"Specific Heat"

Tehani Finch, Howard University GK12 Program

December 2007

I. DCPS Standards:

8.5.1 Explain how energy is the ability to do work and is measured in Joules (J).

8.5.8 Investigate and explain that heat energy is a common product of an energy transformation, such as in biological growth, the operation of machines, the operation of a light bulb, and the motion of people.

8.5.11 Compare and contrast how heat energy can be transferred through conduction, convection, or radiation.

II. Goals:

Students will appreciate the nature of specific heat as a property of substances.

III. Objectives:

Students will observe the process of temperature change and relate it to specific heat.

Prerequisite Knowledge: Energy can roughly be described as the ability to do work. ("Work" actually has a precise definition in physics.) It is in measured in units of Joules (J), named for the English scientist James Prescott Joule. All moving objects have kinetic energy. Mechanical energy (macroscopic energy of material objects not including heat) also involves stored energy called potential energy. The forms most important for this curriculum are gravitational potential energy and elastic potential energy.

Another form of energy is heat. Heat is the completely random kinetic energy of molecules all moving independently in different directions. It has no order to it and therefore specific circumstances (namely a path from higher

temperature to lower temperature) must be put into place to convert heat into any useful work. This is an entire subject called thermodynamics.

An object made mostly of a given substance requires a certain amount of energy to raise its average temperature by one degree Celsius. This is its heat capacity, which is typically proportional to the mass of the object. When the heat capacity is divided by the object's mass, the result is a ratio called the specific heat. Specific heat is a chemical property of the substance that makes up the object, like density.

IV. Essential Questions:

What tends to have a higher specific heat, metals or water? What does this tell you?

V. Materials: Objects made of two different metals (e.g. silver and copper), boiling water bath (shared with class), chilled water, balance, thermometer, graduated cylinder, 45 to 55cm of string, ring stand, cup or mug

VI. Differentiating Instruction: This activity should pose no problem to speakers of English.

VII. Rationale: This activity helps students understand properties of substances that relate to thermodynamics.

VIII. Activity Procedure: The students measure the masses of both sets of metal objects, and measure out 250 mL of the chilled water, pouring it into the mug. Using string and the ring stand, the first set (we'll call "silver") are suspended in the hot water

bath, under instructor supervision. The temperature T_{hot} of the hot water is taken. Then the temperature $T_{initial}$ of the cold water is taken followed soon after by safely removing the silver objects from the hot water and placing them into the cold water. The thermometer is placed in the mug and as the metal heats the water, the highest temperature T_{final} reached is recorded, and the difference ΔT_{water} as well. This is then repeated for the "copper" objects.

See also Wysession *et. al., Physical Science,* Boston: Pearson Prentice Hall, 2006, p. 493 for more details.

IX. Evaluation and Assessment: To obtain the specific heats of the metals, the formula $Q = mc\Delta T$ can be used. The heat capacity of water is 4.18 J/(g °C), and its density is 1.00g/cm^3. Knowing that there was 250mL of water in the mug is enough information to compute the heat Q added to the water. They can then use this same heat, the mass of the metal objects and the difference $\Delta T_{metal} = T_{hot} - T_{final}$ to calculate the specific heat of the metal. This is done for the silver and copper objects. What has the higher specific heat, water or metal [water]. What does this say about the relative ability to conduct heat? [Metal conducts heat better than water, so it takes less energy per gram to raise its temperature.] Does the heat transfer from mostly happen from conduction, convection, or radiation? [Conduction] Students record the results in their notebooks and describe what they have learned.