HEAT AND TEMPERATURE: CALORIMETRY Experiment

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

Equipments: Two digital thermometers, scale, calorimeter (the styrofoam cup), plastic beaker, hot water container, cold water container (with ice), aluminum and copper blocks.

Preliminary questions
1. Make a prediction: what is the temperature in the classroom in °C? _______
2. If I mix 40 grams of 60 °C water with 50 grams of 20 °C 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

Procedure

Setup: Check the two temperature probes are connected to two of the slots A, B or C in the Pasco interface. DO NOT SWITCH to witch port (A,B or C) the thermometers are already connected to (ask for assistance to the TAs if you have problem with the devices). Use “Setup” in DataStudio to check that the probe is attached and graph the temperatures vs. time with both the temperatures on the same graph.

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

\[ M_{\text{calorim.}} = \text{______________} \]

1. Room temperature.
   a) In order to test your prediction of the room temperature, hit “start,” and see what the temperature sensor read. _______

2. Heat losses.
   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. Using the plastic beaker, fill
the calorimeter about \( \frac{3}{4} \) 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 is the
hottest value the probe reads. Observe the temperature for 300 seconds, and then
record the initial and final temperatures from the graph

\[
T_i = \text{______________} \quad T_f = \text{______________}
\]

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

\[M_w = \text{______________}\]

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

\[
Rate: \frac{\Delta Q}{\Delta t} = \text{______________} \text{ J/s}
\]

3. Mixing water.

a) Pour out, about 1/3, of the hot water from the calorimeter. Measure its temperate
and find its mass:

\[T_{\text{hot}} = \text{______________} \quad M_{\text{hot}} = \text{______________}\]

b) 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:

\[T_{\text{cold}} = \text{______________}\]

c) Add some cold water to the hot water contained in the calorimeter. Place both
probes inside the calorimeter and observe how the temperature is changing until
the equilibrium final temperature is reached. Record the final temperature of the
mixture (when the temperatures from the two probes meets on the graph):

\[T_{\text{final}} = \text{______________}\]

From conservation of energy, calculate the mass of cold water added in step
previously in step c) into the calorimeter:

\[M_{\text{cold}} = \text{______________}\]
4. Specific heat of aluminum or copper

a) Use the beaker to get about 200ml of “new” hot water. Place it in the calorimeter and measure the temperature and mass:

\[ T_{\text{water}} = \quad M_{\text{water}} = \]

b) You have a metal block of aluminum (or copper) that is sitting on the table and is thus at room temperature. Measure its mass with the scale.

\[ M_{\text{aluminum/copper}} = \]

c) Place the metal block into the calorimeter making sure the hot water cover it, rput back the calorimeter cover. Monitor the temperature for about 200 seconds or until the temperature levels off so that you know equilibrium has been reached. While doing so, make sure the thermometer does not touch the metal block. Record the final temperature and time.

\[ T_{\text{final}} = \quad \Delta t: = \quad \]

d) Calculate the heat transferred to the aluminum, whose specific heat you know and heat transferred from the water using for both cases \( Q = cm\Delta T \). Calculate also the heat transferred to the environment by using the loss Rate you found in part 2 and the time interval \( \Delta t \) above.

\[ Q_{\text{block}} = \quad \]

\[ Q_{\text{water}} = + \quad \text{(use the absolute value)} \]

\[ Q_{\text{lost}} = + \quad \text{(use the absolute value)} \]

e) Which changed more in temperature, the water or metal block?

f) Why?

g) Calculate now \( Q_{\text{water}} \) in a different way: the heat transferred from the water is equal the heat transferred to the metal block plus the heat lost.

\[ Q'_{\text{water}} = Q_{\text{block}} + Q_{\text{lost}} = \quad + \quad = \quad \]

h) Compare \( Q' \) with \( Q_{\text{water}} \) found above, find the percentage difference:

\[ \%\text{diff:} = \frac{|Q-Q'|}{(Q+Q')/2} \times 100 = \quad \]

i) Discuss any differences you find.