Worksheet: Measure heat capacity with a calorimeter

Name(s)_____

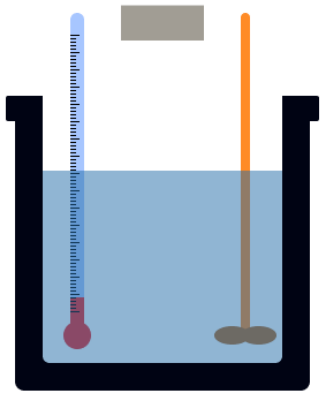
In this experiment, you drop a hot metal cube into an insulated container of water and use the increase in the water temperature to determine the heat capacity of the metal.

Student Learning Objectives

1. Be able to explain the concept of heat capacity.
2. Be able to apply the concept of an adiabatic process.
3. Be able to apply the first law for a closed system.
4. Be aware of assumptions made and sources of error in using a static calorimeter.
5. Learn proper use and calibration of calorimeters.
6. Apply statistics to determine heat capacity from repeat experiments and determine standard deviation.

Equipment

A well-insulated calorimeter that contains 1000 mL of water and a stirrer. A thermometer to record the water temperature.



Questions to answer before starting experiment

In this experiment, 1000 mL of water is in an insulated container.

What is the advantage of using more water?

What is the disadvantage of using more water?

What is an advantage of using more metal? What is a disadvantage?

What is an advantage of heating the metal to a higher temperature? What is a disadvantage?

Assumptions

- The calorimeter is well insulated.
- The heat capacity of the metal sample is independent of temperature.

Calibrate the calorimeter

1. Turn on the stirrer.
2. Measure the initial temperature of water. _____
3. Record mass of water in calorimeter. _____
4. Take a sample of a known metal (Pt), record its mass _____ and its temperature _____, and drop it into the calorimeter.
5. Record the water equilibrium temperature _____.
6. Calculate heat absorbed by the calorimeter to determine $m_{cal}C_{Pcal}$

$m_{Pt}C_{P_{Pt}}(T_{Pt} - T_{final}) = m_W C_{P_W}(T_{final} - T_W) + m_{cal}C_{Pcal}(T_{final} - T_W)$

where m_{Pt} = mass of Pt added to calorimeter

$C_{P_{Pt}}$ = heat capacity of Pt = _____

C_{P_W} = water heat capacity = _____

T_{final} = final equilibrium temperature

m_W = mass of water in calorimeter

T_W = initial temperature of water in calorimeter

$m_{cal}C_{Pcal}$ = mass of calorimeter (not including water) x heat capacity of calorimeter. This product is unknown and is calculated from the above equation. The individual values of m_{cal} and C_{Pcal} cannot be determined.

Value of $m_{cal}C_{Pcal}$ = _____

Measure heat capacity of unknown sample

1. Select a sample (A, B, C, D, E) from the drop-down menu. Sample _____
2. Turn on stirrer.
3. Record mass of water in calorimeter m_W. _____
4. In Table 1 below, record starting temperature of water T_W .
5. Record the starting temperature of the solid sample T_{sample} in Table 1.
6. Record mass of solid sample m_{sample} in Table 1.
7. Drop solid into water.
8. Record the water equilibrium temperature T_{final} in Table 1.
9. Repeat the experiment 3 more times for the same sample but for different starting values of T_W, T_{sample}, and m_{sample}, and record the data in Table 1.
10. Use this energy balance to calculate the heat capacity $C_{Psample}$ of the sample:

$$m_{sample}C_{Psample}(T_{sample} - T_{final}) = m_W C_{P_W}(T_{final} - T_W) + m_{cal}C_{Pcal}(T_{final} - T_W)$$

and record the heat capacity in Table 1.

Table 1					
Exp.	T_W	T_{sample}	m_{sample}	T_{final}	$C_{Psample}$
1					
2					
3					
4					

Calculate the average value of heat capacity (report units) and standard deviation.

$C_{Psample}$ = _____ +/- _____

Questions to answer

1. Does the stirrer add energy to the water?

2. How might you determine how good the assumption is that the system is adiabatic?

3. What else might cause errors in the value of heat capacity measured?