Colorful Heat

Heat versus Temperature Demonstration

Introduction

Students use the terms heat and temperature interchangeably in their daily lives. Scientifically, however, these two terms represent different concepts. This demonstration provides a colorful illustration of the relationship between heat and temperature—a key concept in thermochemistry.

Concepts

- Temperature
- Heat

Materials

Beakers, 250-mL, 5
Food coloring, red
Stirring rod
Water

Safety Precautions

Although the materials in this demonstration are considered nonhazardous, observe all normal laboratory safety guidelines.

Procedure

1. Place five 250-mL beakers on the demonstration table and add the following amounts of water to each:

Beaker	1	2	3	4	5
Water (mL)	10 mL	50 mL	100 mL	150 mL	200 mL

2. Carefully add one drop of red food coloring to each beaker and stir. One drop of food coloring represents a standard amount of heat added to each beaker.
3. Place a piece of white paper behind the beakers and view the red solution from the front, not the top. The intensity of the red color represents the temperature of the liquid.
4. Which beaker has the most "heat" (food coloring) in it? Student should understand all five beakers contain the same amount of heat.
5. Which beaker has the highest "temperature" (color intensity)? *(Beaker #1 has the highest temperature.)*
6. Ask students to propose a relationship between the amount of heat added to a substance and the resulting temperature increase. [This demonstration looks at the relationship between the amount of heat absorbed and the resulting temperature change as a function of the amount of the substance (volume of water). The temperature increase depends on the volume (mass) of water in the beaker. Another factor that influences the resulting temperature change is the ability of a substance to absorb heat, defined as its specific heat. This property is the same in each beaker.]
7. Based on the proposed relationship between heat and temperature, how much "heat" must be added to beaker #5 (200 mL of water) to give it the same "temperature" as beaker #2 (50 mL of water)? Students should deduce that they would have to add four times as much heat because the volume is four times greater. Do the experiment!
8. How much "heat" must be added to beaker #3 (100 mL of water) to give it the same "temperature" as beaker #1 (10 mL of water)? Do the experiment!

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The solutions may be rinsed down the drain with excess water.

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Tip

- Large volumes of water have the ability to store large amounts of heat at moderate temperatures. Water is used in solar heated homes to store energy from the sun. Energy absorbed during the day from the sun's rays is used to heat water in a reservoir. At night, the energy released from the water reservoir is used to heat the air that circulates throughout the home.

Discussion

Students often mistakenly assume that temperature and heat are the same thing. Part of the confusion results from common usage of the words hot and cold. A drop of water from a boiling tea kettle and a cup of hot tea, after all, both may be "hot"—they are at the same temperature. Spill a drop of hot water on your hand and it will burn a little. Spill a cup of tea on your hand, however, and it's off to the emergency room. The difference is not the temperature of the water, but its heat content.

Heat is a form of energy. Heat is defined as the amount of energy transferred from a substance at a higher temperature to a substance at a lower temperature. The best working definition of temperature is that objects in thermal equilibrium must be at the same temperature. Temperature is a quantitative measure of heat intensity on some defined scale (Celsius, Fahrenheit, Kelvin). On a molecular level—according to the kinetic theory—the absolute temperature of a substance in kelvins (degrees Kelvin) is proportional to the average kinetic energy of molecules.

The amount of heat (q) transferred to an object or substance depends on three factors: the amount of the substance (its mass, m), the ability of the substance to absorb heat (its specific heat, s), and the resulting temperature change (ΔT), according to Equation 1.

$$q = m \times s \times \Delta T \qquad \textit{Equation 1}$$

The SI unit for energy (and heat) is the joule (abbreviated J). Specific heat—defined as the amount of heat needed to raise the temperature of one gram of a substance by 1 °C—is a characteristic physical property of a substance. The specific heat of water is equal to 4.18 Joules per gram per degree Celsius (4.18 J/g·°C).

Equation 1 may be introduced within the context of this demonstration. Steps 7 and 8 reveal that the amount of heat that must be added to water to produce a given temperature change is proportional to the mass of water used.

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
Evidence, models, and explanation
Constancy, change, and measurement
Content Standards: Grades 5–8
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, properties and changes of properties in matter, transfer of energy
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, motions and forces, conservation of energy and increase in disorder, interactions of energy and matter

Reference

Flinn ChemTopic™ Labs, Vol. 10 Thermochemistry; Flinn Scientific: Batavia, IL, 2002.

Materials for *Colorful Heat* are available from Flinn Scientific, Inc.

Catalog No.	Description
V0003	Food Coloring, Set of 4

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