Enthalpy of Solution: NH₄NO₃

Have you ever used one of those “instant cold packs” that looks like a plastic bag filled with liquid? If you hit the bag and shake it up it gets extremely cold, but why does it do that? The liquid inside the cold pack is water, and in the water is another plastic bag or tube containing NH₄NO₃ fertilizer. When you hit the cold pack, it breaks the tube so that the water mixes with the fertilizer. The dissolving of a salt, such as NH₄NO₃, in water is called dissolution, and the heat associated with the dissolving process is called the Enthalpy of Solution. In this problem, you will take a sample of NH₄NO₃, dissolve it in water, and after measuring the change in temperature, calculate the enthalpy of solution for NH₄NO₃.

1. Start Virtual ChemLab and select Enthalpy of Solution: NH₄NO₃ from the list of assignments. The lab will open in the Calorimetry laboratory.

2. There will be a bottle of ammonium nitrate (NH₄NO₃) on the lab bench. A weigh paper will be on the balance with approximately 2 g of NH₄NO₃ on the paper. Record the mass of the sample in the data table. If you cannot read the mass on the balance, click in the balance area to Zoom In. Return to Lab when you have recorded the mass.

3. The coffee cup calorimeter will be on the lab bench and filled with 100 mL water. Click the Lab Book to open it. Make certain the stirrer is On (you should be able to see the shaft rotating). In the thermometer window click Save to begin recording data. Allow 20-30 seconds to obtain a baseline temperature of the water.

4. Drag the weigh paper with the sample to the calorimeter until it snaps into place and then pour the sample into the calorimeter. Observe the change in temperature until it reaches a maximum and then record data for an additional 20-30 seconds. Click Stop. (You can click on the clock on the wall labeled Accelerate to accelerate the time in the laboratory.) A blue data link will appear in the lab book. Click the data link and record the temperature before adding the NH₄NO₃ and the highest or lowest temperature after adding the NH₄NO₃ in the data table.

<table>
<thead>
<tr>
<th>Mixture</th>
<th>mass</th>
<th>T_initial</th>
<th>T_final</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₄NO₃ (s) + H₂O (l)</td>
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5. Calculate \( \Delta T (\Delta T = T_{\text{initial}} - T_{\text{final}}) \) for the dissolving process.

6. An exothermic process gives off heat (warms up), and an endothermic process absorbs heat (cools off).

Was the addition of NH₄NO₃ to the water an endothermic or exothermic process? What is the sign of the change in enthalpy (\( \Delta H \))? 

7. Determine the moles of NH₄NO₃ in the sample. The molecular weight of NH₄NO₃ is 80 g/mol.
8. The heat absorbed or lost by the water can be calculated using \( q = m \cdot C_{\text{water}} \cdot \Delta T \). Assume that the density of water is 1 g/mL.

\[ q = m \cdot C_{\text{water}} \cdot \Delta T \]

Calculate the mass of the water and substitute for \( m \). \( \Delta T \) is the change in the temperature of the water and \( C_{\text{water}} \) is the specific heat capacity for water (4.184 J/g·K). What is the heat absorbed or lost, in J, by the water? ________________

9. The heat transferred from/to the \( \text{NH}_4\text{NO}_3 \) can be divided by the moles of \( \text{NH}_4\text{NO}_3 \) to obtain the molar heat of solution for \( \text{NH}_4\text{NO}_3 \).

What is the molar heat of solution, in kJ, of \( \text{NH}_4\text{NO}_3 \)? ________________

10. If the accepted value for the heat of solution for sugar is 25.69 kJ/mol, calculate the percent error.

\[ \% \ Error = \left( \frac{\text{your answer} - \text{accepted answer}}{\text{accepted answer}} \right) \times 100 \]

\[ \% \ Error = \]

This experiment does not consider that all of the conditions are standard state conditions; therefore, you are calculating \( \Delta H_{\text{sol}} \) **not** \( \Delta H^\circ_{\text{sol}} \).