Heat versus Temperature

Physical Science Demonstration

Introduction

Understanding the difference between heat and temperature is a fundamental scientific concept that is frequently overlooked and sometimes misunderstood.

Concepts

- Temperature
- Heat
- Energy transfer
- Thermal energy

Materials (for each demonstration)

Beaker, 250-mL

Hot plate or Bunsen burner setup

Hot vessel–gripping device (optional)

Pipet, small, or medicine dropper

Water, tap

Safety Precautions

Try this demonstration prior to performing it in front of your students to make sure your hands can handle the heat. Use only a small pipet or dropper and do not draw up more than a few drops of hot water. Only use one drop of boiling water at a time and use extreme caution when working with boiling water. Wear chemical splash goggles.

Procedure

1. Fill a 250-mL beaker with approximately 100 mL of tap water.
2. Bring the water to a boil using a hot plate or Bunsen burner setup.
3. Rinse a pipet or dropper with boiling water a few times to heat it up. This should prevent any hot water from spurting out due to pressure buildup.
4. Remove a few drops of boiling water using the preheated pipet or medicine dropper.
5. Carefully place *one drop* of hot water onto the palm of your hand.
6. Shake off the drop or move it around to avoid any burns.
7. Ask your class the following questions:
   a. What Temperature was the water that I just dropped on my hand?
   b. Do you think it hurt?
   c. Why or why not?
   d. What if I poured the whole beaker of boiling water on my hand—would that hurt?
   e. Why or why not?
8. Introduce the concepts of heat and temperature (see *Discussion* section).
9. Ask your class the following questions to determine if they understand the concepts:
   a. If a Venutian (a person from Venus) has a body temperature of 200 °F, would he be able to withstand a bath in boiling water. Why or why not?
   b. Would he be able to withstand a swim at the beach in Florida?
   c. What do you need to know to determine heat energy?

Disposal

No disposal is required for this demonstration.

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Discussion

The concepts of heat and temperature are frequently misunderstood and interchanged, but they are decidedly different. Temperature is the hotness or the measure of thermal energy of an object. It is a quantity that compares how hot or cold an object is compared to a standard scale. The kinetic-molecular theory states that all matter is made up of tiny particles that are always in motion. When these particles (also called atoms or molecules) move faster, they have greater kinetic or thermal energy. As more energy is added to an object, the particles continue to vibrate more and the temperature (and thermal energy) of the object becomes greater. At some point, the thermal energy is great enough to allow the solid to become a liquid or the liquid to become a gas. The temperature of an object must always be compared to a standard scale—three common temperature scales are the Fahrenheit, Celsius, and Kelvin scales.

Heat is the transfer of energy between two objects due to a temperature difference. When two objects are in contact with one another, the thermal energy of the hotter object will be transferred to the cooler object until they both have the same thermal energy or temperature. On the particle or atomic level, the particles that have a greater energy or motion will collide with the particles that have less energy and will share energy until they all have the same thermal energy.

A common misconception is that objects or matter contain heat. This is not true. Objects contain energy in several forms and when an object's thermal energy is transferred to another object—it is transferred in the form of heat. Heat is commonly determined by equation 1 where Q is heat, m is the mass of the object, C is the specific heat of the substance, and ΔT is the change in temperature.

$$Q = mC\Delta T \qquad \textit{Equation 1}$$

In this demonstration, energy is added to the water until the water boils around 100 °C. Boiling water contains a lot of thermal energy. The mass of the material transferred to the hand is very small so that the amount of heat transferred is also small. If 100 mL of boiling water were poured on the hand, the amount of material would be much greater and would result in a larger amount of heat being transferred and substantial burns to body tissue.

If a Venutian has a body temperature of 200 °F, he would be able to handle boiling water because the difference in temperature would only be about 12 °F. However, if he went swimming in water that was only 85 °F, the transfer of heat from his body to the ocean may be too much for him to handle and he may freeze to death due to hypothermia. To determine heat energy, the mass, specific heat, and temperature difference are required.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Systems, order, and organization
Constancy, change, and measurement
Content Standards: Grades 5–8
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, transfer of energy
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, interactions of energy and matter

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Materials for *Heat versus Temperature—Physical Science Demonstration* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP5900	Thermolyne Cimarec Magnetic Stirrer/Hot Plate, 40 × 40
AP1087	Thermolyne Cimarec Magnetic Stirrer/Hot Plate, 70 × 70

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.