

# Determination of Specific Heat and Various Heats of Reactions

## **Background**

- A calorimeter 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 ( $\Delta H$ ).
- The 1<sup>st</sup> 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.

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

## Experiment

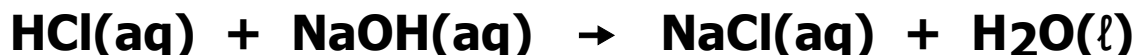
- In Part I, the system is the Aluminum rods and the surroundings are the water. The specific heat of Aluminum and % error will be found.
- In Part II, the system is the reaction and the aqueous solution is the surroundings.

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

*Assume: (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  $\Delta H_{\text{rxn}}$  for the reaction will be determined per mole of HCl neutralized in the reaction.



- In Part III, the system is the  $\text{NH}_4\text{NO}_3$  and the aqueous solution is the surroundings.

*The mass of the solution equals the combined total mass of  $\text{NH}_4\text{NO}_3$  and water.*

*Assume: The specific heat of the solution equals the specific heat of water.*

The  $\Delta H_{\text{rxn}}$  for dissolving  $\text{NH}_4\text{NO}_3$  in water will be determined per mole of  $\text{NH}_4\text{NO}_3$  dissolved.



## Calculations

- For all Parts of the experiment, you are measuring the  $\Delta T$  of the water/solution (surroundings).

So you need to calculate the  $q_{\text{surroundings}}$ .

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

- $q_{\text{surr}} = \text{specific heat}_{\text{H}_2\text{O}} \times \text{mass}_{\text{H}_2\text{O}/\text{soln}} \times \Delta T_{\text{H}_2\text{O}/\text{soln}}$

- Part I

$$q_{\text{Al}} = (-)q_{\text{H}_2\text{O}}$$
$$\text{specific heat}_{\text{Al}} = \left( \frac{q_{\text{Al}}}{\{\text{mass}_{\text{Al}} \times \Delta T_{\text{Al}}\}} \right)$$

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

- Part II

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

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

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

- Part III

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

$$\text{mol}_{\text{NH}_4\text{NO}_3} = \text{mass}_{\text{NH}_4\text{NO}_3} \times \left( \frac{1 \text{ mol}_{\text{NH}_4\text{NO}_3}}{\text{MM}_{\text{NH}_4\text{NO}_3}} \right)$$

$$\Delta H_{\text{rxn}} = q_{\text{rxn}} / \text{mol}_{\text{NH}_4\text{NO}_3}$$