ALT 7

Chemistry 1
Lab 3: Measuring the Specific Heat of a Metal

Name: ______________________
Period ____ Date ______________

Objective: To determine an unknown metal's identity based on the measured specific heat capacity.

Prelab: What is specific heat capacity and why is it unique for different substances?

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Background:

The experimental process that chemists use to measure heat is called **calorimetry**. In this lab you will use your group's calorimeter. When a hot object is placed in the **calorimeter**, it begins to transfer heat. That heat is absorbed by the water and the calorimeter, causing the temperature measured by the thermometer to increase. At some point the object, the water and calorimeter reach the same temperature (thermal equilibrium). This tells the chemist the experiment is finished.

We can write a simple equation to relate the heat gained or lost by the object, the water, and the calorimeter.

Equation 1 $-q_{object} = q_{water} + q_{calorimeter}$

You can think of this equation as the **calorimetry equation**. It tells us that any heat gained by the calorimeter and water must be lost by the object placed in the calorimeter. This makes sense in light of the First Law of Thermodynamics. Energy cannot be created or destroyed. Why is there a negative sign in front of "q_{object}?" The object is *releasing* heat. That means it is *losing* energy. If it is losing energy, its *q* will be negative.

The temperature change in an object is related to the amount of heat it absorbs or releases by the following equation which is discussed on page 494 of your textbook. We will use this equation to determine how much heat the metal transferred to the water in the experiment. The equation is:

Equation 2: $q = m \cdot C \cdot \Delta T$

In this equation, "q" stands for the amount of heat absorbed or released, "m" represents the mass of the object, and "C" is the specific heat of the object. The last symbol of the equation is ΔT (say, Delta-T) and it stands for the change in temperature and is defined as the difference between the final temperature and the initial temperature:

Equation 3: $\Delta T = T_{final} - T_{initial}$

The variable "C" is called **specific heat capacity** or, just specific heat. This is the amount of heat necessary to raise the temperature of 1 gram of a substance by 1 degree Celsius.

In other words, specific heat tells how easy it is to heat up a substance. Like density, each substance has a unique specific heat. We can experimentally measure the specific heat of a metal with calorimetry and use it to identify the metal, which is the purpose of this lab.

Materials:

- Your calorimeter
- A thermometer and beaker clip
- A balance
- A chunk of unknown metal
- Tongs
- Safety goggles
- 1 250 mL beaker (holds calorimeter)
- Hot plate

Procedure:

1. Wear goggles. The hot plates are HOT! BE CAREFUL. Do not leave items in hot bath unattended!
2. Hot water baths are located around the room. These will be used to heat your unknown metal sample to approximately the temperature of boiling water. Help the teacher monitor the volume of water so that it does not evaporate dry in these baths. Turn down the thermostat to 2-3 in between uses.
3. Choose one of the Unknown metal samples and mass it on the balance. Record the mass in column H of the data table. Record the mass with all of the digits shown on the balance. Sample # _________
4. Bring the water to vigorous boil. DO NOT DROP METAL INTO GLASS BEAKER! Using tongs and exercising caution gently place the metal sample into the bath. Record time _______
5. Leave it in the water bath for exactly 5 minutes. This will heat the metal to the temperature of the boiling water. After 5 minutes, record the temperature of the boiling water bath. _________.
6. While the metal is heating another team member will measure the mass of the empty calorimeter with the balance. Record it here: ____________ and copy it to column B.
7. Use the graduated cylinder to measure 50 mL of **room-temperature water** from the flask and then pour it into your calorimeter.
8. Measure the mass of the calorimeter and the water. Record it:_________ and copy it to Column C. Determine the mass of the water by difference and record in Column D.
9. Put the calorimeter with the water into the 250 mL beaker to support it from tipping over.
10. Place your thermometer into the calorimeter for three minutes. Record the initial temperature _____ and copy it to Column E. Remember to estimate between the lines and show temperature with one decimal place!
11. Once your metal has been in the boiling water bath for five minutes, use the tongs to quickly transfer the hot metal directly into your calorimeter.
12. Stir the water carefully and periodically read the temperature without lifting the thermometer out of the water. Record the highest temperature that your water reaches: _________ and copy it to Column F.
13. Remove the metal from the calorimeter and dry it carefully. DO NOT PUT WET SAMPLES into baggie.

Data Tables

A	B	C	D	E	F	G	H
Trial	Mass Calorimeter (g)	Mass Calorimeter and H_2O (g)	Mass of H_2O alone (g)	Initial Temperature (°C)	Final Temperature (°C)	ΔT (°C)	Mass of Unknown Metal (g)
1							

If you perform more than one trial you will need to repeat the calculations for each trial or you can use average values.

Calculations:

Water
Initial Temperature: ________°C
Final Temperature: ________°C
$\Delta T_{water} = T_{final} - T_{initial}$= ____°C

Metal
Initial Temperature: ____°C____ [temp of boiling water bath!]
Final Temperature: ________°C
$\Delta T_{metal} = T_{final} - T_{initial}$= _______ - _______ = ______°C

1) Calculate heat gained by the water, q_{water}

Equation 1: $q_{water} = m \cdot C \cdot \Delta T$ The specific heat capacity of water (C) = 4.184 $\frac{J}{g{\cdot}°C}$. Substitute your experimental values into Equation 1:

2) Calculate the heat lost by the metal, q_{metal}

We can write a simple equation to relate the heat gained or lost by the object, the water, and the calorimeter:

Equation 3: $-q_{metal} = q_{water} + q_{calorimeter}$ [It is negative because the metal transferred heat to the water.]

We will ignore the heat absorbed by the calorimeter so $q_{calorimeter} = 0$. Show your calculation in the space provided.

3) Calculate specific heat of your unknown metal:

Rearrange **Equation 1** to solve for $C_{metal} = \frac{q_{metal}}{m{\cdot}\Delta T_{metal}}$

Calculate the Specific heat of metal (C_{metal}) in $\frac{J}{g{\cdot}°C}$

Analysis:

Why does the water in the Styrofoam cup increase in temperature when the hot metal is added?___________________

____

How much heat does the water gain? ____

Why?____

How much heat does the metal lose? ____

Why?____

What is the specific heat capacity of your metal? ____

Conclusion:

Which metal do you think you have based on the following specific heat capacity values (in $\frac{J}{g{\cdot}°C}$)? ________________

Brass: 0.380 Zinc: 0.389 Tin: 0.21 Aluminum: 0.9000 Iron: 0.4521

What did you learn about heat transfer?

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____

What did you learn about specific heat capacity?____

____

What did you like about this lab?____

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Specific Heat of a Metal Summary

On the next page you will write your lab summary communicated in one or two well written paragraphs.
Here is a sample outline:

1. Write a topic sentence to introduce your reader to the lab and your purpose.
2. Explain how you will identify the metal by relating steps in the lab to key science concepts listed in the rubric.
3. What metal do you think you have based on the standards provided? Explain how your data support this claim.
4. Your method probably wasn't perfect, that's ok, as long as you discuss the issues. Discuss the tools used. Could they be improved? Did you identify and adequately keep controlled variables the same? Were you able to have multiple trials? List at least one specific improvement for next time.
5. Write a concluding sentence that ties to your introduction and summarizes your learning about specific heat capacity.

Rubric for the Lab Summary

Students earning a "2" or "1" may revise one time to raise proficiency to a "3."

Report Aspects	4 "Highly Proficient"	3 "Proficient"	2 "Nearly Proficient"	1 "Beginning Proficient"
Writing Style:	☐ Summary has a strong & unique topic sentence. ☐ The closing sentence relates well with the topic sentence. ☐ It is communicated in a well-written report including complete sentences, correct spelling, grammar and punctuation.	☐ Summary has a relevant topic sentence. ☐ The closing sentence relates well with the topic sentence. ☐ It is includes complete sentences, correct spelling, grammar and punctuation with only minor errors.	☐ Summary has a fairly relevant topic sentence. ☐ The closing sentence does not relate well with the topic sentence. ☐ It includes sentences, spelling, grammar and punctuation with some errors.	☐ Summary may or may not have a topic sentence. ☐ It has no closing sentence or it does not relate with the topic sentence. ☐ It is communicated in paragraphs but includes sentence fragments, poor spelling, poor grammar and punctuation.
Science Concepts: ☐ calorimetry ☐ specific heat capacity ☐ heat transfer ☐ 2nd Law Thermodynamics	☐ All 4 chemistry concepts are included and are accurately defined and used.	☐ All 4 chemistry concepts are included but some are defined or used with minor error.	☐ Some chemistry concepts are not included or are defined with some error.	☐ The chemistry concepts are defined with major error or missing altogether.
Evidence: **Concepts** are supported or explained with evidence from the lab and reading.	☐ Makes a clear claim identifying the unknown metal that is clearly supported by the experimental data. correctly identifies the metal.	☐ Makes a clear claim identifying the unknown metal that is partially supported by experimental data from the lab. May or may not correctly ID the metal.	☐ Makes a claim identifying the unknown metal that is not clearly supported by experimental data from the lab or does not correctly ID the metal..	☐ There is no claim identifying the metal and/or the claim is supported with faulty or incomplete data collected in the lab. Unsupported claim.

Works Cited

Stacey, Angelica M. "Specific Heat Capacity." *Living by Chemistry.* Emeryville, CA: Key Curriculum, 2010. p. 493-496. Print