Honors Chemistry Lab #20: Calorimetry and Heat Flow

Introduction: Enthalpy is a measure of the total energy of a thermodynamic system. It includes the system's internal energy and thermodynamic potential (a state function), as well as its volume and pressure (the energy required to "make room for it" by displacing its environment, which is an extensive quantity). The unit of measurement for enthalpy in the International System of Units (SI) is the joule, but other historical, conventional units are still in use, such as the British thermal unit and the calorie. The enthalpy is the preferred expression of system energy changes in many chemical, biological, and physical measurements, because it simplifies certain descriptions of energy transfer. Enthalpy change accounts for energy transferred to the environment at constant pressure through expansion or heating. Chemical and physical changes are always accompanied by a change in energy. Most commonly this energy change is observed as a flow of heat energy. The purpose of this lab is to understand the basics of heat transfer and to apply knowledge of the various types of energy and thermodynamics.

Pre-Lab Question:

1. Two objects with different temperatures are touching. Describe the heat flow for the following:
   - Which direction does the heat flow? Why?
   - How will the temperatures of each object change?
   - When will the heat flow cease?

Materials: beaker, 200-400-mL, hotplate, electronic balance, four materials in small pieces, thermometer or probe, graduated cylinder, 100-mL, Styrofoam calorimeter, crucible tongs (to hold metal)

Procedure:

1. Turn hotplate on high until water boils, then decrease setting to maintain. Fill your 200-400-mL beaker about 1/4 full of tap water. Set it on your hotplate.
2. Obtain a cup and rod(s). *Record the exact mass on your data table. Choose any two substances from the table, but you will need the other two substances from another group.*

	Masses	
Substances	1 rod	2 rods
Aluminum		
Copper		
Brass		
Glass		

3. GENTLY add the rod to your boiling water. Put your thermometer in the middle of the pieces so it can track the temperature of the sample. *It might be easier to add some pieces, then insert the thermometer, and then add the rest of the metal pieces around it.*
4. Prepare your calorimeter as demonstrated by your teacher (last page of this lab and see SMART Board).
5. Measure exactly 200 mL of tap water into the calorimeter. Make sure you can read the thermometer without removing the top cup, which is like a lid.
6. Insert your second thermometer into the opening in the lid of your calorimeter. *Record the temperature of your water in the data table.*
7. Allow the metal to reach a temperature ~98-100 C by leaving it in boiling water for 3 minutes. Measure and *record the exact temperature of the metal in the beaker in your data table*.
8. *Answer In-Lab Questions #4-5.* Work quickly but carefully: remove the lid of the calorimeter and empty the hot metal from the beaker into the calorimeter. Replace the calorimeter lid and thermometer. Set the beaker aside.
9. *Answer In-Lab Question #6*. Gently swirl the mixture of metal and water in your calorimeter. Watch the reading on the thermometer. *Record the highest temperature reached for the mixture in your data table. Answer In-Lab Question #7*.
10. To cleanup, remove the thermometer from the calorimeter and **save** for the next lab.
11. Repeat Steps 1-11 for the remaining metal samples.

In-Lab Questions (4-7):

Discuss and answer questions with your partner at the appropriate times noted in the procedure.

4. Is the temperature of the metal before heating important? Explain.

5. Why would the hot metal need to be transferred to the water quickly?

6. What is the purpose of the swirling?

7. What would happen to the temperature of the mixture if it was allowed to sit longer? Explain.

Data Table

Pair Data Collected (2 trials each for 2 substances = 4 trials total)				
Type of Substance				
	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**
Mass of substance	g	g	g	g
Temperature of water	°C	°C	°C	°C
Temperature of substance	°C	°C	°C	°C
Temperature of mixture	°C	°C	°C	°C

Post-Experiment Questions (8-27):

Discuss and answer questions with your partner at the appropriate times noted in the procedure. After you have finished, compare your answers with the other members of your larger group and discuss any differences.

8. Which part of the mixture, the substance or the water, was releasing heat? Which was absorbing heat? How do you know?

9. What can you say about the final temperature of the objects?

10. Calculate the specific heat capacity for each sample.

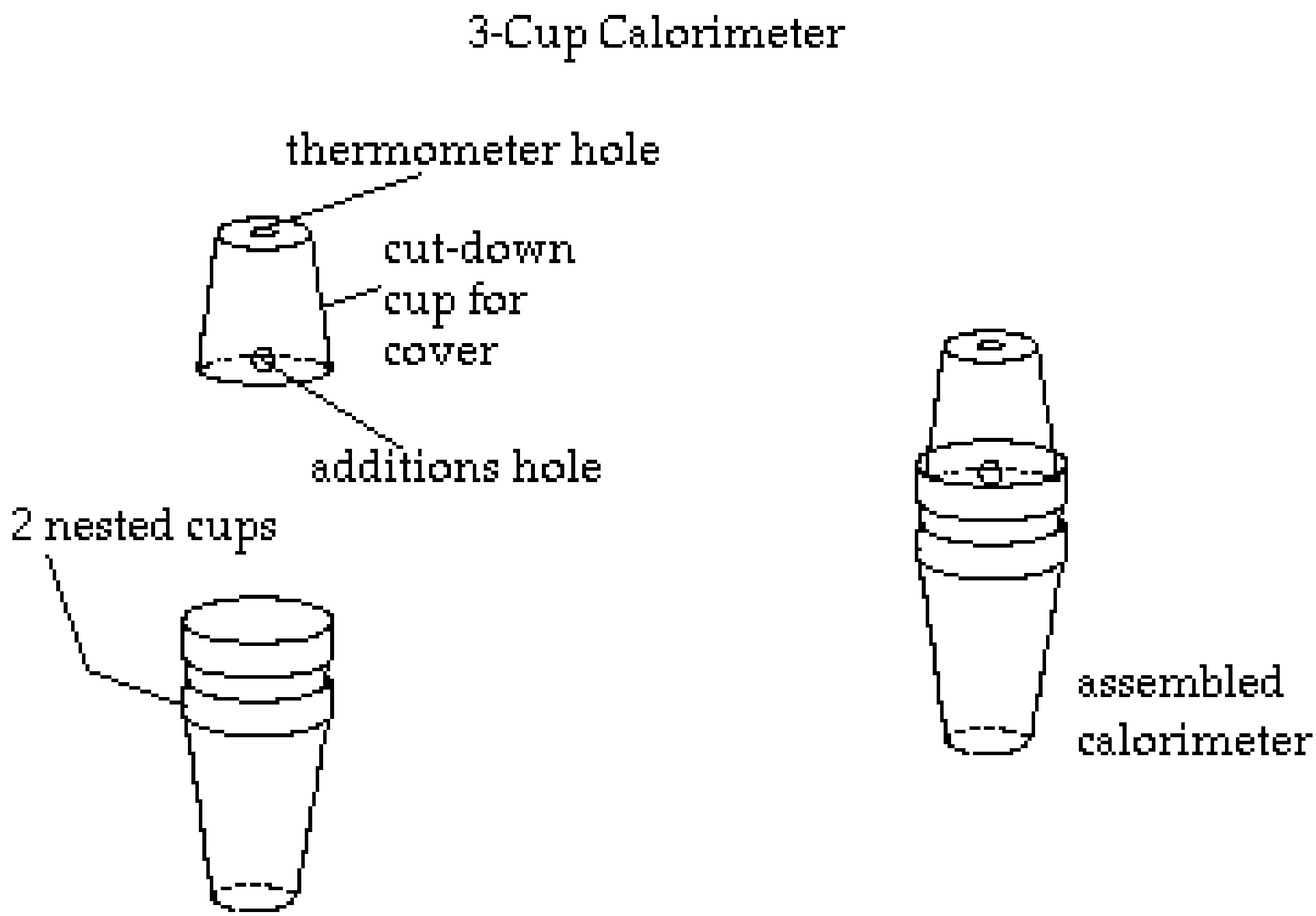
11. Compare these experimental values to the known (accepted) values by determining the percent error.

12. Based on the data from this experiment, summarize the factors that affect heat transfer.

13. Using grammatically correct sentences compare the heat transfer ability of each material tested.

14. If a similar experiment was done using 100 mL of water at 20°C with 100 g of metal at 80°C, what would you expect the approximate final temperature to be? Explain.

15. How would you determine Styrofoam's ability to transfer heat? What difference, if any, would you find in its behavior compared to metal? Please analyze the following equation and incorporate the equation in your written response: $-q_{hot} = q_{cal.} + q_{cold}$



Accepted Values for Specific Heat Capacity (J/g°C)			
Aluminum	Copper	Brass	Glass
0.900	0.385	0.380	0.500

Please self-assess your lab report using the checklist/rubric.