

Specific Heat of a Mystery Metal

Note: Data collection will be done by table groups. Data analysis is to be done individually. Copying data analysis from someone else or allowing someone else to copy your work will result in a zero for the assignment and a referral to the IB Coordinator for cheating.

Discussion:

Specific heat capacity, or simply specific heat, is the amount of heat required to change the temperature of one kilogram of a substance by one degree Celsius. The amount of heat (Q) required to change the temperature of an object is therefore dependent on the mass of the object (m), the object's specific heat capacity (c), and the amount of temperature change (ΔT).

$$Q = mc\Delta T$$

This experiment will attempt to determine the specific heat capacity of an unknown metal. The metal will be heated in hot water. It will then be placed in an insulated cup of water. The thermal energy of the mystery metal will flow to the water until the water and the metal are at the same temperature which is called thermal equilibrium. You will monitor and record the temperature of the water until it reaches thermal equilibrium with the metal. Using a known value for the specific heat capacity of the water, you can then calculate the specific heat capacity of the metal using the following equations,

$$Q_{\text{metal/out}} = Q_{\text{water/in}}$$

$$Q = mc\Delta T$$

$$m_{\text{metal}}c_{\text{metal}}(T_{\text{metal/initial}} - T_{\text{metal/final}}) = m_{\text{water}}c_{\text{water}}(T_{\text{water/final}} - T_{\text{water/initial}})$$

$$c_{\text{metal}} = \frac{m_{\text{water}}c_{\text{water}}(T_{\text{water/final}} - T_{\text{water/initial}})}{m_{\text{metal}}(T_{\text{metal/initial}} - T_{\text{metal/final}})}$$

Materials:

Safety goggles (1 per person)	Lab stands (2 per sta.)	Laptop Computer(1 per sta.)
Large glass beaker	Lab stand clamp (2 per sta.)	Coffee cups with lids (1 per sta.)
Hot plate	LabQuest (2 per sta.)	Mystery Metal (1 per sta.)
Graduated cylinders (1)	Temperature probe (2 per sta.)	Timer (1 per sta.)

Procedure:

1. Record your **MYSTERY METAL NUMBER:** _____.
2. Don safety goggles and wear them throughout the entire experiment.
3. Fill a beaker about 2/3 full, set on hot plate with temperature set to the highest level, and bring the water to a boil.
4. Place your mystery metal in the boiling water for a minimum of 5 minutes before removing
5. Measure 300 ml (0.300 L) of ice water (make sure there is no ice) in a graduated cylinder. Pour the water into your insulated cup.

6. Record the temperature of the ice water at your lab station just prior to adding your mystery metal.
7. Assume that the metal is in thermal equilibrium with the hot water (after sitting a minimum of 5 minutes). Record the temperature of the hot water/metal as the initial temperature of the metal.
8. Remove the metal from the hot water and place it in the insulated cup. Place the lid on the cup and insert the temperature probe through the hole in the lid.
9. Record the temperature of the water every 10 seconds until the water and metal reach thermal equilibrium (temperature stops increasing or starts to decrease). Record the final temperature of the water and metal.

Note: If you are familiar with the use of LabQuest, you can set it to take six samples per minute. You may download the data and use LoggerPro graphs in lieu of Excel or import the LoggerPro data into Excel to make Excel graphs.

10. Use the temperature probe to stir the water in between measurements, but wait at least 3 seconds after stirring to record a temperature measurement.
11. Remove the metal from the water, dry it, and record its mass in kg.
12. Place the mystery metal back in the hot water for at least 5 minutes before starting the next trial. Empty the contents of the insulated cup into a sink and repeat for a total of three trials using the same mystery metal.

Trial 1:

Volume of water (L)	
Initial Water Temperature (°C)	
Initial Metal Temperature (°C)	
Equilibrium Temperature of Water/Metal (°C)	
Mass of the Metal (kg)	

Trial 2:

Volume of water (L)	
Initial Water Temperature (°C)	
Initial Metal Temperature (°C)	
Equilibrium Temperature of Water/Metal (°C)	
Mass of the Metal (kg)	

Trial 3:

Volume of water (L)	
Initial Water Temperature (°C)	
Initial Metal Temperature (°C)	
Equilibrium Temperature of Water/Metal (°C)	
Mass of the Metal (kg)	

Trial 1		Trial 2		Trial 3	
Time (sec)	Temperature(°C)	Time (sec)	Temperature(°C)	Time (sec)	Temperature(°C)
10		10		10	
20		20		20	
30		30		30	
40		40		40	
50		50		50	
60		60		60	
70		70		70	
80		80		80	
90		90		90	
10		10		10	
110		110		110	
120		120		120	
130		130		130	
140		140		140	
150		150		150	
160		160		160	
170		170		170	
180		180		180	
190		190		190	
200		200		200	
210		210		210	
220		220		220	
230		230		230	
240		240		240	
250		250		250	
260		260		260	
270		270		270	
280		280		280	
290		290		290	
300		300		300	
310		310		310	
320		320		320	
330		330		330	
340		340		340	
350		350		350	
360		360		360	
370		370		370	
380		380		380	
390		390		390	
400		400		400	
410		410		410	
420		420		420	
430		430		430	
440		440		440	

Data Analysis:

1. Determine the mass of the water.
 - a. Research the density of water _____
 - b. $\rho = \frac{m}{v}$
 - c. $m = \rho v$
 - d. mass of the water in kg = _____
2. Use a specific heat capacity of water of 4180 J/kg·C.
3. Complete the chart below and compute the specific heat of your mystery metal using
$$c_{\text{metal}} = \frac{m_{\text{water}}c_{\text{water}}(T_{\text{water/final}} - T_{\text{water/initial}})}{m_{\text{metal}}(T_{\text{metal/initial}} - T_{\text{metal/final}})}$$

Trial	m _{water} (kg)	c _{water} (J/kg·C)	ΔT _{water}	m _{metal} (kg)	ΔT _{metal}	c _{metal} (J/kg·C)
1						
2						
3						
Average						

4. Compute an average value for c_{metal}. Use the chart of specific heat capacities on the class website and give your best guess as to the identity of your mystery metal.

5. You are going to prepare an Excel graph of temperature vs time. Before you create the graph, what do you think the slope will look like?

Prepare an Excel graph of temperature vs time showing the results of all three trials on one graph. The graphs should also include a line of best fit (not necessarily linear, use the one that best fits the data [hence the name]), an equation for the line of best fit, and an R² correlation value.

6. What does this graph represent? _____

7. How does the slope compare to your hypothesis in number 5? _____

8. List three potential sources of error in this experiment:
 - a. _____

 - b. _____

c. _____

9. List three ways in which the accuracy of this experiment could be improved:

a. _____

b. _____

c. _____

This data was collected (circle one) by myself / a team. I participated fully and equally in the collection of this data and recorded it myself. The answers on this lab are a product of my own work and effort. Though I may have received some help in understanding the concepts and/or requirements, I did the work myself.

Student Signature (for electronic submission, type student number in lieu of signature)

ROOM FOR IMPROVEMENT

APPLICABILITY: This lab is best suited for (check all that apply):

Physics I Honors/ Pre-IB Physics IB Physics 2 IB Physics 3 None of These

Comments:

IMPROVEMENT: This lab can be improved by:

Comments: