

Enthalpy Changes and Calorimetry

30 minutes, 3 stages

Calorimetry lets chemists measure heat transfer experimentally and use that data to calculate the enthalpy change of a reaction. This assignment reviews the relationship $Q = mc\Delta T$ (Outcome), the meaning of enthalpy and molar enthalpy (Outcome), and how calorimetry data translates into a ΔH , value (Outcome).

Stage 1: Warm-up (8 min)

Answer these short-response questions in your notebook.

1. Define enthalpy in your own words, and explain what makes molar enthalpy different from enthalpy (Outcome).
2. Write the equation $Q = mc\Delta T$. Each variable represents, including units (Outcome).
3. A calorimetry experiment uses 150 g of water. The specific heat capacity of water is $4.19 \text{ J/(g}\cdot^\circ\text{C)}$. The water's temperature rises from 21.5°C to 34.8°C . Calculate Q , the heat absorbed by the water, in joules. Show your substitution and your final answer with correct sign and units.

Stage 2: Worked calculations (14 min)

Work through the following calorimetry problems. Show all steps, including the setup of $Q = mc\Delta T$ and the conversion from Q to molar enthalpy.

Problem 1.

In a coffee-cup calorimeter, 2.15 g of ethanol ($\text{C}_2\text{H}_5\text{OH}$, molar mass 46.07 g/mol) is burned under a container holding 200.0 g of water. The water's temperature increases from 19.2°C to 45.6°C . Assume the specific heat capacity of water is $4.19 \text{ J/(g}\cdot^\circ\text{C)}$ and that all heat released is absorbed by the water.

- a) Calculate Q , the heat absorbed by the water.
- b) Calculate the number of moles of ethanol burned.
- c) Calculate the molar enthalpy of combustion of ethanol, in kJ/mol , and express it with the correct sign to show that the reaction is exothermic (Outcome, Outcome, Outcome).

Problem 2.

A student mixes 50.0 mL of 1.00 mol/L HCl(aq) with 50.0 mL of 1.00 mol/L NaOH(aq) in a polystyrene-cup calorimeter, similar to the calorimeter built in Resource. The temperature rises from 22.0°C to 28.9°C . Assume the combined solution has a mass of 100.0 g, a specific heat capacity of $4.19 \text{ J/(g}\cdot^\circ\text{C)}$, and that the calorimeter absorbs no heat.

- a) Calculate Q for the neutralization reaction.
- b) Calculate the number of moles of HCl that reacted.
- c) Calculate the molar enthalpy of neutralization in kJ/mol , with the correct sign (Outcome, Outcome).

Stage 3: Consolidation (8 min)

Write a short paragraph (4 to 6 sentences) that explains how a calorimetry experiment, such as burning a fuel sample under water as in Resource, allows a chemist to determine the molar enthalpy of a reaction. Your paragraph should mention the role of $Q = mc\Delta T$ and how Q connects to moles of reactant to give a ΔH , value in kJ/mol (Outcome, Outcome, Outcome).

Self-check

1. In Problem 1 above, is the sign of your molar enthalpy value positive or negative, and does this match the fact that combustion reactions release energy?
2. If a calorimetry experiment loses heat to the surroundings instead of trapping it all in the water, would the calculated molar enthalpy be an overestimate or an underestimate of the true value? Explain your reasoning.
3. State the difference between Q , the heat transferred in joules, and ΔH in kJ/mol, in terms of what each quantity depends on.