EXPERIMENT 1
SPECIFIC HEAT CAPACITY

I. THEORY

In this experiment, we will determine the specific heat capacity of a metal and compare it to an accepted value.

The heat capacity of an object, C, is defined as the amount of heat that must be added to the object to raise its temperature by 1 K (or 1 °C).

The specific heat capacity of a substance, c, is defined as the amount of heat that must be added to one kilogram of a sample of that substance to raise its temperature by 1 K (or 1 °C).

Since specific heat capacity does not depend on the object in question, only the substance from which it is made, specific heat capacities are much more useful.

In this experiment, we will add a metal sample at a high temperature to water at a low temperature. We will consider the specific heat capacity of the water to be known, 1.00 kcal/kg•K. We will measure the mass of metal and water used. We will also measure the initial temperature of each and the final equilibrium temperature of the system.

We will make use of an insulated calorimeter to avoid the exchange of heat between our system and the room. If this exchange is completely eliminated, we know that the total heat absorbed by the system is zero.

The heat absorbed by each component of our system is, by the definition of specific heat capacity, $Q = mc\Delta T$.

The specific heat capacity of a substance does vary with temperature; however, in our experiment this dependence can be ignored, because of our temperature range. (Even if it is not ignored an *average* specific heat capacity over our temperature range can be computed.)

The initial high temperature of the metal sample will be achieved by suspending it in boiling water. Although the boiling point of water is often taken as 100 °C, the boiling point actually varies with pressure. We will use a mercury barometer to measure atmospheric pressure, and calculate the boiling point by using the equation $T = 71.5 °C + (0.375 °C/cmHg) P$. The pressure unit cmHg stands for centimeters of mercury.

II. LABORATORY PROCEDURE

CAUTION: You will be adding and removing a metal object from boiling water. Be careful.

1. Fill the steam generator approximately 2/3 full, plug it in and turn it on. You will need the water to be boiling for step 4.

2. Measure and record the mass of the **empty and dry** calorimeter you will use.

3. Measure and record the mass of your **dry** metal sample. Also, note the type of metal (copper, aluminum, or lead).

4. Attach a thread to the metal samples and suspend it in the **boiling** water. Allow a few minutes for the samples to heat thoroughly. Do not let the sample touch the bottom or sides of the steam generator or its initial temperature may be **above** the boiling temperature.

5. While the metal sample is heating, fill the calorimeter approximately 1/2 full of cool water from the tap. Use enough water to easily cover your metal sample. Measure and record the mass of the calorimeter and cool water.

6. Place a thermometer in the calorimeter. Measure and record the temperature of the cool water, when the reading on the thermometer stabilizes.

7. Immediately following your temperature measurement, remove the metal sample from the boiling water, quickly **and carefully** wipe it dry, then suspend it in the cool water in the calorimeter (the sample should be completely covered but should not touch the bottom of the calorimeter). Leave the steam generator on.

8. Stir the water with a stirring rod and record the highest temperature attained by the water as it comes into thermal equilibrium with the metal sample.

9. Repeat steps 4-8, with the same sample. Turn the steam generator off to cool after repeating step 7.

10. Adjust the knob at the bottom of the mercury barometer so that the pointer just touches the surface of the pool of mercury. Move the vernier scale so that the lower edge of the metal marker is even with the top of the mercury meniscus. Record the atmospheric pressure to the nearest hundredth of a centimeter, noting that the vernier scale runs downward, even though the main scale runs upward.

11. Empty the steam generator and wipe up all spilled water.

III. CALCULATIONS AND ANALYSIS

1. Use the measured atmospheric pressure to calculate the boiling point temperature for water.

2. Make a table with four columns: quantity measured, symbol for that quantity, value for run 1, and value for run 2. The table must include the following quantities: mass of water used, mass of metal sample, initial temperature of water, initial temperature of metal, and final equilibrium temperature.

3. Assuming that the water and metal comprised a **closed system**, exchanging no heat with the outside, write out a heat exchange equation. Your equation should contain only symbols from your table and c_w for the specific heat capacity of water.

4. Solve your heat equation symbolically for the specific heat capacity of your metal.

5. Calculate the specific heat capacity of your metal as found in each run. For the first run, show the substitution of the values from your table. Use 1.00 kcal/kg•K for the specific heat capacity of water.

6. Calculate the average of your two values. Convert the average to J/kg•K and compute the percent error.

7. What effect did ignoring the thermometer and stirrer have on your calculated specific heat capacity?