Thermochemistry Formal Lab #1: Heat Flow; SC5 a,c

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. This formal lab must be typed, but does not require a "rerun" section due to the extensive set of questions that accompany each section of the investigation.

Pre-Lab Questions (1-2):

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?
2. Discuss with your group the Essential Question. Present a summary of your ideas to the rest of the class.

Materials: beaker, 200-400-mL, hotplate, electronic balance, four materials in small pieces, thermometer or probe, graduated cylinder, 100-mL, metal 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 with four rods. *Record the exact mass on your data table. Put an X in the box for the sample that you will be studying.** other ideas: sand, soil, antifreeze, water,*

	Masses		
Substances	1 rod	2 rods	3 rods
Aluminum			
Copper			
Brass			
Glass			

3. 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. Gently place the test tube in the warm water. Be sure that the entire sample of the substance is below the water line. *Answer In-Lab Question #4.*
5. Prepare your calorimeter by stacking the metal cups together with the gasket and stir rod.
6. Measure exactly 100 mL of tap water into the calorimeter.
7. Insert your second thermometer into the opening in the lid of your calorimeter. *Record the temperature of your water in the data table.*
8. 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 test tube in your data table*.
9. *Answer In-Lab Question #5.* Work quickly but carefully: remove the lid of the calorimeter and empty the hot metal from the test tube into the calorimeter. Replace the calorimeter lid and thermometer. Set the test tube aside.
10. *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.*
11. To cleanup, remove the thermometer from the calorimeter. With the lid on your calorimeter to catch the metal rod(s), pour the water into the sink. Put the wet metal caught in the lid in the labeled container to dry.
12. Repeat Steps 1-11 two more times.

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			
Type of Substance			
	Trial 1	**Trial 2**	**Trial 3**
Mass of substance	g	g	g
Temperature of water	°C	°C	°C
Temperature of substance	°C	°C	°C
Temperature of mixture	°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 change in temperature of the water for each trial and then calculate the average of these values.

11. Calculate the change in temperature of the metal for each trial and then calculate the average of these values.

12. Compare the change in temperatures of the three metal samples. Describe any trend you find.

13. Propose a hypothesis for the pattern you have observed.

14. Compare the change in temperature of the water to the change in temperature of the metal. Describe any trend you find.

15. Propose a hypothesis for the pattern you have observed.

16. Create one line graph of mass of metal vs. the inverse of the average change in temperature of the metal (mass vs. $1/\Delta T$) for each of the four metals. Make each of the four lines a different color. Add a line of best-fit for each metal and display the equation on the chart.

17. Discuss with your group the meaning of the slope. Summarize your ideas here.

18. Which metal has the highest slope? Which has the lowest slope?

19. What do these differences suggest about how these metals transfer heat?

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

21. Brainstorm properties of the different materials that might account for their different heat flow behaviors.

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

23. 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.

24. Assuming an island and inland areas or exposed to the same amount of heat energy, why would the island have less drastic temperature changes than inland area?

25. How would you determine Styrofoam's ability to transfer heat? What difference, if any, would you find in its behavior compared to metal? What is a common use of Styrofoam that capitalizes on this idea?

26. If 5 g samples of glass and copper are placed on the same hot plate and allowed to heat for one minute, how would their final temperatures compare? Explain.

27. Reflecting on what you have learned throughout the experiment, summarize what you have learned about heat transfer.