(H) Chemistry **Name:**
Specific Heat of a Metal **Blk:** **Date:**
Lab#___________

Introduction:

Heat is not the same as temperature nor is it exactly the same thing as thermal energy. It is the flow of thermal energy which passes spontaneously from an object at a high temperature to an object at a lower temperature. If the two objects are in contact, they will, given sufficient time, both equilibrate – reach the same temperature.

Heat flow is ordinarily measured in a device called a calorimeter. A calorimeter is simply a container with insulating walls, made so that essentially no heat is exchanged between the contents of the calorimeter and the surroundings. Within the calorimeter chemical reactions may occur or heat may pass from one part of the contents to another, but no heat flows (theoretically) from or to the surroundings.

Specific Heat:

When heat flows into a substance, the temperature of that substance will increase. The quantity of heat q required to cause a temperature change ?t of any substance is proportional to the mass m of the substance and the temperature change, as shown in Equation 1. The proportionality constant is called the specific heat (SH) of that substance.

$$q = (specific\quad heat) \times m \times \Delta t = SH \bullet m \bullet \Delta t$$ ***Equation 1***

The specific heat can be considered to be the amount of heat required to raise the temperature of one gram of the substance by 1°C (if you make m and ?t both equal to 1, then q will equal SH). Amounts of heat are measured in either joules or calories. To raise the temperature of 1 g of water by 1°C, 4.184 joules of heat must be added to the water. The specific heat of water is therefore 4.184 J/g°C. Since 4.184 joules equals 1 calorie, we can also say that the specific heat of water is 1 calorie/g°C. Ordinarily heat flow into or out of a substance is determined by the effect that the flow has on a known amount of water. This would be heat exchange between the *system* and the *surroundings* (water). Because water plays such an important role in these measurements, the calorie, which was the unit of heat most commonly used until recently, was actually defined to be equal to the specific heat of water.

The specific heat of a metal can readily be measured in a calorimeter. A weighed amount of metal is heated to some known temperature and is then quickly poured into a calorimeter that contains a measured amount of water at a known temperature. Heat flows from the hot metal to the cooler water, and the two equilibrate at some temperature between the initial temperatures of the metal and the water.

Since heat gained by the cooler substances must equal the heat lost by the warmer substance (***Law of Conservation of Energy***), this relationship is the basis for calculating specific heat of a substance.

$$-q_{lost} = q_{gained}$$

$$C_{sp} \bullet mass \bullet \Delta T = C_{sp} \bullet mass \bullet \Delta T$$

metal *water*

In this experiment, you will determine the specific heat of a metal sample. The metal sample will be heated to a high temperature, then placed into a 'student' calorimeter containing a known quantity of water at a lower temperature. Having a known mass, a measurable ΔT, and the C_{sp} of water (4.18 kJ/g °C), the heat gained by the water can be calculated and will be the heat lost by the metal, allowing us to complete the above equation and solve for the C_{sp} of the metal.

Procedure:

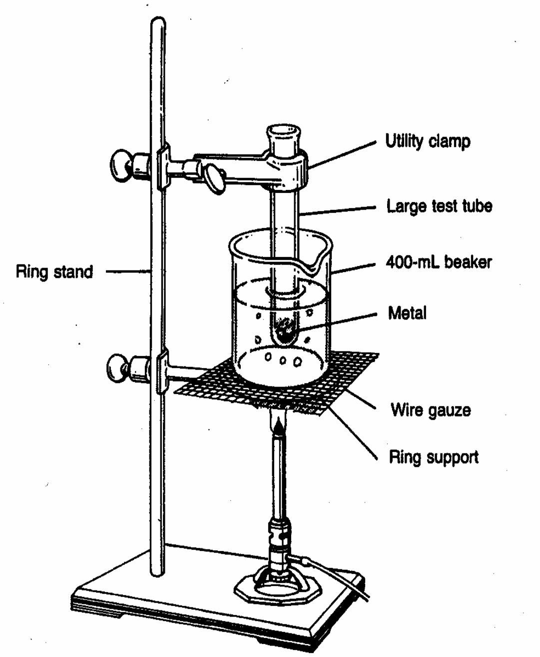
1. Wear safety goggles and apron.

2. Set up a ring stand with clamp, wire gauze
with ceramic center and Bunsen burner.

3. Fill a 600 mL beaker about ½ full of tap water
and begin heating to boiling.

4. Using a condiment cup, tare its mass and weigh
out your metal sample depending on your table assignment.
(~ 35-40 g aluminum metal) OR
(~ 100-110 g lead pellets) OR
(~ 50-60 g copper beads) **Record this mass (metal)**

Figure 15.1



5. CAREFULLY using a scrap paper funnel, 'pour' your metal down the side of the test tube. Do not crack the tube by dumping the metal in quickly.
6. Using a utility clamp around the upper neck of the large test tube (~18X150 mm), secure the clamp to the stand and lower the test tube into boiling water. (check your temperature to be certain the bp has been reached).

7. The metal in the test tube must be below the level of the water outside the tube in the beaker to uniformly heat the entire sample. Allow the metal to heat in this manner for ~10-15 min.

8. During this time, obtain a 'student' calorimeter (2 styrofoam cups nested inside each other with a lid), tare this mass and dispense into the cups ~ 100 mL of tap water. (??what is the mass of this water?? Hint: recall the density of water) **Record this mass (water)**

9. Place the calorimeter with lid into a 400 mL beaker for stability. Insert a thermometer into the lid punch-out so that it is below the water surface about ½ way into the liquid, but not touching the bottom of the cups.

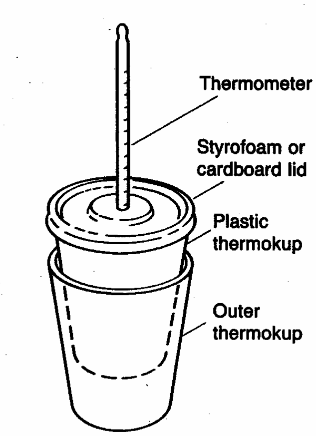


Figure 1-16

10. **Record the initial temperature of the water.** If possible, take readings to 0.1 °C

11. **Record the initial temperature of the metal.** (hint: what is the temperature of its surroundings with which it has equilibrated?)

12. After the 15 min of heating, carefully remove the test tube with metal using the utility clamp as a 'handle' and quickly but carefully pour the metal into the calorimeter water.

13. Immediately secure the lid with thermometer stabilized in the punch-out opening. You can then gently swirl the beaker to mix the water without spilling or damaging the thermometer.

14. After about 2 min. take a **final temperature of the water. Record this.**

15. Recover the metal by carefully pouring off the water (decanting) without letting any metal get into the sink. Spread the solid metal on a paper towel to dry.

16. Obtain the values from your table partners so that you have calculations for 2 different metals to complete.

Data:	**sample 1 ( )**	**sample 2 ( )**
A. mass of metal	______________________	______________________
B. mass of water	______________________	______________________
C. $T_i(water)$	______________________	______________________
D. $T_i(metal)$	______________________	______________________
E. $T_f(water)$	______________________	______________________

Analysis:

1. Show all calculations for the specific heat of each of the 2 metals in your samples. Use the equation at the top of the lab. (don't forget to use the correct value for specific heat of water) **Look up reference values for your metals and calculate a % error for each sample.**

(Sample 1)

(Sample 2)

<u>Conclusions:</u> Use complete sentences for all responses.

1. What physical properties, other than specific heat, could you use to identify a sample such as those used in this lab?

2. Why is water an excellent material to use in a calorimeter?

3. We assumed that the initial temperature of our metal was the same as that of the boiling water. If the metal was actually at a lower temperature than the water, how **EXACTLY** would this affect your value for the specific heat?

4. Identify other possible sources of error in this experiment.

5. **Calculate the specific heat of a metallic element** if 314 J of energy are needed to raise the temperature of a 50.0 g sample from 25.0 °C to 50.0 °C .

6. A metal sample weighing 71.9 g and at a temperature of 100.0℃ was placed in 41.0 g of water in a calorimeter at 24.5℃. At equilibrium the temperature of the water and metal was 35.0 ℃. **Calculate the specific heat of the metal.**

The specific heat of a metal is related in a simple way to its molar mass. Dulong and Petit discovered many years ago that about 25 joules were required to raise the temperature of one mole of many metals by 1℃. This relation is known as the Law of Dulong and Petit.

$$MM \cong \frac{25}{SH(J/g^{o}C)}$$

Calculate the approximate molar mass of the metal.