Course and Section_______ Names ___________________________

Date___________ _________________________________

CALORIMETRY EXPERIMENT

Introduction

In this experiment, we will use two temperature probes to measure the changes in temperatures as substances at different temperatures are mixed.

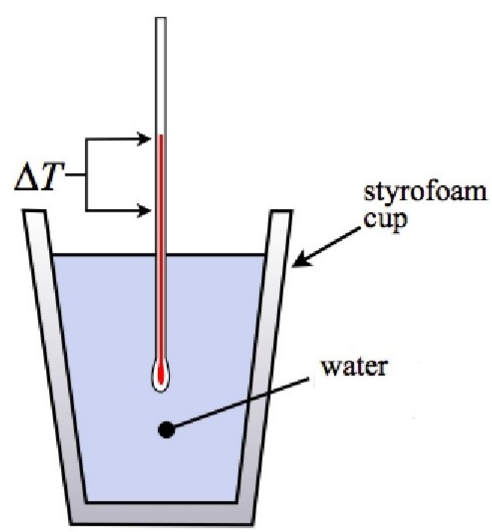
Equipment

Two digital thermometers, scale, calorimeter (the Styrofoam cup), plastic beaker, hot water container (NOTE: it takes at least 30 mins to warm up), cold water container, aluminum and copper blocks.

Theory

A calorimeter is a device in which the exchange of heats between various substances is studied.

A simple calorimeter is a container, for example a Styrofoam cup, with water and a thermometer.



If the calorimeter is insulated (no heat is exchanged with the surrounding) we have

$$\sum Q_i = 0 \qquad (1)$$

Where Q_i are the heats exchanged by the substances inside the calorimeter. The heat Q_i is positive for the substances absorbing heat, negative for the substances releasing heat.

If the calorimeter is not perfectly insulated then we have

$$\sum Q_i = Q_{Lost} \qquad (2)$$

where Q_{Lost} is the heats lost to the surrounding by the calorimeter. Q_{Lost} is negative.

In this experiment, we'll study the exchange of specific heats, given by

$$Q = mc\Delta T \qquad (3)$$

where m is the mass, c the specific heat capacity and ΔT the change in temperature.

Preliminary questions

1. Make a prediction: what is the temperature in the classroom in ^oC? __________

2. If I mix 40 grams of 60 ^oC water with 50 grams of 20 ^oC water, what will the final temperature be?

3. 20 grams of metal *X* at temperature 300K are placed in 20 grams of fluid *Y* which is at 250K. If *X* has a higher specific heat than *Y*, the equilibrium temperature will be

(a) 250K
(b) between 250 and 275K
(c) 275K
(d) between 275 and 300K
(e) 300K

PART1 – The calorimeter's heat lost.

Step 1. Open the capstone file "**T1T2.cap**" located in the T:\Capstone folder and pair the two wireless thermometers. The Capstone software will display the graph of the temperatures vs time of each thermometer. Check with the TA for any technical issue.

Step 2. Place the two sensors on your table and observer the reading of the two temperatures.

4. What are the two temperatures? T_1 = ________ T_2 = ________

5. Calculate the percentage difference of the two temperatures.

% difference =

6. Use the average of the two temperatures as the estimate of room temperature.

T_{Room} = ____________

7. Measure the mass of the calorimeter (the Styrofoam cup) using the digital scale.

$M_{calorim.}$ = _____________________

In order to know how well our calorimeter is insulated, we will measure the temperature of hot water as it just sits in the calorimeter.

Step 3. Using the plastic beaker, fill the calorimeter about ¾ of the way with hot water from the hot water container. Put the cover over it, and insert a temperature probe. Note that it takes several seconds for the probe to reach the temperature of the water. The "initial" temperature would be the the hottest value the probe reads, before it starts to decrease.

8. Observe the temperature for about 300 seconds after the initial value, and then record both initial and final temperatures from the graph

T_i = ________________ T_f = ____________________

9. Measure the mass of the water by weighing the calorimeter and water together, and subtracting the mass of the calorimeter that you found earlier.

M_w = ___________________

10. Knowing the masses of the water, its specific heat, and the temperature change, calculate how much heat has been lost in 300 seconds; convert this to the rate of joules per second.

Rate: $\frac{|\Delta Q|}{\Delta t}$ = ______________ J/s

PART 2 - Mixing waters

Step 1. Pour out about 1/3 of the hot water from the calorimeter into the plastic beaker. Use the beaker to carry and put this 1/3 of water back into the hot water container.

11. Measure the temperature and find the mass of the water left in the calorimeter.

T_{hot} = ________________ M_{hot} = ________________

Step 2. Get some cold water from the water cooler using the plastic beaker (about 1/3 of it) and measure its temperature with the second probe:

T_{cold} = ________________

Step 3. Add some cold water to the hot water contained in the calorimeter. Place both probes inside the calorimeter and observe how the temperatures are changing until the equilibrium final temperature is reached.

12. Record the final temperature of the mixture (when the temperatures from the two probes meets on the graph):

T_{final} = ________________

13. From conservation of energy, the Eq. 1, calculate the mass of cold water added previously in step 3 into the calorimeter. (In this step we ignore the energy lost by the calorimeter).

M_{cold} = ________________

PART 3 - Specific heat of the metal block

Step 1. Empty the calorimeter into the hot water container and use the beaker to add about 200ml of “new” hot water into the calorimeter.

14. Measure the temperature and mass of the added water:

T_{Water} = ________________ M_{Water} = ________________

There is a metal block of aluminum (or copper) sitting on the table. You can assume its initial temperature to be room temperature: T_{block} = ______

15. Measure its mass with the scale.

$M_{Metal\ Block}$ = ________________

Step 2. Place the metal block into the calorimeter making sure the hot water cover it. Put back the calorimeter cover. Use one probe to monitor the temperature until it levels off, so that you know the equilibrium temperature T_{final} is reached (about 2-3 minutes). While doing so, make sure the probe does not touch the metal block.

16. Record the final temperature and time interval needed to reach it

T_{final} = ________________ Δt =________ (s)

Analysis

We want to find the heat absorbed by the metal block in two different ways named respectively Q_{Block} and Q'_{Block}. Be careful to specify the signs of the following heats. The specific heat capacities are c_{Copper} = 386 J/(kg ºC) and $c_{Aluminum}$ = 902 J/(kg ºC)

17. Use the Eq. (3) to calculate directly the *heat gained* by the metal block.

Q_{Block} =________ (positive)

18. Use the Eq. (3) to calculate the *heat lost* by the water

Q_{Water} = _______ (negative)

19. Which did change more in temperature, the water or metal block?

20. Calculate the *heat lost* to the environment by using the loss R*ate* you found previously in question 10, and the time interval Δt above.

Q_{Lost} = ______ (negative)

21. By knowing Q_{Water} and Q_{Lost} and using Eq. (2) calculate Q'_{Block}. Show your calculations.

Q'_{Block} = ________

22. Calculate the percentage difference of the two heats absorbed by the block

% difference = ________

23. Which of the two measurements do you think is more precise, and why?