Discussion

Enrichment Activities

1. Have students present their data and calculation to the class. Did every metal have the same specific heat? Use the densities from the previous activities to look for a relationship between density and specific heat by using a line graph. Is there a trend?

2. Students can research and discuss how large bodies of water influence local weather because of the high specific heat of water. Orange groves use the high specific heat of water to protect the fruit if a freeze is anticipated.

National Next Generation Science Standards

Students who demonstrate understanding can:

MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Standards Key

K = Kindergarten
3 = 3rd Grade
(numbered by grade)
MS = Middle School
HS = High School
PS = Physical Science
LS = Life Science
ES = Earth Science

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MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

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).

TEACHERS GUIDE

CUBES OF SIX METALS
ITEM # 3510-SERIES

CHEMISTRY - PROPERTIES OF MATTER

One of the most fundamental of skills for students is to observe the different properties of matter. This set of six metal cubes with identical volumes will allow your students to investigate the properties of metallic solids, including mass, volume, density, specific heat, and color. Your class will practice making accurate measurements while engaging in fundamental laboratory skills.
Includes one cube each of aluminum, brass, copper, iron, lead, and zinc without hook. Packed in a cardboard box.
Cube sides: 1” (25mm) and 3/4” (20mm).

Materials

- metals cube
- insulated coffee cup
- 400 mL beaker
- hotplate
- water
- metal tongs
- thermometers
- metric ruler
- graduated cylinder
- pan balance

Goals & Objectives

see page 8 for National Next Generation Science Standards

History

Specific Heat for a substance is a ratio of energy, temperature, and mass. It informs us how much heat energy a substance can absorb for the size of the sample for each degree of temperature change it undergoes. It is an extensive property of matter. The amount of heat a material can absorb depends on how much of the substance you have. Density is an intensive property of matter. The amount you have of a substance does not affect the density because the mass and volume both change.

How it works

Metals have a different specific heat than water, therefore when you have room temperature water and add a metal that is heated to it, the heat will flow from the metal to the water. However, the temperature change the metal has is not equal to the temperature the water has. Metal has lower specific heats than water, meaning they cannot store as much heat without experiencing a temperature change, but water can absorb a lot of heat energy without as much of a temperature change. An accepted value for the specific heat of water is 4.18 J/g-1OCelsius. A gram of water can absorb 4.18 J of energy while only changing one degree of temperature. Most metals have much higher specific heats and are good conductors of heat.
Metals are denser than water. The accepted value for the density of water is 1g/mL and routinely we compare the densities of other matter to it. Matter that is denser than water will sink and matter that is less dense will float.

ACTIVITIES

1 Calculate the mass of your metal cube if you are given the density and a ruler. It's a fun idea to make this a measurement challenge. You give the student the density of their cube and ask them to predict the mass. They should be able to measure the sides and multiply Length x Width x Height to calculate the volume. They will then have to rearrange the density equation density = mass/volume to predict the mass of their cube. Once they have their prediction they bring the cube to you to mass on the balance to see how close their answer is. Ask them to calculate their percent error using the equation error=|actual-measured|/actual x 100. Small percent errors are ideal and they should discuss possible sources of error in their measurements.

> It is always best to DO an experiment ahead of time to be able to best present it to the class. !

2 Calculate density using water displacement. Have your student measure the mass of their cube using the pan balance and measure the volume using water displacement. They should use a graduated cylinder large enough to fit the cube into. Put approimately 50mL of water into the cyliunder and read the exact volume of water. Slowly lower the cube into the water (no splashing) and read the new volume of water plus the metal cube. The difference is the volume of the cube. They can now calculate density using D=M/V. How close are they to the accepted value?

3 Calculate specific heat for their metal cube. Heat a beaker of water with a cube in it to approximately 40 degrees celsius. While it is heating, measure exactly 100mL of water into the insulated coffee cup (foam cups work fine). How many grams of water is this? Hint: density of water is 1g/1mL. Measure the temperature of the water in the insulated cup. Once the metal and the water in the beaker is approximately 40 degrees record the exact temperature of the hot water bath. Since you have been heating the metal in it for so long the metal will be the same temperature as the water it is in. Now use the tongs to move the metal cube to the water in the insulated coffee cup. Record the temperature of the water in the insulated coffee cup once it has stopped rising. This is the final temperature for both the metal and the water.
The heat energy absorbed by the water is equal to the heat energy released by the metal.

- $Q_{metal} = Q_{water}$
- Q_{metal} = specific heat of the metal x mass x $(T_{final} – T_{initial})$
- Q_{water} = specific heat of the water x mass x $(T_{final}-T_{initial})$

Be certain they are using the temperature of the water in the insulated cup (before and after heat transfer) in the calculation for the water. They should understand that the temperature of the heated water is the temperature of theie metal before heat transfer and the temperature in the insulated cup is the after heat transfer temperature.

