Chemistry **Name____________________**

Specific Heat of a Metal **Date___________ Block____**

The **specific heat capacity** of a substance is the amount of heat energy necessary to raise the temperature of 1 gram of a substance by 1°C. It may be thought of as 'heat storing ability.' Every substance has its own specific heat capacity – this physical property relates energy change to temperature change. Materials with low specific heat values need low energy to increase/decrease temperature. The opposite is true of materials with high specific heat – they need high energy to increase/decrease temperature.

Metals have relatively low specific heats. On the other hand, the specific heat of water is relatively high: it is **1 cal / g * °C**. Water will absorb much energy before its temperature increases even slightly. This helps to explain why the climate near a large lake is generally warmer in the winter and cooler in the summer, and why your body (which is nearly 60% water) can tolerate rapid changes in external temperatures.

The relationship between heat and temperature is shown in Big Equation #1 of Thermochemistry:

Energy = (mass of material) × (its specific heat) × (its change in temp)

$$\Delta H = m \times C \times \Delta T$$

Finally, remember that calorimeters work because they let no heat in or out. As a result, the heat energy gained by the water in a calorimeter is assumed to be equal to the heat loss by the metal:

$$\Delta H \text{ water} = -\Delta H \text{ metal}$$

PROCEDURE:

1. Select a metal sample and record its mass.
2. Create a 'Hot Water Bath' using a 250 mL beaker - filled halfway with tap water. Bring the water to a boil.
3. Using crucible tongs or, if your metal sample has a hook, the end of a test tube brush, carefully transfer your metal sample into the boiling water and **continue to boil for an additional 5 minutes** (to ensure that the piece of metal reaches the same temperature as the boiling water).
4. In the meantime, assemble your calorimeter. Place a Styrofoam cup into a 400 mL beaker. Have a thermometer and cardboard lid ready. Finally, measure **exactly** 100 mL of tap water in a graduated cylinder and carefully pour this water into the calorimeter. *Due to water's density* ***1 mL H_2O = 1 g of H_2O***.
5. Record the temperature of the cool tap water in the calorimeter. This is the initial temperature of **water**.
6. Following the 5-minute boiling period of your metal sample, record the temperature of boiling water. This is the initial temperature of the **metal**.
7. Turn off Bunsen burner to stop heating the boiling water.
8. Using tongs, carefully transfer the piece of boiling-hot metal to the calorimeter and cap with lid. Place the thermometer through the center of the lid and be sure the tip is submerged in the water. **DO NOT PUSH TOO HARD OR THE CALORIMETER MAY BREAK!**
9. Gently swirl the sample and container. Watch the thermometer and record the highest temperature reached. This is the final temperature for **both the water and the metal**.
10. Answer the discussion questions. Note that you will be working in calories. ***1 cal = 4.184 J***

DATA TABLE:

CALORIMETER WATER DATA		METAL DATA	
Mass of tap water (in calorimeter)		**Mass of metal**	
Initial temperature of water (°C)		**Initial temperature of metal (°C)**	
Final temperature of water (°C)		**Final temperature of metal (°C)**	
Specific Heat Capacity of Water (cal/g•°C)		**Experimental Specific Heat Capacity of Metal (cal/g•°C)**	*TO BE CALCULATED (in Question # 3)*

Actual Specific Heat Capacities (cal/g•°C): **Al:** 0.215; **Cu:** 0.092; **Zn:** 0.093; **St. Steel:** 0.107; **Sn:** 0.056; **Pb:** 0.031 c; **Cd:** 0.060

ANALYSIS AND CONCLUSION QUESTIONS:

1. The water in the calorimeter gained energy directly from the piece of metal. Determine the amount of **<u>heat</u>** gained by the water. Show the calculation. Express this number in *J* and *cal.(HINT: Solve for ΔH)*

2. Assuming a very efficient transfer of energy within the "calorimeter," how much **<u>energy</u>** was "lost" by the piece of metal? Express this number in *J* and *cal*. *(HINT: Read the introduction)*

3. Determine the **<u>specific heat</u>** of the metal. Show the calculation. *(HINT: You know ΔH from #2)*

4. Determine the **<u>percent error</u>** of your calculated specific heat. The theoretical value is in the footnotes on the first page in cal/g•°C – make sure your units match. You must show work.

5. Aside from human error, list several experimental conditions/techniques that could lead to inaccuracy of the result. (*HINT: This should be about the <u>calorimeter</u>)*

6. A silver-colored necklace with a mass of 43.0 grams is heated in the drying oven to a temperature of 120.0°C. It is then dropped into a calorimeter containing 95.0 grams of water at 20.0°C. The water and necklace reach a final temperature of 25.5°C. Determine, in Joules and in calories, how much energy the water gained. Calculate the specific heat of the metal.

   Silver's specific heat is 0.0558 cal/g•°C. Was the necklace pure silver? Provide an explanation for your answer.