CHEMISTRY LAB

THE SPECIFIC HEAT OF A METAL

INTRODUCTION:

The amount of heat energy that is required to raise the temperature of one gram of a substance by one degree Celsius is called the **specific heat capacity**, or simply the specific heat., of that substance. Water, for instance, has a specific heat of **4.2 J/°C**

The amount of heat energy involved in changing the temperature of a sample of a particular substance depends on three parameters -- the specific heat of the substance, the mass of the sample, and the magnitude of the temperature change. The Greek letter delta (Δ) is used to indicate a change.

$\Delta T = \text{temperature}_{\text{final}} - \text{temperature}_{\text{initial}}$

The amount of heat energy that is transferred in the process of producing a temperature change can be calculated from this information, according to the following equation:

$$\begin{array}{c}\text{change in}\\ \text{heat energy}\\ \text{of sample}\end{array} = \begin{array}{c}\text{specific heat}\\ \text{of sample}\end{array} \times \begin{array}{c}\text{Mass}\\ \text{of sample}\end{array} \times \begin{array}{c}\Delta T\\ \text{of sample}\end{array}$$

In this experiment, you will determine the specific heat of a metal. A heated sample of this metal will be poured into a crude calorimeter, consisting of cool water contained in a plastic foam cup. Shortly after mixing, the water and the metal will have come to the same temperature. Because plastic foam is a good insulator, heat cannot easily escape from the calorimeter to the surroundings. Therefore, the heat lost by the metal can be said, for the purpose of this experiment, to be equal to the heat gained by the water. The amount of heat energy gained by the water will be calculated in the following manner.

(1) $\text{heat gained}_{\text{water}} = (\text{specific heat}_{\text{water}})(\text{mass}_{\text{water}})(\Delta T_{\text{water}})$

The heat lost by the metal is given by a similar equation.

(2) $\text{heat lost}_{\text{metal}} = (\text{specific heat}_{\text{metal}})(\text{mass}_{\text{metal}})(\Delta T_{\text{metal}})$

Because the heat gained must equal the heat lost, a third equation can be written.

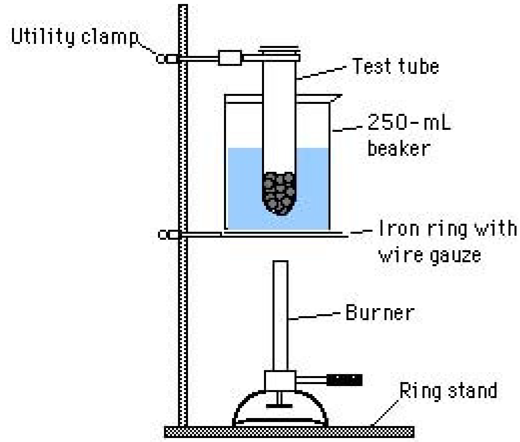
(3) $(\text{specific heat}_{\text{water}})(\text{mass}_{\text{water}})(\Delta T_{\text{water}}) = (\text{specific heat}_{\text{metal}})(\text{mass}_{\text{metal}})(\Delta T_{\text{metal}})$

The specific heat of water is known. The temperature changes of the water, and of the metal, can be measured, as can the mass of the water and the mass of the metal. Using this data, the specific heat of the metal can be calculated using equation (3). The specific heat of an unknown metal can also be determined by application of this method.

MATERIALS:

SAFETY GOGGLES
Balance
Large weighing dish
250-mL beaker
400-mL beaker
100-mL graduated cylinder
25 x 150-mm test tube
Stirring rod
Utility clamp
Ring stand
Ring support
Wire gauze
Gas burner
Plastic foam cup
(**2**) thermometers
Metal shot (#4 or larger lead

shot works well)
Paper towel
Distilled water



Apparatus for heating metal sample.

PROCEDURE:

1. Fill a 250-mL beaker about 3/4 full of water. Place the beaker on a wire gauze on a ring support clamped to a ring stand (see drawing). Use a gas burner to bring the water to a slow boil. While the water is heating, proceed to step 2.

2. Using your large weighing dish, and the proper procedure for the balance used, obtain a sample of the metal being used that will fill the test tube about 1/4 full. Find the mass of the metal shot to the nearest **0.01 g** and record on the <>.

3. CAREFULLY transfer the metal shot to a large, dry test tube. Be careful to pour the metal shot into the tube slowly so that the bottom of the test tube is not broken in this process. Suspend the test tube in the boiling water with a utility clamp. Position the test tube so that the metal shot is below the level of water in the beaker (be sure the bottom of the test tube does not touch the bottom of the beaker). Adjust the flame so the water is just boiling gently. Allow the test tube to remain in the boiling water bath for at least **10 minutes**. Proceed to step 4 while the metal shot is heating.

4. Carefully measure out **100.0 mL** of distilled water in a graduated cylinder, and pour the water into a plastic foam cup. Place the cup in a 400-mL beaker for support. Place a thermometer and stirring rod in the cup. Record on the **DATA TABLE** the mass of the **100.0 mL** water sample, REMEMBER that 1 milliliter of water has a mass of 1 gram.

5. After the metal shot has been heating for at least 10 minutes, using the other thermometer, measure the temperature of the hot water bath. The temperature of the metal shot is the same as the water bath. Record this temperature to the nearest **0.5 °C** as the initial temperature of the metal sample in the **DATA TABLE**. Read the temperature of the water in the calorimeter to the nearest **0.5 °C** and record in the **DATA TABLE** as the initial temperature of the water.

6. Remove the test tube from the bath, using the clamp as a holder. Carefully, but quickly, pour the metal shot into the water in the plastic cup (use a paper towel to keep any hot water on the tube from dropping into the calorimeter). Use the stirring rod to gently stir the metal shot (do not stir the shot with the thermometer). Note the temperature frequently. As the temperature begins to change more slowly, watch the thermometer continuously so as not to miss the maximum temperature reached. Record this maximum temperature on the **DATA TABLE** to the nearest **0.5 °C**, as the final temperature of water and metal.

DATA TABLE:

Mass of the metal sample. = _________ g

Mass of water in calorimeter. = _________ g

Initial temperature of metal sample. = ________ °C

Initial temperature of water in calorimeter. = ________ °C

Final temperature of water and metal. = ________ °C

CALCULATIONS:

7. Calculate the changes in temperature of the water (ΔT_{water}) and of the metal shot (ΔT_{metal}). These are just simple subtractions. Remember, the water and metal had the same final temperature, but different initial temperatures. Also remember that ΔT is never negative, so one calculation will be temperature $_{final}$ - temperature $_{initial}$, and the other will be temperature $_{initial}$ - temperature $_{final}$.

ΔT_{water}. = ________ °C

ΔT_{metal}. = ________ °C

8. Calculate the heat energy gained by the water. Use formula (1) from the introduction for this calculation.

Heat energy gained by the water. = ________ J

9. Remember that the heat gained by the water is equal to the heat lost by the metal, calculate the specific heat of the metal. This is simply rearranging formula (3) from the introduction to solve for the specific heat of the metal, and plugging-in your data. The specific heat of water is again, 4.2 J/°C

The formula would be:

$$\text{specific heat}_{metal} = \frac{\text{specific heat}_{water} \text{ X } \text{mass}_{water} \text{ X } \Delta T_{water}}{\text{mass}_{metal} \text{ X } \Delta T_{metal}}$$

Specific heat of the metal = ________ J/°C

Look up the specific heat for your metal on a good periodic table or in a chemistry handbook, and compare your experimental answer.