Worksheet: Measure heat capacity with a calorimeter

Name(s)_____

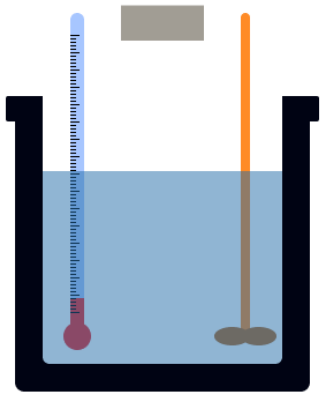
In this experiment, a hot metal cube is dropped into an insulated container of water and the increase in the water temperature is used to determine the heat capacity of the metal.

Student Learning Objectives- Measure heat capacity with a calorimeter

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 and a disadvantage of using more metal?

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

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 water temperature as a function of time in the table below to determine the final equilibrium temperature _____.

Time (s)	Temperature (°C)

6. Calculate heat absorbed by the calorimeter to determine $m_{cal}C_{Pcal}$

$$m_{Pt}C_{P_{Pt}}\left(T_{Pt}-T_{final}\right)=m_W C_{P_w}\left(T_{final}-T_W\right)+m_{cal}C_{Pcal}\left(T_{final}-T_W\right)$$

7. where m_{cal} = mass of Pt added to calorimeter
8. $C_{P_{Pt}}$=¿heat capacity of Pt = _____
9. C_{P_w} = water heat capacity = _____
10. T_{final} = final equilibrium temperature
11. m_W = mass of water in calorimeter
12. T_W = initial temperature of water in calorimeter

12. $m_{cal}C_{Pcal}$= mass of calorimeter (not including water) x heat capacity of calorimeter. This is unknown and is calculated from the above equation.

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}.
6. Record mass of solid sample m_{sample}.

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

7. Drop solid into water.
8. Record temperature as function of time in Table 2 on the next page.
9. Determine when temperature stabilizes and record the final temperature in Table 1.

Exp 1		Exp 2		Exp 3		Exp 4	
Time (s)	Temp (°C)	Time (s)	Temp (°C)	Time (s)	Temp (°C)	Time (s)	Temp (°C)

Calculate the heat capacity of sample.

Use this energy balance to calculate the heat capacity $C_{Psample}$ of the sample:

$$m_{sample} C_{Psample} \left(T_{sample} - T_{final}\right) = m_W C_{P_w} \left(T_{final} - T_W\right) + m_{cal} C_{Pcal} \left(T_{final} - T_W\right)$$

Record the calculated heat capacity in Table 1

Repeat the experiment at least 3 times for the same sample but for different starting conditions and record the data in Tables 1 and 2.

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

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

What can cause errors in the value of heat capacity you measured?

1. Does the stirrer add energy to the water?

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