SPECIFIC HEAT OF A METAL

Chemists identify substances on the basis of their chemical and physical properties. One physical property of a substance is the amount of energy it will absorb per unit of mass. This property can be measured quite accurately and is called **specific heat** (C*p*). Specific heat is the amount of energy, measured in joules, needed to raise the temperature of one gram of the substance one Celsius degree. Often applied to metallic elements, specific heat can be used as a basis for comparing energy absorption and transfer.

To measure specific heat in the laboratory, a **calorimeter** of some kind must be used. A calorimeter is a well- insulated container used in measuring energy changes. The calorimeter is insulated to reduce the loss or gain of energy to or from the surroundings. Energy always flows from an object at a higher temperature to an object at a lower temperature. The heat gained by the cooler substance equals the heat lost by the warmer substance, if we assume no loss of heat to the surrounding environment.

heat lost = heat gained

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 calorimeter containing a known quantity of water at a lower temperature. Having measured the mass of the water in the calorimeter, the temperature change of the water (ΔT), and knowing the specific heat of water (4.184 J/g°C), the heat gained by the water (lost by the metal) can be calculated as follows:

Heat gained by the water (J) = mass of water (g) x specific heat of water (4.184 J/g ˚C) x change in temperature (ΔT)

The specific heat of the metal can now be calculated:

Specific heat of metal (Cp) = heat gained by the water (J) / mass of metal (g) x ΔT of metal (˚C)

$$C_p = \frac{\text{heat gained by the water (J)}}{\text{mass of metal (g)} \times \Delta T \text{ of metal (˚C)}}$$

Table 1
Specific Heat Capacities of Common Substances

Substance	Specific Heat Capacity (J/g·˚C)
Water (l)	4.18
Ethanol (l)	2.44
Water (s)	2.06
Water (g)	1.87
Aluminum	0.897
Iron	0.449
Brass	0.380
Copper	0.385
Lead	0.16
steel (alloy)	0.50
Zinc (s)	0.385

Objectives

In this experiment, you will

• measure the mass and temperature of water in a calorimeter,
• heat a metal sample of known mass to a specific temperature,
• calculate the change in water temperature caused by adding the hot metal sample, and
• identify the metal calculate the specific heat of the metal using your mass and temperature data.

EQUIPMENT

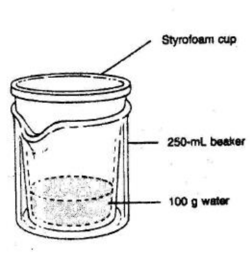
hot plate	thermometer	Styrofoam cups
balance	beaker (250 cm^3)	

PROCEDURE

1. Fill a 250-mL beaker *about* half full of water. Place the beaker of water on a hot plate or a ring stand with wire gauze. Begin heating the water to the boiling point. Continue with the procedure while the water is heating.

2. Measure the mass of a metal sample. Record the mass and the kind of metal.

3. Place the metal sample (in a test tube) into the beaker of water and continue heating. Leave the metal sample in the boiling water bath while you complete Steps 4–6.



4. Obtain two plastic foam cups, and nest them together in a beaker. These will be used as a calorimeter. Measure their mass carefully. Record the mass in your data table.

5. Fill the plastic foam cups with just enough room temperature water to cover the level of metal in the test tubes. **DO NOT FILL TO THE TOP**. Record the mass.

6. Measure the temperature of the water in the cup with a thermometer. Do not add the hot metal until a steady temperature has been reached (*at least* 30 seconds). *(It will be assumed the temperature of the metal is the same as the boiling water.)*

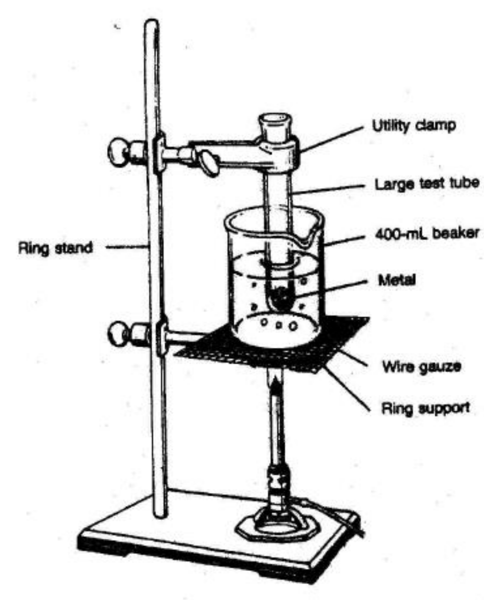
7. Remove the metal from the boiling water – it has to be in **BOILING WATER** for at least 2 minutes – and *immediately* put it into the plastic foam cup.

8. Stir the water in the plastic foam cup and continue to watch the temperature and stir the water until the temperature starts to drop. Write down the highest temperature reached.

9. Repeat steps 2 to 8 with 2 different metals. Return all metal samples to your instructor. ***If time permits do a second trial for each metal***.

10. An alternative method to heat the metals may be advised by your instructor. A hot plate will be provided in which to boil the water and hold the metal samples. Mass both metal samples and place them in the water as it heats up and leave it in the ***boiling*** water for a **<u>minimum of 5 minutes</u>** as described in procedure step 7.

If you do not write on this page of instructions please turn it in so it can be reused! Thank you!



Name ____Date ____________________ Period ______ Score ______

SPECIFIC HEAT OF A METAL

DATA & RESULTS

	Metal 1	Metal 2
1. mass of cup + water		
2. mass of empty cup		
3. mass of water (*this can be determined by a simple calculation rather than a measurement!*)		
4. initial temp. water, T_{wi}		
5. final temp. water, T_{wf}		
6. change in temp. of water, ΔT_w		
7. specific heat of water, C_p, J/g.°C		
8.* heat gained by water, q		
9. symbol of metal		
10. mass of metal		
11. initial temp. metal, T_1	100.0 °C	100.0 °C
12. final temp. metal, T_2		
13. change in temperature of metal, ΔT_m		
14. heat lost by metal, q		
15.* experimental specific heat of metal, C_p		
16. theoretical specific heat of metal, C_p		
17.* percentage error		

bold = lab measurement * = calculations must be shown in table

DATA ANALYSIS

1. Fill in the required data on the front of this page. Please be neat!
2. Calculate the heat gained by the water (lost by the metal) in the calorimeter using the equation in the Introduction. Do this for both metal samples. ***Show your work in the data table***.
3. Calculate the specific heat of the metal using the answers from number 2 and the equation in the Introduction. Do this for both metal samples. ***Show your work in the data table***.
4. Calculate the % of error for each metal used. ***Show your work in the data table***.

Pre lab QUESTION:

1. What physical properties, other than specific heat, could you use to help you identify the sample (s) used in this experiment? ______________________________
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Post lab QUESTIONS:

2. Why is water an excellent material to use in a calorimeter? ______________________________
____
3. **Calculate** the specific heat of a metallic element if 314 joules of energy are needed to raise the temperature of a 50.0 g sample from 25.0°C to 50.0°C. Show your work here!
4. Propose a method for determining the specific heat, C_p, for a metal, like sodium, that reacts with water. ______________________________
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____
5. How would the following errors ***affect the VALUE of the specific heat of a metal***? Explain.
   a. Not allowing the metal to come to the temperature of the boiling water.
   ____
   ____
   b. Loss of heat to the air during the transfer of the metal to the water.
   ____
   ____
   c. Using cold water in the calorimeter. ______________________________
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CONCLUSION: ______________________________
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