Unit Plan: Phase Changes and Heat Transfer

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 the Phase Changes and Heat Transfer to your students.

Grade Level
High School

Objectives
By the end of this unit, students should be able to
- Explain how temperature is related to average kinetic energy.
- Provide evidence and explain what temperature measures.
- Describe how the temperature difference between substances can change the forces of attraction between the particles in the substances.
- Distinguish between the states of matter at the particle level.
- Explain, using examples how matter is different in one state versus another.
- Identify examples of different states of matter.
- Identify a state of matter based on a particle diagram.
- Differentiate between the states of matter based on the behavior of particles in a sample.
- Analyze data associated with physical properties (melting point and boiling point) to determine the state of matter of a given sample.
- Determine which phase change is occurring by analyzing the behavior of particles in a sample.
- Accurately distinguish between six possible phase changes: melting, freezing, evaporation, condensation, sublimation, and deposition.
- Realize that when a state change occurs, a temperature change does not take place.
- Quantify how much energy it takes to heat water from one temperature to another.
- Study the effects of heating and cooling a pure substance through a change of phase.
- Construct heating and cooling curves of a pure substance using experimental data.
- Determine the freezing and melting point temperatures of a pure substance.
- Use and understand specific heat.
- Recognize that all liquids don’t behave the same when it comes to heat transfer.
- Understand the difference between thermal conductivity and specific heat capacity.
- Understand that each substance has its own unique specific heat capacity.
- Understand that three factors contribute to the amount of heat that is transferred when two substances are mixed: temperature, mass, and specific heat capacity.
- Compare and contrast the insulating properties of various materials.
- Discuss the thermal energy flow in a system.
- Collect appropriate laboratory data for use in calorimetric calculations.
- Calculate the specific heat capacity of a metal using calorimetry.
- Identify an unknown metal based on specific heat capacity values determined.

Chemistry Topics
This unit supports students’ understanding of
- Energy
- Particle motion
- Temperature
• Average kinetic energy
• States of matter
• Pure substances
• Mixtures
• Particle representations of elements and compounds
• Intermolecular forces
• Phase changes
• States of matter
• Physical properties
• Melting point
• Boiling point
• Heating curve
• Specific heat capacity
• Heat transfer
• Phase diagram
• Thermal Conductivity
• Energy transfer
• Calorimetry
• Law of Conservation of Energy

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
• 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 this unit by exploring the difference between bond and molecular movements with The Molecular Dance. This activity shows students how to mimic molecular motion and distinguish between bonds and interparticle forces. Movements explored include the stretching, bending and rotating properties of a bond, as well as the vibration, rotation, and translation movements of molecules. After completing this introductory activity, use the Density simulation to help students analyze movement and energy of different states of matter at the particle level as temperature is increased or decreased.

• Another quick activity that allows students to observe the effect of temperature on molecular motion is the demonstration, What is Temperature. This classroom demo helps students explain how temperature is related to average kinetic energy and challenges them to explain what a temperature measurement really means, using supporting evidence. Pair this demonstration with The Temperature Guys video which tells the story of how the concept of temperature the thermometers have evolved. This resource includes an activity sheet with questions for your students to answer while they are watching the video.
• Move on to phase changes and states of matter with one or more of the following activities:
  o The activity, Visualizing States of Matter has students view, sort and classify pure substances and mixtures into the 3 common states of matter found in the laboratory. It is also aligned with the NGSS. By the end of the activity, students will able to classify the three states of matter using molecular level particle representations, identify differences in the particle representations to classify them as pure substances, elements or compounds, and verbally explain the classification system they developed.
  o Students explore and explain behaviors of liquids and solids based on the individual particles in the states of matter and their intermolecular forces with The Behavior of Solids and Liquids activity, which also includes NGSS alignment.
  o The activity, Categorizing States of Matter allows students to analyze both written statements and images that describe the properties of a solid, liquid or gas. They then determine which state of matter the description best describes and categorize it accordingly.

• Assess student understanding of phase changes, and melting and boiling point with an online quiz in the States of Matter and Phase Changes simulation. This activity includes questions that will challenge students to analyze data to identify the correct state of matter and then connect it with an animated particle diagram.

• Use the Heating Curve of Water simulation to introduce the concepts of heat capacity and phase changes. In this simulation, students investigate qualitatively and quantitatively what happens as water changes temperature and states. This lesson accompanies the simulation from the May 2015 issue of Chemistry Solutions. By the end of this lesson, students will understand the difference between the states of matter, discover that when a state change occurs a temperature change does not take place, and quantify how much energy it takes to heat water from one temperature to another.

• Next, move on to the Heating & Cooling Curve lab, where students create a phase change graph by adding and removing heat to observe and record data during actual phase changes. Instead of just memorizing a heating/cooling curve they see in a textbook, students will create their own. They will also determine the freezing and melting point temperatures of a pure substance.

• After exploring temperature and phase changes for water, use another lab, Understanding Specific Heat to help students investigate what happens when two liquids at different temperatures are mixed. This lab will help students understand that all liquids do not have the same heat capacity and behave differently with respect to heat transfer.

• Then, use the Dramatic Demonstration of Thermal Conductivity to introduce heat capacity of metals. This entertaining classroom demo will show students how low the heat capacity of copper metal is when compared to other substances. Follow it up with the Measuring Heat demonstration, which allows students to collect data when two liquids at different temperatures are mixed and also when a liquid and a solid at different temperatures are mixed. By the end of this demonstration, students will understand that each substance has its own unique heat capacity and that the amount of heat transferred when two substances are mixed depends upon several variables, including: initial temperature, mass, and specific heat capacity.

• Finish up your study of heat transfer with the lab, How Much Energy is in Your Snack Food, which allows students to calculate the amount of heat energy stored in some of the foods they eat. This lab will help students understand the law of conservation of energy in addition to letting them measure the heat released by common snack food.
Culminating Activities

Use one of these labs to assess student understanding of the concepts of specific heat and heat transfer if you end your unit with a summative activity:

- Students take on the role of a forensic investigator and use lab results to help them determine if a suspect’s vehicle was potentially involved in a hit and run incident in The Search for a Hit and Run Suspect lab by collecting data and completing calorimetric calculations to determine the specific heat capacity of multiple unknown metal samples.

- Students design and build a device capable of insulating an ice cube submerged in boiling water for two minutes in the Chemistry is Cooler Stress Challenge. This open-ended inquiry based activity requires students to critically think about structure and function of the materials they wish to use to build a device to solve a complex real-world problem.