Demonstration: Energy

FOR THE TEACHER

Summary
In this demonstration, students will observe first-hand the exothermic and endothermic properties of state changes by dipping a finger in water and wax—substances with different freezing and boiling points. They will use the sense of touch to verify whether freezing and boiling are processes that require heat or release heat.

Grade Level
High and Middle school

AP Chemistry Curriculum Framework
This demonstration supports the following unit, topic, and learning objective:

- **Unit 6: Thermodynamics**
  - **Topic 6.1:** Endothermic and Exothermic Processes
    - **ENE-2.A:** Explain the relationship between experimental observations and energy changes associated with a chemical or physical transformation.

NGSS Alignment
This demonstration will help prepare your students to meet the performance expectations in the following standards:

- **HS-PS3-4.** Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
- **Science and Engineering Practices:** Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.
- **Crosscutting Concepts:**
  - **Systems and System Models:** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

Objectives
By the end of this demonstration, students should be able to
- Better understand what happens in terms of energy when a substance evaporates or freezes.

Chemistry Topics
This demonstration supports students’ understanding of
- Energy
- Exothermic/endothermic

Time
**Teacher Preparation:** 10 minutes
**Lesson:** 15–20 minutes
Materials
- Hot plate
- Beakers (2 x 250 mL)
- Thermometers (2)
- Water
- Paraffin wax

Safety
- Always wear goggles when working in the lab.
- The teacher should use a thermometer when heating both the water and the wax to ensure the temperature of each remains safe and does not exceed 50-55°C.
- Paraffin wax SDS

Procedure
Expected student responses are in italics
- On a hot plate, have two beakers: one with water, one with wax. Heat both beakers until the temperatures of the water/wax reaches approximately 50°C. It is important that both the water and the wax are the same temperature.
- Have students make predictions about what will happen when a volunteer dips their finger into each beaker and then removes it.
- Have at least one student volunteer to dip one finger from each hand into the two beakers at the same time so at least the second knuckle is covered.
- They should share with the class how each of their fingers feel. (They should feel the same temperature, relative to each other because the two solutions are the same temperature.)
- When the volunteer removes his/her fingers from the beakers, they should share with the class how their fingers feel (did they get warmer or cooler)? (The finger in the water should feel cooler, and the finger in the wax should feel warmer. Their finger is above the freezing point of water but below the freezing point of wax. Water at body temperature evaporates readily.)

Teacher Notes
- Paraffin wax can be bought at most craft stores and online.
- The paraffin we used had a melting point of 55°C, so we heated the water to the same temperature.
- It is difficult to completely clean the paraffin from the beaker. You may want to let the paraffin harden in the beaker and save it to use it again.
FOR THE STUDENT

Energy

Pre-lab Questions
Circle the choice of words in parentheses that you think is correct.

1. When wax freezes on your finger, the PE goes (up, down) and the KE goes (up, down). Your finger should get (hot, cold).
2. When water evaporates from your finger, the PE goes (up, down) and the KE goes (up, down). Your finger should get (hot, cold).

Safety
Always wear goggles when working in the lab.

Results
Compared to each other, what do the fingers feel like when in the beakers?

After removing the fingers from the beakers, how do they feel?

Water
Wax

Conclusion
Were your predictions in the prelab correct? Explain.