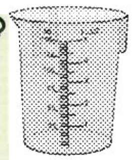
Lab 7 Specific Heat of an Alloy

     Balance Thermometer Styrofoam cup calorimeter (or nested cardboard coffee cups) Plastic cup or glass 150-mL polypropylene beaker Wash bottle	    Stove Small saucepan Strainer 10 quarters (post 1967, Cu 92% Ni 8 %) or coins that have a mass of about 50 g Ice

Hazards for this experiment are just the hazards of cooking. You will be using a stovetop. Take care not to burn yourself.

Unless a substance is undergoing a phase change, substances change temperature as they absorb energy. The amount of heat needed to change the temperature of 1 gram of a substance 1°C (or 1 K) is the specific heat of that substance. The specific heat depends on the atomic and molecular properties of the substance[1].

Water's specific heat is 4.18 J/g°C. One gram of water will change temperature 1°C on the addition of 4.18 J of energy.

You will experimentally find the specific heat of a metal alloy.

1 The specific heat changes slightly with temperature, but for our experiment this is not a factor.

Procedure:

1. Assemble your calorimeter by nesting two Styrofoam cups together. If you don't have or want to use Styrofoam cups, you can use paper coffee cups. As paper cups do not insulate as well as Styrofoam, you should nest the two cups together with a paper towel between the cups to create an insulating space. You will be doing this experiment without the cover. Record the calorimeter's mass.

2. 1/3 fill a plastic cup or large glass with ice and then add water (tap water will do) to fill the glass. The object is to get about 50 mL of water chilled to close to 0°C.

3. Get approximately 50 g of coins (10 US quarters are ideal). If you are using gold or silver coins you will need at least 150 g of coins. Record the mass of the coins.

4. Half fill a small saucepan with water and add the coins to the water.

5. Heat the coins on a stove monitoring the water temperature until it reaches 60°C. Then turn off the heat and take the saucepan off the source of heat.

6. Go back to the ice-water cup. Stir the ice-water and measure the temperature of the water. If the temperature is 5°C or lower, pour the cold water without the ice into the 150-mL beaker using its graduations to get approximately 50 mL of cold water.

7. Immediately pour the cold water into the calorimeter and find the mass of the calorimeter and cold water.

8. Carefully measure the temperature of the water, T_{1water}, to the nearest 0.1°C.

9. Then go to the saucepan and measure the temperature of the water, which is also the temperature of the coins, $T_{1\ coins.}$

10. Using the strainer, quickly strain the coins from the water, shaking to minimize the amount of water on the coins, and add the hot coins to the cold water in the calorimeter. Take care not to splatter water out of the calorimeter.

11. Stir and monitor the temperature. Record the highest stable temperature as the final temperature of both the water, T_{2water}, and coins, T_{2coins}.

12. Use the data to calculate the specific heat of the metal alloy in the coins.

Element	Specific heat J/g°C
Gold	0.125
Tin	0.215
Silver	0.233
Iron	0.460
Aluminum	0.91
Cu-Ni mix	0.39

AP L07	Specific Heat of an Alloy	Unambiguous Date

Purpose: To experimentally find the specific heat of an alloy

Equipment:

- *Strainer*
- *Saucepan*
- *Stove*
- *Balance*
- *Thermometer*
- *Styrofoam Calorimeter (or nested paper coffee cups)*
- *9.5 oz plastic cup*
- *150-mL graduated polypropylene beaker*

I 1/3 filled the plastic cup and then filled the cup with cold water to cool the water down to close to 0°C.
I found the mass of my empty Styrofoam calorimeter and the mass of 10 US quarters.
I then half-filled the saucepan with water and added the coins to the pan and started heating the pan, coins, and water on an electric stovetop burner at medium-high.
When the water and coins reached about 60°C, I turned off the heat and set the saucepan to the side.
I poured the cold water from the cup, taking care that no ice was transferred, into the 150-ml graduated beaker, to get an estimated 50 mL of cold water.
Then I poured the cold water into the calorimeter and measured the mass of the calorimeter-cold water.
I then measured the temperature of the cold water to the nearest 0.1°C.
Next, I measured the temperature of the hot water and coins to the nearest 0.1°C.
I poured the coins and water through a strainer, catching all the coins and shaking them so that there was almost no water remaining on the coins.
I then transferred the coins into the calorimeter. This was done quickly so that the coins had little time to cool.
I stirred the water-coins in the calorimeter and measured the final stable temperature.

Data:

(a) mass of empty calorimeter	49.61 g
(b) m_{coins} mass of 10 US quarters	58.65 g
(c) mass of calorimeter and approx. 50 mL cold water	105.16 g
(d) $T_{1\text{-}water}$ temperature of cold water	2.2°C
(e) $T_{1\text{-}coins}$ temperature of heated coins	57.8°C
(f) $T_{2\text{-}water\ and\ coins}$ temperature of water and coins after mixing	8.8°C

Calculations:

m_{water} = (c) – (a)	55.55 g
$\Delta T_{water} = T_{2\text{-}water} - T_{1\text{-}water}$	+6.6°C
c_{water} specific heat of water	4.18 J/g°C
$q_{water} = m_{water}\, c_{water} \times \Delta T_{water}$ heat change of water	1530 J
$q_{coins} = -\, q_{water}$ (assuming no heat loss to surroundings)	-1530 J
$\Delta T_{coins} = T_{2\text{-}coins} - T_{1\text{-}coins}$	-49.0°C
c_{coins} using $q_{coins} = m_{coins}\, c_{coins} \times \Delta T_{coins}$	0.53 J/g°C

The coins were primarily copper with a specific heat of 0.39 J/g°C. My value 0.53 J/g°C was a bit high, which meant that the final temperature of the water was higher than would be expected. That could be because the coins were wet, and the hot water on the coins would have heated the water in addition to the heat from the metal. Also, since the room temperature was warmer than the water in the calorimeter and the calorimeter was not a perfect insulator, heat from the room could also have warmed the water.