Lab: The Search for a Hit and Run Suspect

FOR THE TEACHER

Summary
In this lab, students will determine the specific heat capacity of multiple unknown metal samples through collecting data and completing calorimetric calculations. Students will take on the role of a forensic investigator and use their results to help them determine if a suspect’s vehicle was potentially involved in a hit and run incident.

Grade Level
High School

Objectives
By the end of this lab, students should be able to
- Collect appropriate laboratory data for use in calorimetric calculations.
- Calculate the specific heat capacity of a metal using calorimetry.
- Identify an unknown metal based on specific heat capacity values determined.

Chemistry Topics
This lab supports students’ understanding of
- Energy
- Calorimetry
- Specific Heat Capacity
- Identifying and Unknown

Time
Teacher Preparation: 30 minutes
Lesson: 60 minutes

Materials
Per student or Lab Group:
- Calorimetry cup (Styrofoam cup)
- Water
- Spoon
- Stirring Rod
- Thermometer
- 3 Metal Samples: Aluminum, Nickel, Zinc (approximately the size of a tablespoon)

Shared amongst all students:
- Electronic Balance
- Heat Resistant Glove/Oven Mitten
- Lab Heating/Drying Oven set at about 120°C

Safety
- Always wear safety goggles when handling chemicals in the lab.
- Students should wash their hands thoroughly before leaving the lab.
- When students complete the lab, instruct them how to clean up their materials and dispose of any chemicals.
- Exercise caution when using a heat source. Hot plates should be turned off and unplugged as soon as they are no longer needed.
- Use caution when handling the metal samples, they will be hot!
Teacher Notes

- I suggest having students complete this lab in groups of 3. Each student can be responsible for analyzing each of the metal samples.
- For the 3 metal samples from each suspect’s car, I like to use aluminum, nickel, and zinc because they have similar colors but very different specific heat values.
- As the students finish reading about the last suspect, I write the accepted specific heat value of one of the metals on the board and explain to the students that this is the specific heat of the metal that was found at the crime scene. If the students do the lab correctly, their results should closely match the value of one of the suspects.
- A drying oven is used in this lab, it should be set at approximately 120°C, and that will serve as the initial temperature of the metal samples.
- The teacher will need to be in charge of the oven. Metal samples should spend several minutes in the oven before being removed. 5-7 minutes should be sufficient.
- The transfer of the metal from the oven to the calorimeter cup should be a swift orchestrated event. When ready, the instructor will open the door to the oven during the transfer and quickly close the door when finished.
- One student, using oven mitts, will remove the metal and place a large (tablespoon amount) of metal into the calorimeter cup that is held by another student. As soon as the metal enters the water, that student holding the calorimeter cup should begin stirring in order to take temperature reading.
- When finished taking the highest temperature reading, students decant the water from the calorimeter cup into the sink and place the metal into a paper towel to dry.

**For the Student**

**Lesson**

**The Search for a Hit and Run Suspect**

**Scenario**

*Police are in search of a hit-and-run suspect who crashed into the front security gate at Xavier’s School for Gifted Youngsters. No one was injured when a vehicle hit the main entrance gate, causing it to collapse. “I suspect that this is the work of my nemesis, Magneto,” claims Professor Xavier, director of the school. “He has been trying to disrupt the education at this school for some time now.” After viewing video surveillance, police were able to determine that the vehicle was a mid-size car, but could not determine the make or model. Metal pieces left from the crime scene are being analyzed by a separate crime lab and will help police determine which car may have been involved in the accident. The police have three suspects, who each own a mid-size car with damage to the right front fender.*

<table>
<thead>
<tr>
<th>Suspect 1</th>
<th>John Allerdyce (aka Pyro) used to attend the special school, but rumors indicate that he has joined Magneto. “I know there is some good in him” said Rogue, a friend who is attending the school. “He couldn’t have done this!”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspect 2</td>
<td>Tyler Maine’s (aka Sabertooth) employment records show that he is working for Magneto. An abandoned car, registered under his name, was discovered by police outside the tiger section of the city zoo. The car had damage that is consistent with crashing into a gate.</td>
</tr>
</tbody>
</table>
Suspect 3

Mystique does not have any record of owning a car, but police did find her purse and ID in an unregistered, damaged vehicle outside of Wolverine’s apartment the night after the crime. “I betcha it was her! She is always snooping around and posing as other people,” claimed Bobby Drake. “I am gonna put her on ice!”

Because you are such a great chemistry student, you realize that every type of metal has a unique ability to conduct heat. Therefore, you can determine the specific heat of the metal from each suspect’s car and compare it with the results found with the metal collected at the gate.

Materials
- Calorimetry cup (Styrofoam cup)
- Water
- Electronic Balance
- Thermometer
- Lab Heating/Drying Oven
- Spoon
- Stirring Rod
- Heat Resistant Glove/Oven Mitten
- Unknown Metal Sample

Safety
- Always wear safety goggles when handling chemicals in the lab.
- Wash your hands thoroughly before leaving the lab.
- Follow the teacher’s instructions for cleanup of materials and disposal of chemicals.
- Use caution when handling the metal samples, they will be hot!
- Exercise caution when using a heat source. Hot plates should be turned off and unplugged as soon as they are no longer needed.

Procedure
1. Record the mass an empty calorimeter cup in the provided data table.
2. Fill the cup with 100 mL of tap water, measure and record its mass.
3. Record the initial temperature of the water in the cup.
4. Record the temperature of the metal sample in the oven (it should be near 120°C).
5. With the help of your teacher, use an oven mit/heat resistant glove and a spoon to quickly transfer the metal sample from a suspect into the water.
6. Quickly stir and record the highest temperature reached - you will know when the temperature begins to decline.
7. Measure the final mass of the cup, water and metal.
8. When the water is cool, gently pour out the water and dry off the remaining metal.
9. Repeat the procedures with the metal sample from each suspect.

Data for Suspect 1

<p>| Data Table 1 |</p>
<table>
<thead>
<tr>
<th>Suspect name</th>
<th>Empty cup (g)</th>
<th>Cup and 100 mL water (g)</th>
<th>Mass of just water (g)</th>
<th>Initial Temperature of water (°C)</th>
<th>Temperature of metal/oven (°C)</th>
<th>Highest temperature of water after metal is added (°C)</th>
<th>Mass of cup and water and metal (g)</th>
<th>Mass of metal (g)</th>
<th>Temperature change of water (°C)</th>
</tr>
</thead>
</table>

**Calculations for Suspect 1**

1. Using the data collected from your experiment, complete the following table:

<table>
<thead>
<tr>
<th>Change in Water Temp due to metal</th>
<th>Change in Metal Temp due to water</th>
<th>Specific Heat of Water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4.184 J/g°C</td>
</tr>
</tbody>
</table>

2. Using the following equation, and the information previously determined, plug in values and solve the equation for the specific heat of the metal sample:

**Specific Heat Calculation:**

\[ 4.184 \text{ J/g°C} \times \text{mass of water (g)} \times \Delta T_{\text{Water}} = SH_{\text{metal}} \times \text{mass of water (g)} \times \Delta T_{\text{metal}} \]

**Data for Suspect 2**

<table>
<thead>
<tr>
<th>Data Table 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspect name</td>
</tr>
<tr>
<td>Empty cup (g)</td>
</tr>
</tbody>
</table>
Calculations for Suspect 2

1. Using the data collected from your experiment, complete the following table:

<table>
<thead>
<tr>
<th>Change in Water Temp due to metal</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Metal Temp due to water</td>
<td></td>
</tr>
<tr>
<td>Specific Heat of Water</td>
<td>4.184 J/g°C</td>
</tr>
</tbody>
</table>

2. Using the following equation, and the information previously determined, plug in values and solve the equation for the specific heat of the metal sample:

Specific Heat Calculation:

\[ 4.184 \text{ J/g°C} \times \text{mass of water (g)} \times \Delta T_{\text{Water}} = S_{\text{metal}} \times \text{mass of water (g)} \times \Delta T_{\text{metal}} \]

Data for Suspect 3

<table>
<thead>
<tr>
<th>Data Table 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspect name</td>
</tr>
<tr>
<td>Empty cup (g)</td>
</tr>
<tr>
<td>Cup and 100 mL water (g)</td>
</tr>
<tr>
<td>Mass of just water (g)</td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>Initial Temperature of water (°C)</td>
</tr>
<tr>
<td>Temperature of metal/oven (°C)</td>
</tr>
<tr>
<td>Highest temperature of water after metal is added (°C)</td>
</tr>
<tr>
<td>Mass of cup and water and metal (g)</td>
</tr>
<tr>
<td>Mass of metal (g)</td>
</tr>
<tr>
<td>Temperature change of water (°C)</td>
</tr>
</tbody>
</table>

**Calculations for Suspect 3**

1. Using the data collected from your experiment, complete the following table:

| Change in Water Temp due to metal |  |
| Change in Metal Temp due to water |  |
| Specific Heat of Water | 4.184 J/g°C |

2. Using the following equation, and the information previously determined, plug in values and solve the equation for the specific heat of the metal sample:

**Specific Heat Calculation:**

\[
4.184 \text{ J/g}^\circ\text{C} \times \text{mass of water (g)} \times \Delta T_{\text{Water}} = S H_{\text{metal}} \times \text{mass of water (g)} \times \Delta T_{\text{metal}}
\]

**Analysis**

1. What is the Specific Heat Capacity of the metal found at the crime scene?

2. Using data from the lab, explain which suspect the police should investigate as possibly damaging the front gate of the School for Gifted Youngsters.