

### Introduction:

The amount of heat energy that is required to raise the temperature of one gram of a substance by one degree Celsius is called the specific heat capacity, or simply the specific heat, of that substance. Water, for instance, has a specific heat of 4.184 joules per gram degree Celsius [4.184J / (g x deg. °C)].

The amount of heat energy involved in changing the temperature of a sample of a particular substance depends on three parameters -- the specific heat of the substance, the mass of the sample, and the magnitude of the temperature change. The Greek letter delta ( $\Delta$ ) is used to indicate a change.

$\Delta T$  = temperature<sub>final</sub> - temperature<sub>initial</sub>

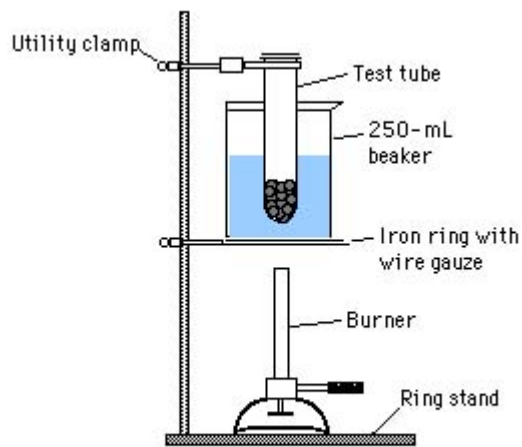
The amount of heat energy that is transferred in the process of producing a temperature change can be calculated from this information, according to the following equation:

$$\begin{array}{l} \text{change in} \\ \text{heat energy} \\ \text{of sample} \end{array} = \begin{array}{l} \text{specific heat} \\ \text{of sample} \end{array} \times \begin{array}{l} \text{mass} \\ \text{of sample} \end{array} \times \begin{array}{l} \Delta T \\ \text{of sample} \end{array}$$

**Problem:** To determine the specific heat of a metal.

### Materials:

Goggles  
Balance  
Large weighing dish  
250-mL beaker  
400-mL beaker  
100-mL graduated cylinder  
25 x 150-mm test tube  
Stirring rod  
Utility clamp  
Ring stand  
Ring support  
Wire gauze  
Gas burner  
Plastic foam cup  
Thermometers (2)  
Paper towel  
Distilled water



Apparatus for heating metal sample.

**Procedure:**

1. Fill a 250-mL beaker about 3/4 full of water. Place the beaker on a wire gauze on a ring support clamped to a ring stand (see drawing). Use a gas burner to bring the water to a slow boil. While the water is heating, proceed to step 2.
2. Using your large weighing dish, and the proper procedure for the balance used, obtain a sample of the metal being used that will fill the test tube about 1/4 full. Find the mass of the metal shot to the nearest 0.01 g and record in the data table.
3. CAREFULLY transfer the metal shot to a large, dry test tube. Be careful to pour the metal shot into the tube slowly so that the bottom of the test tube is not broken in this process. Suspend the test tube in the boiling water with a utility clamp. Position the test tube so that the metal shot is below the level of water in the beaker ( be sure the bottom of the test tube does not touch the bottom of the beaker). Adjust the flame so the water is just boiling gently. Allow the test tube to remain in the boiling water bath for at least 10 minutes. Proceed to step 4 while the metal shot is heating.
4. Carefully measure out 100.0 mL of distilled water in a graduated cylinder, and pour the water into a plastic foam cup. Place the cup in a 400-mL beaker for support. Place a thermometer and stirring rod in the cup. Record on the data table the mass of the 100.0 mL water sample, REMEMBER that 1 milliliter of water has a mass of 1 gram.
5. After the metal shot has been heating for at least 10 minutes, using the other thermometer, measure the temperature of the hot water bath. The temperature of the metal shot is the same as the water bath. Record this temperature to the nearest 0.5 deg.°C as the initial temperature of the metal sample in the data table Read the temperature of the water in the calorimeter to the nearest 0.5 deg.°C and record in the data table as the initial temperature of the water.
6. Remove the test tube from the bath, using the clamp as a holder. Carefully, but quickly, pour the metal shot into the water in the plastic cup (use a paper towel to keep any hot water on the tube from dropping into the calorimeter). Use the stirring rod to gently stir the metal shot (do not stir the shot with the thermometer). Note the temperature frequently. As the temperature begins to change more slowly, watch the thermometer continuously so as not to miss the maximum temperature reached. Record this maximum temperature on the data table to the nearest 0.5 deg.°C, as the final temperature of water and metal.

**Observations:**

**Data Table:**

Mass of the metal sample. = \_\_\_\_\_ g

Mass of water in calorimeter. = \_\_\_\_\_ g

Initial temperature of metal sample. = \_\_\_\_\_ deg.°C

Initial temperature of water in calorimeter. = \_\_\_\_\_ deg.°C

Final temperature of water and metal. = \_\_\_\_\_ deg.°C

**Analysis:**

1. Calculate the changes in temperature of the water ( $\Delta T_{\text{water}}$ ) and of the metal shot ( $\Delta T_{\text{metal}}$ ). These are just simple subtractions. Remember, the water and metal had the same final temperature, but different initial temperatures. Also remember that  $\Delta T$  is never negative, so one calculation will be temperature<sub>final</sub> - temperature<sub>initial</sub>, and the other will be temperature<sub>initial</sub> - temperature<sub>final</sub>.

$$\Delta T_{\text{water}} = \text{_____ deg.}^\circ\text{C}$$

$$\Delta T_{\text{metal}} = \text{_____ deg.}^\circ\text{C}$$

2. Calculate the heat energy gained by the water using the following formula:

$$\text{heat gained}_{\text{water}} = \text{specific heat}_{\text{water}} \times \text{mass}_{\text{water}} \times \Delta T_{\text{water}}$$

$$\text{Heat energy gained by the water.} = \text{_____ joules}$$

3. Remember that the heat gained by the water is equal to the heat lost by the metal; calculate the specific heat of the metal. This is simply rearranging formula (3) from the introduction to solve for the specific heat of the metal, and plugging-in your data. The specific heat of water is again, 4.184J / g deg. $^\circ\text{C}$

The formula would be:

$$\text{specific heat}_{\text{metal}} = \frac{\text{specific heat}_{\text{water}} \times \text{mass}_{\text{water}} \times \Delta T_{\text{water}}}{\text{mass}_{\text{metal}} \times \Delta T_{\text{metal}}}$$

**Conclusions:**

Name:

	Excellent LEVEL 4	Good LEVEL 3	Poor LEVEL 2	Unacceptable <LEVEL 1	Category WEIGHT
<b>Purpose</b>	Clear and concise statement of goal.	Workable statement of goal. Some ambiguity.	Purpose of lab not clearly identified or understood.	"What was this lab about?"	Knowledge  0
<b>Procedure, Equipment &amp; Diagrams</b>	Clear procedures, with all equipment listed and diagrams of the apparatus set-up	Possible to do the lab if some assumptions are made. One or two omissions in equipment or diagram.	Very difficult to follow, poor description of equipment and set-up	"I think we used that gizmo with all the lights and buttons."	Communication  0
<b>Observations</b>	Clear collection of data in a well presented format. Quantitative information shown in properly formatted tables.	Data given in a format that needs to be tidied up. Some information may be misleading because of the presentation.	Information is difficult to recognize. Does not allow for easy analysis later in lab.	"Was I supposed to write that down?"	Communication  5
<b>Analysis &amp; Questions</b>	Perfect analysis based on available observations. Nicely formatted graphs.	Answers objective without completely supporting answer. Some minor calculation errors.	Major calculation errors seriously affect overall analysis.	"That number means the Earth stopped moving for a second."	Inquiry  1) 2 2) 2 3) 2
<b>Conclusion &amp; Sources of Error</b>	Complete list of sources of error, and calculation of error (where appropriate). Wraps up the lab like a neat package.	List of errors has some weakness and/or calculation of error has mistakes. Person still has sight of the purpose of this lab.	Incomplete list of errors and/or no calculation of error. Does not show link between objective, hypothesis, and analysis.	"is that my sock hanging off that dial? Is that a problem?"  "The End."	Application  4
<b>Final Product</b>	Nicely formatted, double sided report.	Some "Hanging Titles", not double sided.	Out of order, missing items, hard to follow.	"My dog got to the printer before I did."	Communication  2