Physics 251 Laboratory
Thermodynamics – Part 1

Pre-Lab: Please do the pre-lab exercises on the web.

Introduction

It had been recognized by the 18th century that the amount of heat, Q, required to change the temperature of a system is proportional to the mass, m, of the system and to the temperature change, ΔT. This proportion is what we now know as "specific heat" and is often abbreviated by c. This value is valid for heat flow into or out of the system. This lab will help us see how to determine the specific heat of a known substance.

Equipment/Supplies

Calorimeter	Unknown sample #2	Unknown sample #1
Thermometer	Water	Stirrer
Graduated cylinders	Paper towels	Boiler
Balance		

Section 1: Calorimetry

Calorimetry is the quantitative measurement of heat exchange. When different parts of an isolated system are at different temperatures, heat will flow from the portion at higher temperature to the portion at lower temperature. If the system is completely isolated, no heat can flow into or out of the system, that is, the energy of the system is conserved. You can determine the specific heat of an unknown material by recognizing the First Law of Thermodynamics, in this case, Q_{sys} lost = Q_{sys} gained. The specific heat of water is $4190 J/kg \cdot K$. The density of water is 1.0 g/cm^3. The specific heat of the calorimeter is $910 J/kg \cdot K$.

Q_{sys} lost is found by adding up all the $Q=mc\Delta T$ from each object whose temperature decreases. Similarly, Q_{sys} gained is found by adding up all the $Q=mc\Delta T$ from objects whose temperature rises.

1. In the pre-lab exercise on the web you derived the formula to calculate the specific heat of an unknown object given its mass, m_s, by adding it at temperature T_a to a mass, m_w, of water at T_b and the system coming to an equilibrium temperature T_f. Write this equation on your results sheet for use in section 2.

2. Develop an experiment to determine the specific heat of an unknown sample using the formula you derived for number 1 and using the materials listed above. Use a large amount of metal (on the order of 300g) when you design your experiment.

Section 2

1. Using the procedure you have developed in Section 1, experimentally determine the specific heat of unknown sample #1.

What value did you obtain for the specific heat? Using the table in your book, identify the substance.

2. Using the same procedure, experimentally determine the specific heat of unknown sample #2.

What value did you obtain for the specific heat? Using the table in your book, identify the substance.

DATA	
Unknown Sample # 1	
Mass of sample	**kg**
Mass of water	**kg**
Initial temperature of water	**^{o}C**
Initial temperature of sample	**^{o}C**
Final temperature of system	**^{o}C**
Unknown Sample #2	
Mass of sample	**kg**
Mass of water	**kg**
Initial temperature of water	**^{o}C**
Initial temperature of sample	**^{o}C**
Final temperature of system	**^{o}C**

Physics 251 Laboratory
Thermodynamics – Part 2

Pre-Lab: There is no lab prep for this lab. Please review the procedure and relevant sections in your book prior to lab.

Introduction

A transition from one state of matter to another is called a phase change. Water changes phase from ice to liquid and again from liquid to water vapor. When we add heat to ice it changes phase rather than increasing its temperature until after the phase change is complete. The amount of heat required to change one kilogram of ice to liquid is called the heat of fusion mL_f. The plus sign is used when heat is entering (melting) and the minus is used when heat is leaving (freezing). The heat of fusion for water is 3.34×10^5. The amount of heat required to turn one kilogram of water into water vapor is called the heat of vaporization. The heat of vaporization for water is 2.56×10^6.

Equipment

Calorimeter		
Thermometer	Water	Ice
Stirrer	Graduated cylinders	Paper towels
Boiler	Balance	

Section 1

1. Derive a formula for finding L_f for a known quantity of ice.

2. Develop an experiment to determine the heat of fusion of ice using the formula you derived for number 1 and using the materials listed above.

3. Using the procedure you developed in step 2, find the heat of fusion for your sample of ice and compare with the known value.

Section 2

1. Derive a formala for finding L_v for steam. Remember the transition from steam to water heat $Q = -mL_v$ because heat is leaving the system.

2. Determine the heat of vaporization for water
   a. Weigh the calorimeter and water before and after adding the steam to get the mass of steam which condensed.
   b. Start with cold water (below room temperature) and introduce steam under the surface of the water until the temperature rises to about 50°C.
   c. Remove the steam hose, wait a few seconds and record the final temperature.

Ice	
Initial mass of ice	kg
Mass of water	kg
Initial temperature of water	^{o}C
Final temperature of system	^{o}C
Steam	
Initial mass of water	kg
Initial mass of calorimeter + water	
Initial temperature of water	^{o}C
Final temperature of water	^{o}C
Final mass of water + calorimeter	kg
Amount of steam condensed	kg

Thermodynamics Part 1
Results

Please use the back of this page or attach another sheet if you need more room for your calculations.

Section 1

1. What is the heat capacity of your calorimeter? ___________________________________

2. Derived formula for specific heat of an unknown sample? _______________________
____

3. Describe how you would go about your experiment_____________________________
____
____
____
____

Section 2

1. Unknown # 1 Specific Heat? ________ Identity? _____________ Percent Error ________

2. Unknown # 2 Specific Heat? ________ Identity? _____________ Percent Error ________

Overall

What was good about this lab? ____
____
____
____

What would you do to improve it?____
____
____
____

NAME____DATE__________________

Thermodynamics Part 2
Results

Please use the back of this page or attach another sheet if you need more room for your calculations.

Section 1 - ICE

1. Derived formula for heat of fusion for water? ______________________________

____

2. Describe how you would go about your experiment__________________________

____

____

____

3. Heat of fusion ___________________ Percent Error ________________________

Section 2 - STEAM

1. Derived formula for heat of vaporization for water?__________________________

____

2. Heat of vaporization ____________________Percent Error __________________

Overall

What was good about this lab? ____

____

____

What would you do to improve it?____

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