 \text{ J/g°C} \)
  - \( Q = (12.21 \text{ g})(4.184 \text{ J/g°C})(31.3°C - 20.1°C) = 572 \text{ J} \)
- + Q means water absorbs (endothermic). Therefore the salt released (exothermic). So \( \Delta H \) for the 1.01 g of LiBr is -572 J. What is the MOLAR heat of solution?

  \[ \Delta H = \frac{-572 \text{ J}}{0.01163 \text{ moles LiBr}} = -49183 \text{ J/mole} \]
  \(-49.2 \text{ kJ/mole}\)

EXIT TICKET

A calorimeter was used to determine the molar enthalpy of a solution of AlCl₃. When a sample of AlCl₃ was dissolved in water the following data were collected.

<table>
<thead>
<tr>
<th>Mass of AlCl₃ (g)</th>
<th>Mass of H₂O (g)</th>
<th>Initial Temp. (°C)</th>
<th>Final Temp. (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0</td>
<td>250.0</td>
<td>20.0</td>
<td>46.3</td>
</tr>
</tbody>
</table>

Determine the molar heat (kJ/mol) of solution.