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## Thermodynamics—Enthalpy of Reaction and Hess's Law AP Chemistry Laboratory #13

### Introduction

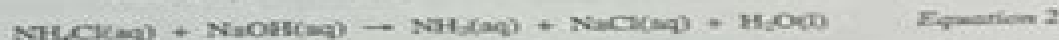
The release or absorption of heat energy is a unique value for every reaction. Were all these values experimentally determined? This lab demonstrates the principle of Hess's Law—if several reactions add up to produce an overall reaction, then the heat transfer of the reactions will add up to the value of the heat transfer for the overall reaction.

### Concepts

- Enthalpy of reaction
- Hess's Law
- Heat of formation
- Calorimetry

### Background

In this experiment, the enthalpy changes for the reaction of ammonia and hydrochloric acid will be determined using Hess's law. If the enthalpy change for the reaction between sodium hydroxide and hydrochloric acid and the reaction between sodium hydroxide and ammonium chloride are determined, the enthalpy change for the reaction between ammonia and hydrochloric acid can be calculated. The balanced equations for these reactions are as follows:



When Equation 2 is reversed and added to Equation 1, the result is Equation 3.

The heat or enthalpy change for a chemical reaction is called the *enthalpy of reaction*,  $\Delta H_{\text{rxn}}$ . This energy change is equal to the amount of heat transferred, at constant pressure, in the reaction. This change represents the difference in enthalpy of the products and the reactants and is independent of the steps in going from reactants to products.

According to *Hess's Law*, if a reaction can be carried out in a series of steps, the sum of the enthalpies for each step equals the enthalpy change for the overall reaction. Another way of stating Hess's Law is: If a reaction is the sum of two or more other reactions, the  $\Delta H_{\text{rxn}}$  for the overall reaction must be the sum of the  $\Delta H_{\text{rxn}}$  values of the constituent reactions. In this laboratory experiment, the value of  $\Delta H_{\text{rxn}}$  for Equation 1 minus the value of  $\Delta H_{\text{rxn}}$  for Equation 2 will equal the value of  $\Delta H_{\text{rxn}}$  for Equation 3. Unfortunately, there is no single instrument that can directly measure heat or enthalpy in the way a balance measures mass or a thermometer measures temperature. It is

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**Xiang Xie**



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