

# chapter 6 thermochemistry homework problems

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## Introduction

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Thermochemistry is a cornerstone of chemistry that helps students understand how energy flows in chemical reactions. For many learners, Chapter 6 of their textbook presents a series of challenging homework problems that test both conceptual knowledge and practical calculation skills. This guide is designed to walk you through the most common types of chapter 6 thermochemistry homework problems, offering clear explanations, step by step solutions, and helpful strategies for mastering the material. By the end of this article, you will feel confident tackling even the toughest problems in this chapter.

## Understanding Thermochemistry

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### What Is Thermochemistry?

Thermochemistry studies the heat changes associated with chemical reactions and physical transformations. It focuses on enthalpy ( $\Delta H$ ), the measure of heat absorbed or released at constant pressure. Understanding enthalpy changes allows chemists to predict whether a reaction will be exothermic or endothermic and to calculate the energy required for processes such as melting, vaporization, and combustion.

### Key Concepts in Chapter 6

Chapter 6 typically covers topics such as:

- Heat capacity and calorimetry
- Exothermic vs. endothermic reactions
- Enthalpy of formation and reaction
- Hess's Law and standard enthalpies
- Energy diagrams and reaction coordinates

These concepts form the foundation for solving the homework problems you'll encounter.

## Chapter 6 Thermochemistry Homework Problems: An Overview

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### Common Problem Types

When students look at chapter 6 homework, they often see a mix of calculation heavy tasks and conceptual questions. Typical problem categories include:

1. Calorimetry calculations – determining heat absorbed or released using moles, mass, and specific heat capacities.
2. Enthalpy of reaction problems – using  $\Delta H_f^\circ$  values of reactants and products to compute overall  $\Delta H_r^\circ$ .
3. Hess's Law applications – combining multiple reactions to find unknown enthalpy changes.
4. Energy diagram interpretation – identifying activation energy, intermediates, and reaction pathways.
5. Conceptual questions – explaining the difference between exothermic and endothermic processes or the role of enthalpy in chemical equilibria.

Each of these problem types requires a slightly different approach, but the underlying principles are the same.

## Why These Problems Are Important

Mastering chapter 6 homework problems equips students with the analytical skills needed for advanced chemistry courses, engineering studies, and real world applications such as energy production, pharmaceuticals, and environmental science. Moreover, these problems reinforce the connection between theoretical concepts and experimental data, a skill that is invaluable in any scientific discipline.

## Step by Step Solutions to Typical Problems

### Example 1: Calorimetry Calculation

Problem: A 50 g sample of water at 25 °C is heated to 75 °C in a calorimeter with a heat capacity of 2.5 kJ/K. What is the heat absorbed by the water?

Solution:

1. Calculate the temperature change:  $\Delta T = 75^\circ\text{C} - 25^\circ\text{C} = 50^\circ\text{C}$
2. Use the calorimeter's heat capacity ( $C_{\text{cal}} = 2.5 \text{ kJ/K}$ ):  $Q_{\text{cal}} = C_{\text{cal}} \times \Delta T = 2.5 \text{ kJ/K} \times 50^\circ\text{C} = 125 \text{ kJ}$
3. Since the calorimeter's heat capacity already accounts for the water's heat, the heat absorbed by the water is 125 kJ.

Answer: 125 kJ of heat is absorbed by the water.

### Example 2: Enthalpy of Reaction

Problem: The standard enthalpy of formation for methane ( $\text{CH}_4$ ) is  $-74.8 \text{ kJ/mol}$ , and for oxygen ( $\text{O}_2$ ) it is  $0 \text{ kJ/mol}$ . Calculate  $\Delta H^\circ$  for the combustion of methane:  $\text{CH}_4(\text{g}) + 2 \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{l})$ .

Solution:

1. Write the standard enthalpies of formation for the products:  $\text{CO}_2(\text{g}) = -393.5 \text{ kJ/mol}$ ,  $\text{H}_2\text{O}(\text{l}) = -285.8 \text{ kJ/mol}$ .
2. Apply the formula  $\Delta H^\circ = \sum \Delta H_f^\circ(\text{products}) - \sum \Delta H_f^\circ(\text{reactants})$
3. Compute:  $\Delta H^\circ = 1(-393.5) + 2(-285.8) - 1(-74.8) = -890.3 \text{ kJ/mol}$ .

Answer: The combustion of methane releases  $-890.3 \text{ kJ/mol}$  of heat.

### Example 3: Hess's Law

Problem: Determine the enthalpy change for the reaction:  $\text{C}_2\text{H}_2(\text{g}) + 3.5 \text{O}_2(\text{g}) \rightarrow 2 \text{CO}_2(\text{g}) + 3 \text{H}_2\text{O}(\text{l})$ . Given  $\Delta H_f^\circ$  values:  $\text{C}_2\text{H}_2 = -84.7 \text{ kJ/mol}$ ,  $\text{O}_2 = 0$ ,  $\text{CO}_2 = -393.5 \text{ kJ/mol}$ ,  $\text{H}_2\text{O} = -285.8 \text{ kJ/mol}$ .

Solution:

1. Compute  $\Delta H_f^\circ$  for each species.
2. Sum the products:  $2(-393.5) + 3(-285.8) = -787.0 - 857.4 = -1,644.4 \text{ kJ}$ .
3. Sum the reactants:  $-84.7 + 3.5(0) = -84.7 \text{ kJ}$ .
4. Subtract reactants from products:  $\Delta H^\circ = -1,644.4 - (-84.7) = -1,559.7 \text{ kJ}$ .

Answer: The reaction releases  $-1,559.7 \text{ kJ}$  of heat.

### Example 4: Energy Diagram Interpretation

Problem: In an energy diagram for a reaction, the activation energy ( $E_a$ ) is  $75 \text{ kJ/mol}$ , and the reaction enthalpy ( $\Delta H^\circ$ ) is  $-50 \text{ kJ/mol}$ . Identify the reaction type and the relative heights of the transition state and products.

Solution:

1.  $\Delta H_{\text{rxn}} = -2 \text{ kJ/mol}$ , so the reaction is exothermic.
2. The transition state lies 75 kJ above the reactants.
3. Since  $\Delta H_{\text{rxn}} = -2 \text{ kJ/mol}$ , the products are 50 kJ below the reactants.
4. The transition state is higher than both reactants and products, with the product well below the reactant level.

Answer: Exothermic reaction with a transition state 75 kJ above reactants and products 50 kJ below reactants.

## Practice Problems with Answers

### Problem Set 1: Calorimetry

1. A 10 g sample of ice at 0 °C melts and then warms to 20 °C. Given the heat of fusion of ice is 334 kJ/kg and the specific heat of water is 4.18 kJ/kg·K, calculate the total heat absorbed.
2. Answer: Heat to melt ice:  $10 \text{ g} \times 334 \text{ kJ/kg} = 3.34 \text{ kJ}$ . Heat to warm water:  $10 \text{ g} \times 4.18 \text{ kJ/kg} \cdot \text{K} \times 20 \text{ K} = 8.36 \text{ kJ}$ . Total heat =  $3.34 \text{ kJ} + 8.36 \text{ kJ} = 11.70 \text{ kJ}$ .
3. A 200 g sample of ethanol (C<sub>2</sub>H<sub>5</sub>OH) at 25 °C is heated to 100 °C. The specific heat capacity of ethanol is 2.44 kJ/kg·K. Calculate the heat absorbed.
4. Answer:  $Q = m \cdot c \cdot \Delta T$ . Mass in kg = 0.200 kg.  $Q = 0.200 \text{ kg} \times 2.44 \text{ kJ/kg} \cdot \text{K} \times 75 \text{ K} = 36.6 \text{ kJ}$ .

### Problem Set 2: Enthalpy of Reaction

1. Calculate  $\Delta H_{\text{rxn}}$  for the reaction:  $\text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \rightarrow 2 \text{NH}_3(\text{g})$ , given  $\Delta H_f^\circ$  values:  $\text{NH}_3(\text{g}) = -46.1 \text{ kJ/mol}$ .
2. Answer: Reactants have zero enthalpy of formation.  $\Delta H_{\text{rxn}} = 2 \text{ mol} \times (-46.1 \text{ kJ/mol}) = -92.2 \text{ kJ}$ .
3. Determine  $\Delta H_{\text{rxn}}$  for the combustion of glucose:  $\text{C}_6\text{H}_{12}\text{O}_6(\text{s}) + 6 \text{O}_2(\text{g}) \rightarrow 6 \text{CO}_2(\text{g}) + 6 \text{H}_2\text{O}(\text{l})$ . Given  $\Delta H_f^\circ$  values:  $\text{C}_6\text{H}_{12}\text{O}_6(\text{s}) = -1274 \text{ kJ/mol}$ ,  $\text{CO}_2(\text{g}) = -393.5 \text{ kJ/mol}$ ,  $\text{H}_2\text{O}(\text{l}) = -285.8 \text{ kJ/mol}$ .
4. Answer:  $\Delta H_{\text{rxn}} = 6 \text{ mol} \times (-393.5 \text{ kJ/mol}) + 6 \text{ mol} \times (-285.8 \text{ kJ/mol}) - (-1274 \text{ kJ/mol}) = -2802.6 \text{ kJ}$ .

### Problem Set 3: Hess's Law

1. Find  $\Delta H_{\text{rxn}}$  for the reaction:  $2 \text{CH}_4(\text{g}) + 3 \text{O}_2(\text{g}) \rightarrow 2 \text{CO}(\text{g}) + 4 \text{H}_2\text{O}(\text{l})$ , using  $\Delta H_f^\circ$  values:  $\text{CH}_4(\text{g}) = -74.8 \text{ kJ/mol}$ ,  $\text{CO}(\text{g}) = -110.5 \text{ kJ/mol}$ ,  $\text{H}_2\text{O}(\text{l}) = -285.8 \text{ kJ/mol}$ .
2. Answer:  $\Delta H_{\text{rxn}} = 2 \text{ mol} \times (-110.5 \text{ kJ/mol}) + 4 \text{ mol} \times (-285.8 \text{ kJ/mol}) - 2 \text{ mol} \times (-74.8 \text{ kJ/mol}) = -1452.6 \text{ kJ}$ .

## Tips for Mastering Chapter 6 Thermochemistry

### Organize Your Work

Use a clear, step by step approach:

- Write down all known values.
- Identify what you need to find.
- Choose the correct formula ( $Q = mc\Delta T$ ,  $\Delta H_{\text{rxn}} = \sum \Delta H_f^\circ(\text{products}) - \sum \Delta H_f^\circ(\text{reactants})$ ,  $\Delta H_{\text{rxn}} = \sum \Delta H_{\text{comb}}^\circ(\text{reactants}) - \sum \Delta H_{\text{comb}}^\circ(\text{products})$ ).
- Check units for consistency.
- Double check calculations for errors.

### Understand the Physical Meaning

Instead of memorizing formulas, focus on what each term represents. For instance, heat capacity tells you how much energy is needed to change temperature, while enthalpy change indicates whether a reaction releases or absorbs heat.

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