Data Tables

Part 1 Data Table. Determination of the Heat Capacity of the Calorimeter

Initial temperature (°C)

        50.0 mL H_2O—room temperature   _____

        50.0 mL H_2O—heated   _____

Mixing Data

Time (sec)	Temperature (°C)	Time (sec)	Temperature (°C)
20		120	
40		140	
60		160	
80		180	
100			

T_{mix}, °C _____ q_{cal}, J _____

T_{ave}, °C _____ C_{cal}, J/°C _____

Part 2 Data Table. Determination of Heats of Reaction

Reaction 1: $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

Initial temperature (°C)

        50.0 mL 2.0 M HCl   _____ °C

        50.0 mL 2.0 M NaOH   _____ °C
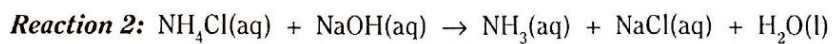
Mixing Data

Time (sec)	Temperature (°C)	Time (sec)	Temperature (°C)
20		120	
40		140	
60		160	
80		180	
100			

T_{mix}, °C _____ ΔH, kJ/mol _____

q_{rxn}, J   _____

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Experiment 6

Reaction 2: $NH_4Cl(aq) + NaOH(aq) \rightarrow NH_3(aq) + NaCl(aq) + H_2O(l)$

Initial temperature (°C)

      50.0 mL 2.0 M NH_4Cl _____ °C

      50.0 mL 2.0 M NaOH   _____ °C

Mixing Data

Time (sec)	Temperature (°C)	Time (sec)	Temperature (°C)
20		120	
40		140	
60		160	
80		180	
100			

T_{mix}, °C _____ ΔH, kJ/mol _____

q_{rxn}, J   _____

Reaction 3: $NH_3(aq) + HCl(aq) \rightarrow NH_4Cl(aq)$

Initial temperature (°C)

      50.0 mL 2.0 M NH_3 _____ °C

      50.0 mL 2.0 M HCl   _____ °C

Mixing Data

Time (sec)	Temperature (°C)	Time (sec)	Temperature (°C)
20		120	
40		140	
60		160	
80		180	
100			

T_{mix}, °C _____ ΔH, kJ/mol _____

q_{rxn}, J   _____

Post-Lab Calculations and Analysis

(Use a separate sheet of paper to answer the following questions.)

Part 1. Calculate the Heat Capacity of the Calorimeter

1. Plot the Mixing Data with temperature on the vertical axis and time on the horizontal axis.

   The first few data points may be erratic due to incomplete mixing and lack of equilibration with the thermometer. Draw a straight line through the subsequent points and extend the line back to the maximum temperature at time zero. Record this temperature as T_{mix} in the Part 1 Data Table.
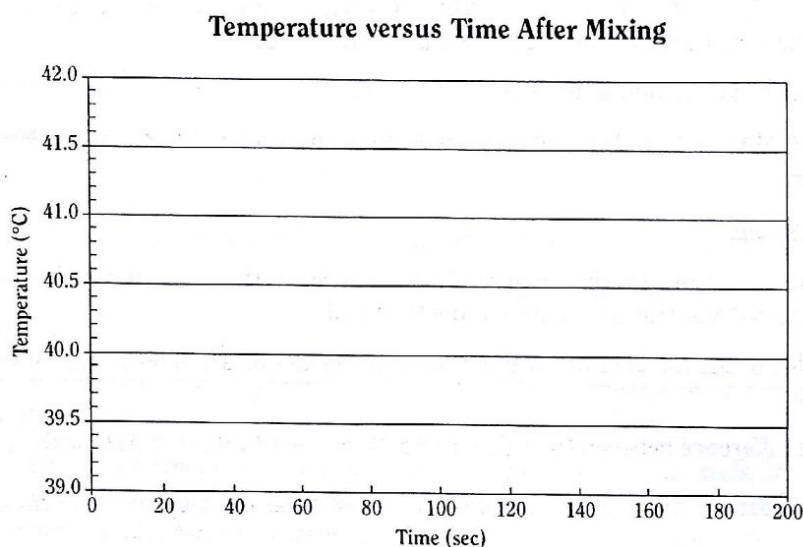

Temperature versus Time After Mixing

Figure 2.

2. Calculate the average initial temperature, T_{ave}, of the hot and cold water. Record this temperature as T_{ave} in the Part 1 Data Table.

3. The difference between T_{ave} and T_{mix} is due to the heat lost by the water and absorbed by the calorimeter. The heat lost by the water, q_{water}, is:

   $$q_{water} = (\text{grams of water}) \times (\text{specific heat of water}) \times (T_{mix} - T_{ave})$$

   where the specific heat of water is 4.18 J/(g·°C).

   The heat gained by the calorimeter, q_{cal}, is equal to that lost by the water, but opposite in sign.

   Calculate q_{cal} for the calorimeter and enter this value in the Part 1 Data Table.

4. Calculate the heat capacity of the calorimeter, C_{cal}. This is equal to the heat the calorimeter absorbs when 100 mL of solution changes 1 °C in temperature.

   $$C_{cal} = \frac{q_{cal}}{(T_{mix} - T_{initial})}$$

   where $T_{initial}$ is the initial temperature of the cool water. Record the heat capacity, C_{cal}, in the Part 1 Data Table.

Experiment 6

Part 2. Calculate the Enthalpy of Reaction, ΔH_{rxn}

1. Graph the temperature versus time on a separate sheet of graph paper for each of the three reactions tested. Extrapolate the line back to find the instantaneous mixing temperature, T_{mix}, for each reaction. Record this value for each reaction in the Part 2 Data Table.

2. Calculate the amount of heat evolved in each reaction, q_{rxn}. If it is assumed that all the heat of reaction is absorbed by the solution and calorimeter, then:

$$q_{rxn} = -[\text{heat absorbed by solution} + \text{heat absorbed by colorimeter}]$$

$$q_{rxn} = -[(\text{grams of solution} \times \text{specific heat of solution} \times \Delta T_{solution}) + (C_{cal} \times \Delta T_{solution})]$$

where $\Delta T_{solution} = (T_{mix} - T_{initial})$ for each reaction mixture. Assume the density of the final solutions is 1.03 g/mL and the specific heat of all the solutions is 4.18 J/g·°C.

Record the q_{rxn} for each reaction in the Part 2 Data Table.

3. Calculate the enthalpy change, ΔH_{rxn}, in terms of kJ/mole, for each of the reactions. Record the values in the Part 2 Data Table.

Part 3. Verify Hess's Law

1. Write the net ionic equations for the three reactions involved in the experiment. Show how the first two reactions are arranged algebraically to determine the third.

2. Calculate the value of ΔH for the third reaction from the values of ΔH determined for the first two reactions using Hess's Law.

3. Find the percent difference between the calculated and measured values of ΔH for the third reaction.

Post-Lab Questions *(Use a separate sheet of paper to answer the following questions.)*

1. What is meant by calorimetry?

2. How does graphical analysis improve the accuracy of the data?

3. The equation for calculating the heat evolved in each reaction is:

$$q_{rxn} = -[(\text{grams of solution} \times \text{specific heat of solution} \times \Delta T_{solution}) + (C_{cal} \times \Delta T_{solution})]$$

What is the meaning of the negative sign in front of the brackets?

4. Do the lab results support Hess's Law?

5. How could the procedure be modified to achieve greater accuracy?

6. Find a table in a reference that lists standard heats of formation for the species included in your net ionic equations. Use them to calculate ΔH_{rxn} for each of the three net ionic equations. Do these values support Hess's Law?

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