

# Thermochemistry Lab Report: Calorimeter Constants, Hess's Law, and Enthalpy Changes

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## Abstract

The aim of these three experiments was to determine the heat capacity of a calorimeter, confirm Hess's Law, and observe enthalpy changes within reactions. By measuring the change in temperature resulting from the interaction of various reactants, we determined both the calorimeter constant and the change in enthalpy for the reactions. The results varied, with some values closely resembling theoretical ones, while others showed greater discrepancies.

## Introduction

The first experiment focuses on finding the calorimeter constant for a polystyrene cup. During chemical reactions inside a calorimeter, some heat is lost to the surroundings. To ensure accurate results in subsequent experiments, it is crucial to determine the amount of heat lost. The equation used to calculate this constant is derived from the overall heat of the reaction equation: Overall Heat = - [(Sp.Ht. hotwater \* Mass of water \* Change in temperature) + (Sp.Ht. coolwater \* Mass of water \* Change in temperature) + (Cp calorimeter \* Change in temperature)] Since experimental errors are inevitable, three calculations were performed to obtain an average calorimeter constant. This experiment is vital for the success of the following two thermochemistry experiments. The second experiment, known as Hess's Law, aims to confirm this fundamental law. Three reactions are examined, where one of them is the same as the other two, and the heats of reaction for each are measured. Hess's Law states that the heat of reaction for one reaction should equal the sum of the heats of reaction for the other two reactions. The reactions used are:

1.  $\text{NaOH}(s) \rightarrow \text{Na}^+(\text{aq}) + \text{OH}^-(\text{aq})$
2.  $\text{NaOH}(s) + \text{HCl}(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq})$
3.  $\text{Na}^+(\text{aq}) + \text{OH}^-(\text{aq}) + \text{H}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq})$

To find the heat released by each reaction, a modified version of the overall heat of reaction equation is used:  $q = - [\text{Sp.Ht.} * m * \Delta t]$  Additionally, changes in entropy ( $\Delta S$ ) are calculated using theoretical values from reference tables. Finally, the overall free energy change ( $\Delta G$ ) is determined using the equation:  $\Delta G = \Delta H - (\text{Temperature} * \Delta S)$  All of this is used to verify Hess's Law by calculating the percent error involved in the experiment. The third experiment, titled "Thermochemistry: Acid + Base," combines the concepts of the previous two experiments. It observes the change in enthalpy resulting from various reactions between strong and weak acids and bases. Four reactions are investigated:

1.  $\text{HCl}(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
2.  $\text{HCl}(\text{aq}) + \text{NH}_3(\text{aq}) \rightarrow \text{NH}_4\text{Cl}(\text{aq})$
3.  $\text{HC}_2\text{H}_3\text{O}_2(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{NaC}_2\text{H}_3\text{O}_2(\text{aq}) + \text{H}_2\text{O}(\text{l})$
4.  $\text{HC}_2\text{H}_3\text{O}_2(\text{aq}) + \text{NH}_3(\text{aq}) \rightarrow \text{NH}_4\text{C}_2\text{H}_3\text{O}_2(\text{aq})$

By monitoring the change in temperature resulting from the reaction of an acid and a base, the overall energy change for each reaction ( $\Delta H_{\text{rxn/mole}}$  of limiting reactant) is calculated. This experimental value is compared to the theoretical value to determine the accuracy of the experiment.

## Experimental

In order to do any calculation for energy, we first had to find the calorimeter constant. In order to do that, we first took and weighed a polystyrene cup (our calorimeter) and added approximately 100 g of warm water to it. The actual measurements are recorded in...

# Enthalpy Calorimeter Lab Report

**J Dewey**



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