Unit Plan: Thermochemistry and Thermodynamics

FOR THE TEACHER

Summary
The AACT high school classroom resource library and multimedia collection has everything you need to put together a unit plan for your classroom: lessons, activities, labs, projects, videos, simulations, and animations. We constructed a unit plan using AACT resources that is designed to teach thermochemistry and thermodynamics to your students.

Grade Level
High School

Objectives
By the end of this unit, students should be able to

- Construct a macroscopic model of how energy is transferred.
- Explain how perception of hot or cold is related to heat and temperature.
- Use the particulate model of matter to explain how kinetic energy is demonstrated amongst the particles of a substance.
- Define endothermic and exothermic processes.
- Differentiate between endothermic and exothermic chemical reactions.
- Write balanced chemical equations including heat energy.
- Identify processes as either exothermic or endothermic based on evidence, such as temperature changes in a chemical reaction.
- Associate an endothermic and exothermic chemical reaction with their related energy diagram.
- Understand how a chemical reaction is related to an energy diagram.
- Interpret data to determine if an endothermic reaction or an exothermic reaction has occurred.
- Be able to solve problems using Hess’s Law.
- Perform a calorimetry experiment to successfully calculate ΔH_rxn.
- Apply Hess’s Law to successfully calculate ΔH_rxn of an unknown reaction.
- Successfully perform error analysis.
- Define entropy.
- Recognize entropy changes in chemical reactions.
- Relate entropy to states of matter.
- Observe a chemical or physical process, and predict the sign of the entropy change.
- Observe a chemical or physical process, and predict the sign of the enthalpy change.
- Given the signs of both ΔH° and ΔS°, determine if a process is thermodynamically favorable, and if that favorability occurs at higher or lower temperatures.
- Calculate ΔH°, ΔS°, ΔG°.
- Relate the significance of the signs of ΔH° and ΔS° to thermodynamic favorability.
- Predict what will happen in terms of thermodynamic favorability if temperature of system is increased or decreased (how the value of ΔG is affected).

Chemistry Topics
This unit supports students’ understanding of

- Energy & Thermodynamics
- Heat
- Temperature
- Specific Heat Capacity
- Endothermic & Exothermic Reactions
- Energy Diagrams
- Energy Transfer
- Hess’s Law
• Calorimetry
• Thermal conductivity
• Entropy
• Enthalpy
• Thermodynamic favorability
• Gibb’s free energy
• Chemical Reactions
• Chemical Change
• Error Analysis

**Time**

**Teacher Preparation:** See individual resources.

**Lesson:** 8-12 class periods, depending on class level.

**Materials**

• Refer to the materials list given with each individual activity.

**Safety**

• Refer to the safety instructions given with each individual activity.

**Teacher Notes**

• Many teachers start their thermodynamics unit with a study of heat transfer, specific heat capacity, and calorimetry. These topics were covered in our [Phase Changes and Heat Transfer](#) unit plan.

• The activities shown below are listed in the order that they should be completed.

• The teacher notes, student handouts, and additional materials can be accessed on the page for each individual activity.

• Please note that most of these resources are AACT member benefits.

**Classroom Resources**

• Start the unit with the [What Makes Something Feel Warm](#) activity, which engages thinking about energy in chemistry and the nature of thermal transfer. This will allow students to construct a macroscopic model that represents how energy is transferred and explain how their perception of hot and cold is related to heat and temperature. Alignment to [NGSS](#) is included in this resource.

• Then use the simulation, [Energy Changes in Chemical Reactions](#) from the [November 2016](#) issue of [Chemistry Solutions](#) to introduce the topic of exothermic and endothermic reactions. This simulation allows students to evaluate the energy changes in different reactions and compare how energy is absorbed and released during the reaction process. Students will also learn how to connect energy diagrams with each reaction type.

• After introducing the topic of enthalpy of a reaction, have students complete the lab, [Determining Endothermic and Exothermic Reaction](#). During this hands-on activity, students carry out two common reactions and analyze evidence to determine if energy is released or absorbed. After making observations and drawing conclusions about the direction of energy flow, students are then tasked with determining if other common physical and chemical equations are exothermic or endothermic.
  
  o An alternate activity is the [Exothermic and Endothermic Lab](#) which has students determine whether mixing two substances together is a physical or chemical change and then determine if it is an endothermic or exothermic process.
If your students need additional reinforcement, consider using the **Endothermic & Exothermic Reactions** activity to help them understand the difference between the two processes. This resource includes alignment with Common Core standards.

Another option is the **Energy in Hot and Cold Packs** activity which uses chemical hot and cold packs to demonstrate endothermic and exothermic processes. This resource includes alignment with NGSS and the AP Chemistry Curriculum Framework.

- **Hess’s Law** lesson plan to teach your students about the concepts of Hess’s Law and problem solving techniques involving them. This lesson includes a PowerPoint presentation along with a student activity sheet and answer key. This resource includes alignment with the AP Chemistry Curriculum Framework.

- In a related lesson plan, **Hess’s Law Application**, students determine the value of $\Delta H$ of an unknown reaction through laboratory data collection using calorimetry and Hess’s Law. This lesson also includes a formative quiz to access student’s readiness for the lab activity as well as answer keys for the quiz and example lab data. Additionally, it includes ties to the AP Chemistry Curriculum Framework.

- The **Entropy** activity will help students define the concept and be able to recognize entropy changes in chemical reactions. The lesson includes a PowerPoint presentation, which introduces the topic with pictures of everyday items, then moves on to discuss changes in physical state, and ends by investigating changes that result from a chemical reaction. This resource includes alignment with the AP Chemistry Curriculum Framework.

- Follow this introduction with the activity, **Connecting States to Entropy**, which uses blocks to model different states of matter.

- The **Enthalpy and Entropy as Driving Forces** lesson plan will help students see the connections between enthalpy, entropy, and free energy. Students engage in an activity to observe various chemical and physical processes to qualitatively predict and explain the signs of $\Delta S$ and $\Delta H$. Based on their observations, they then predict the sign of $\Delta G$ and determine the driving force of the process. This lesson focuses on thermochemical predictions, calculations and explanations and includes alignment with the AP Chemistry Curriculum Framework.

- The **Thermochemistry Infographic** is a great culminating activity to use to check student understanding of the principles of thermochemistry and thermodynamics. Student groups select a real world phenomenon involving a type of energy change and explain the process using the concepts learned during this unit. This project supports student understanding of exothermic and endothermic reactions, bond energy, energy flow in systems, the Law of conservation of Energy, and temperature. It also includes NGSS alignment.