

Heat Transfer & Specific Heat

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Lesson Overview

Find standards, vocabulary, and the unit essential question in the unit outline [here](#).

Lesson Outline

TOTAL TIME: 45 min



Time



Topic



Assignments

5 min	Introduction: Methods of Heat Transfer
15 min	Activity: Conduction, Convection, and Radiation
5 min	Activity: Explore Heat Transfers Around Me
10 min	Specific Heat Demonstration and Explanation
10 min	Evaluate: Reflection

Extension: [Heating Water Calculations](#) - Students apply the specific heat equations to observe how much energy is needed to heat the water in a home and how this can be reduced. (30-45 min)

Lesson Objectives

Students will be able to...


- Determine the method of heat transfer involved in a process
- Explore why some materials heat up faster than others by introducing specific heat capacity

Preparation

Materials

- Fly swatter, ruler, or other object to point to words on the projector
- Specific heat demo: materials listed on [Teaching Chemistry](#) if conducting an in-person demo
- Optional: [Heating Water Handout](#) - one per student
 - Students will analyze the energy it takes to heat water for a shower and identify potential water and energy savings. This can also be done as an assignment.

Introduction: Methods of Heat Transfer

Follow along with the [Heat Transfer slides](#) as you lead this lesson. The  symbol indicates a corresponding slide.

- Have students write or draw: How do you get warm around a fire? How does heat reach you? Students should try to think of 2-3 methods.

Methods of Heat Transfer

- There are three methods in which heat is transferred from one material to another.
 - **Conduction** occurs when heat is transferred through substances in direct contact with each other. In the image, the fire is heating the metal fire poker and the heat is “conducted” through the fire poker.
 - **Convection** is the movement of a heated gas or liquid away from the heat source. Through the process of convection, heat moves through a fluid such as a liquid or a gas. One common expression about convection is “hot air rises.” Hot air rises because air becomes less dense as it is heated which causes the air to rise. For the campfire example, heat rises from the flame and typically creates the hottest surrounding area.
 - **Radiation** is the change in temperature as a result of electromagnetic radiation. Electromagnetic radiation includes natural light, microwaves, and ultraviolet light. For a fire, radiation is the heat emitted around the flame.

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Cooking and Heat Transfer

- Ask students: How does heat transfer to warm up a pot of soup on the stove?
- Conduction transfers heat from the stove to the pot, heating the liquid at the bottom.
- Convection allows heat to circulate - the soup at the bottom rises, allowing the liquid at the top to fall to the bottom and also heat.

Activity: Conduction, Convection, and Radiation

In this activity, students will identify different types of heat transfer.

Radiation, Conduction, and Convection Song

- Show this three minute video as a way to help students remember the difference between the three methods of heat transfer: [Radiation, Conduction, Convection Song](#).

Activity: Conduction, Convection, and Radiation

- Divide the class into two teams. Use the projector to project the slide in the PowerPoint with “Conduction, Convection, Radiation” written on it. Have one student from each team come to the front of the class with a flyswatter facing away from the screen. Read one of the items below. The students at the front should turn around and use the flyswatter to hit the screen of the correct type of heat transfer.
 - A hot air balloon rising (convection)
 - The handle on a pot on the stove heating up (conduction)
 - The heat from the asphalt warming your hand which is not touching the asphalt (radiation)
 - Ocean currents (convection)
 - Hot tailpipe on a motorcycle (conduction)
 - Hot car in the sun (radiation)
 - Boiling water (convection)
 - A warm seat after someone stands up (conduction)
 - Microwave (radiation)
 - Baking cookies (convection)
 - Heating pad for sore muscles (conduction)
 - Getting a suntan (radiation)
 - A greenhouse (convection)

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- A warm coffee mug (conduction)
- Warmth from a light bulb (radiation)
- Steam (convection)
- Warm phone during charging (conduction)
- Hair dryer (radiation)

Activity: Explore Heat Transfers Around Me

Mapping Heat Transfer

- Have students write or share:
 - What are some additional examples of heat transfer?
 - What examples of heat did you experience today?
- Have students draw a map of the heat transfer and how it got to them.

Activity: Specific Heat Demonstration

Which will heat up faster?

- Ask students: Does air heat up faster than water? Why?
- On a hot day, why do bodies of water (ocean, lakes, pools) stay cool?

Demonstration: Specific Heat

Play the AACT video for the class or conduct the demonstration following the instructions and materials listed in the link below. The following experiment demonstrates specific heat capacity and thermal conductivity (covered in [Lesson: Thermal Conduction and Insulation](#)). Instructions and materials are listed on the Teaching Chemistry website:

[Classroom Resources | Dramatic Demonstration of Thermal Conductivity and Specific Heat Capacity | AACT](#)

Explain: Specific Heat

Energy to Heat Water

- It takes lots of energy to heat water! The equation below can be used to determine the amount of heat required to raise the temperature of water.

$$\text{Heat} = \text{specific heat} \times \text{mass} \times \text{change in temperature } (^\circ\text{C})$$

$$Q = cm\Delta T$$

- The specific heat (c) of a substance is the amount of energy required to raise the temperature of 1 gram of that substance by 1 °C. The specific heat for water is 4.186 J/(g*°C). The table below¹ lists the specific heat of different substances. Note that water has the highest specific heat on this list:

Substance	Specific Heat (J/(g*°C))
Aluminum	0.897
Copper	0.385
Air	1.005
Wood	1.30-2.40
Rubber	1.88
Concrete	0.88
Sand	0.83
Glass	0.67
Water	4.186
Sea Water ²	4.00

- Ask students: Does water or Sea Water have a higher specific heat? **Water**
- Ask students: Based on the table, will it take more energy to heat glass or to heat rubber? (Assume mass and ΔT are the same!) **Rubber**
- A typical energy efficient water heater has an energy factor of about 0.67³. The energy factor is a ratio of the useful energy output of the water heater to the energy delivered to the water heater. The higher the energy factor the more efficient the water heater.

¹ The Engineering Toolbox. "Specific Heat of some Common Substances". Accessed July 20, 2021.

https://www.engineeringtoolbox.com/specific-heat-capacity-d_391.html

² The Engineering Toolbox. "Seawater Properties". Accessed July 20, 2021.

https://www.engineeringtoolbox.com/sea-water-properties-d_840.html

³ Energy Star. "Water Heater Key Product Criteria". Accessed June 2, 2021.

http://www.energystar.gov/index.cfm?c=water_heat.pr_crit_water_heaters

Evaluate - Reflection

Ask students to prove the answers to these questions through the use of the specific heat formula:

- Will a body of saltwater heat up faster than a body of freshwater of the same size? Which will cool down faster? Why?
- Will the saltwater or the freshwater require more energy to heat?
- Bonus (not in the slides because it contains a spoiler to the above): can you think of an example when boiling fresh water would use less energy than boiling sea water? (Answer: Yes, if there is less fresh water (lower mass) and/or the salt water starts at a higher temperature)
- What are three different uses of water heating from today's lesson? What fuel sources are needed to produce hot water?

Extension: Heating Water Calculations

Provide each student with a copy of the [Heating Water Handout](#). The handout provides individual steps that students can take to determine how much energy is needed to heat water. This activity will help students concretize the amount of energy needed to heat water for common activities like taking a shower, and identify ways they can reduce their water heating energy usage. Check students' work using the [Teacher Key](#).

