Name: ___________________________________ **Date:** ________

Chemistry ~ *Ms. Hart* <u>**Class:**</u> Anions or Cations

THE URBAN ASSEMBLY SCHOOL FOR CRIMINAL JUSTICE

<u>Lab #5: Calorimetry Lab: Measuring a Quantity of Heat Transferred</u>

<u>Reading:</u>

The amount of heat required to raise the temperature of a material depends on its change in temperature (ΔT), its mass (m), and an intensive property (what is an intensive property? _________ ____) of the material called specific heat (C). The unit for C is heat per unit mass per unit temperature and is dependent on the phase of the material. For example the specific heat of H_2O (l) is 4.18 J/ g°C whereas the specific heat of H_2O (s) is less than 2.05 J/ g°C. The heat is calculated from the equation

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

Historically, heat (q) was measured in terms of calories. The calorie was defined as the amount of heat required to raise the temperature of 1 gram of water by 1°C from 14.5°C to 15.5°C at 1 atmosphere pressure. With this definition, the specific heat of water is 1.00 cal/(g°C). The use of the calorie began before it was established that heat is a form of energy and 1 calorie is equivalent to 4.18 J. The joule (J) has become the more favored unit in recent years. Thus, the units for C that we will use are J/(g°C). The specific heat of water is then 4.18 J/(g°C).

When two bodies in an isolated (what does isolated mean? ___________________________) system, initially at different temperatures, are placed in intimate contact (what is intimate contact? ___________________________) with each other, in time they will come to equilibrium at some common intermediate temperature. Because of energy conservation, **the quantity of heat lost by the hot object is equal to that gained by the cold object** provided that no heat is lost to the surroundings. This is the basis for the method of Calorimetry: A metal sample whose specific heat is to be determined is heated in boiling water to 100 °C. It is then quickly transferred to a Styrofoam calorimeter cup, which contains a known volume of water of known temperature. When the metal specimen (what is a specimen? ________________________) and the calorimeter (including the water) come to equilibrium, the final temperature is measured with a thermometer. It is assumed that the heat loss to the Styrofoam cup and thermometer is negligible and if the heat exchange with the environment is kept small, then the heat lost by the metal sample is equal to the total heat gained by the water.

Introduction:

The sun beat down on the beach, reflecting off the smooth surface of the lake and the bright white sand. A beach-goer stepped eagerly off the blanket anticipating the relief of the cool water. Yipes!!! The sand was hot! How could the sand be so hot and the water so cool with the same sun beating down on them? Simple. Water has a higher specific heat than sand. Water is resistant to temperature change. In this laboratory investigation, you will measure the specific heat of brass and compare brass's resistance to temperature change to water's.

Purpose: The purpose of this lab is to quantify the amount of heat transferred between a hot metal object and colder water. Also, we will determine the specific heat capacity of a known metal through experimentation.

Materials:

- ❖ Brass cube
- ❖ Styrofoam cup
- ❖ Triple Beam Balance
- ❖ Thermometer
- ❖ 50 mL RT water
- ❖ 500 mL beaker
- ❖ Hot plate
- ❖ Hot water
- ❖ Tongs

Safety: Metal objects are HOT! USE CAUTION!

Procedure: CHECK THIS OFF AT YOU GO

1. Gather home made calorimeter materials and put on goggles.
2. Determine the mass of the brass cube using a triple beam balance.
3. Record the mass of brass in your data table.
4. Using a graduated cylinder, add 50 mL of water to the calorimeter (styrofoam cup).
5. Read the initial temperature of your water and record this on the data table.
6. Heat the metal block to 100°C by carefully placing it in the boiling water using the tongs and waiting 20 seconds for the block to heat up.
7. Measure the temperature of the boiling water. This is the initial temperature of hot brass. Record this in your table.
8. Use the tongs, carefully place the brass cube into your calorimeter. Stir the water gently with the thermometer.
9. When the water temperature stops rising, record the highest temperature that the H_20 reaches. This is the final temperature of the metal and the water because the heat has transferred and the "isolated system has finished equilibrium."
10. Clean up your station by returning all materials to exactly where you found them!

Data: (be sure to include units and measure to the appropriate sig figs!)

#1 Mass of brass	
#2 Volume of RT water	
#3 Mass of RT water	
#4 Initial temperature of water	
#5 Initial temperature of hot brass (the temperature of the hot beaker!)	
#6 Final temperature of water and brass	

Mass of RT water: remember the density of water is 1g/mL so

1 mL of water = 1 g of water

Fill in this part of the data table AFTER you have completed your calculations:

ΔT of the water	
ΔT of the brass	
*Specific heat capacity of the brass	

Calculations: BE SURE TO INCLUDE UNITS AND CONSIDER SIG FIGS!

1. Calculate the **temperature change of the water** by finding the difference between the final and initial temperatures. $\Delta T = T_f - T_i$ (hint: ΔT = #6 - #4)

   ΔT_{water} = __________

2. Calculate the amount of heat absorbed by the water. The specific heat capacity (c) of water is 4.18 J/(g°C) and the density of water is 1.00 g/mL. $q_{water} = mc\,\Delta T$
   (hint: identify your variables first. Use the ΔT you JUST calculated in 1. Don't forget you have the mass in data #3)

   q_{water} = __________

3. Calculate the temperature change of the brass by finding the difference between the final and initial temperatures. $\Delta T = T_f - T_i$ (hint: ΔT = #6 - #5)

   ΔT_{brass} = __________

4. Assume that the energy absorbed by the water is equal to the energy lost by the metal. Therefore, the number of joules gained by the water must be equal to the number of joules lost by the metal $q_{brass} = - q_{water}$. Calculate the specific heat capacity of the metal.
   STEP 1: solve for c of the metal in the equation, $q_{brass} = mc\,\Delta T$.

   STEP 2: WRITE YOUR VARIABLES:
   $q_{brass} = - q_{water} =$
   Mass of brass (#1) =
   ΔT_{brass} (from 3.) =

   STEP 3 = SOLVE q_{brass} = ______________

5. Use the known value of the specific heat of the metal (Brass = 0.380 J/(g°C)) to calculate your % error. Refer to your reference table! Does your answer make sense? If not, check your work on the calculations above!

Conclusion/Reflection Questions:
Answer all questions in full sentences using your own words.

1. Restate the purpose of the lab and what you were looking for.

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2. What was the amount of heat transferred? What direction did the heat transfer? How do we know that the heat gained by the water must be equal to the heat loss by the brass?

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3. Why should the final temperature of both the water and the brass be the same?

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4. Which had the larger temperature change, water or brass? Why? (think about sand and water at the beach)

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5. What was your percent error? What are at least three sources of experiment error in your lab? Describe how each error would have affected your data/results.

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