Determination of Specific Heat and Various Heats of Reactions

Background

- **A <u>calorimeter</u> is used to measure the heat exchanged in a chemical or physical change. Since the measurements are made at atmospheric conditions, heat (q) equals the enthalpy change (ΔH).**
- **The 1st Law of Thermodynamics states Energy is conserved. So the heat change of the system plus the heat change of the surroundings must equal zero.**
- **Thus the heats of the system and surrounding are equal in magnitude, but opposite in sign.**

$$q_{\text{system}}\ (\text{J}) = -\,q_{\text{surroundings}}\ (\text{J})$$

- **Polystyrene coffee cups are good insulators, and it is assumed that all of the heat lost or gained by the system will be transferred to the water/solution (surroundings).**
- **Heat (q) can be calculated from the equation below.**

$$q\ (\text{J}) = \text{specific heat}(\text{J/g°C}) \times \text{mass(g)} \times \Delta T(°\text{C})$$

Experiment

- **In Part I, the <u>system</u> is the Aluminum rods and the <u>surroundings</u> are the water. The specific heat of Aluminum and % error will be found.**
- **In Part II, the <u>system</u> is the reaction and the aqueous solution is the <u>surroundings</u>.**

  The mass of the solution equals the combined total mass of HCl and NaOH solutions.

  <u>Assume</u>: (1) The density of solution equals the density of water. Use density to find mass of solution.
  (2) The specific heat of solution equals the specific heat of water.

  The ΔH_{rxn} for the reaction will be determined per mole of HCl neutralized in the reaction.

  $$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(\ell)$$

- **In Part III, the <u>system</u> is the NH_4NO_3 and the aqueous solution is the <u>surroundings</u>.**

  The mass of the solution equals the combined total mass of NH_4NO_3 and water.

  <u>Assume</u>: The specific heat of the solution equals the specific heat of water.

  The ΔH_{rxn} for dissolving NH_4NO_3 in water will be determined per mole of NH_4NO_3 dissolved.

  $$NH_4NO_3(s) \rightarrow NH_4NO_3(aq)$$

Calculations

- **For all Parts of the experiment, you are measuring the ΔT of the water/solution (<u>surroundings</u>).**
  So you need to calculate the $q_{surroundings}$.

  For each Part, you will use the specific heat of water (4.18 J/g°C) for your calculations.

- q_{surr} = specific heat$_{H_2O}$ × mass$_{H_2O/soln}$ × $\Delta T_{H_2O/soln}$

- **<u>Part I</u>**

  $q_{Al} = (-)q_{H_2O}$

  $$\text{specific heat}_{Al} = \left(\frac{q_{Al}}{\{\text{mass}_{Al} \times \Delta T_{Al}\}} \right)$$

$$\%\ \text{error} = \left(\frac{(\text{"accepted value"} - \text{"exp. value"})}{\text{"accepted value"}} \right) \times 100\%$$

- **<u>Part II</u>**

  $q_{rxn} = (-)q_{soln}$

  $\text{mol}_{HCl} = M_{HCl} \times L_{HCl}$

  $\Delta H_{rxn} = q_{rxn}\ /\ \text{mol}_{HCl}$

- **<u>Part III</u>**

  $q_{rxn} = (-)q_{soln}$

  $$\text{mol}_{NH_4NO_3} = \text{mass}_{NH_4NO_3} \times \left(\frac{1\ \text{mol}_{NH_4NO_3}}{MM_{NH_4NO_3}} \right)$$

  $\Delta H_{rxn} = q_{rxn}\ /\ \text{mol}_{NH_4NO_3}$