Specific Heat

Equipment

Qty	Items	Parts Number
1	Calorimeter, Styrofoam	TD-8557A
1	Thermometer	
1	Beaker	
1	Heating pad	
1	Mass Balance	
3	Metal Samples	
1	Syringe	SE-7562
3	sting	

Theory

When two systems or objects of different temperatures come into contact, energy in the form of heat is transferred from the warmer system into the cooler. This transfer of thermal energy raises the temperature of the cooler system, and lowers the temperature of the warmer system. Eventually the two systems reach some common, intermediate temperature, and the thermal energy transfer stops. At which time it is said the two systems are in thermal equilibrium with each other.

The standard unit for measuring heat transfer is the calorie. A calorie is defined as the amount of energy required to raise the temperature of one gram of water from 14.5^oC to 15.5^oC. However, for our purposes, we can generalize this definition by simply saying that a calorie is the amount of energy required to raise the temperature of one gram of water one degree Celsius due to the fact that the real variation in energy required changes very slightly with the temperature. (Please note that the calorie we are discussing is not the calorie listed on food packaging. Those are technically called ‘food calories’, but are just called ‘calories’ for short. Food calories are equal to a *1000* calories as we have defined them. Yes, it can be confusing at times.)

The Specific Heat of a substance, usually indicated by the symbol c, is the amount of thermal energy required to raise the temperature of one gram of the substance by 1^oC (or *1K*). From the definition of the calorie given, it can be seen that the specific heat of water is $1\,\frac{cal}{gK}$. If an object is made of a substance with specific heat equal to *c*, then the thermal energy, *Q*, required to raise the temperature of that object by an amount ΔT is:

$$Q = mc\Delta T \qquad \text{eq (1)}$$

A calorimeter is a vessel, or a device that thermally isolates an experiment from its surroundings. By thermally isolating the experiment from the external surroundings, one can apply the Conservation of Energy to the experiment. Particularly that the thermal energy contained by the material inside the calorimeter is conserved. Ideally, this means that the results of an experiment performed in a calorimeter are independent of the temperature of the surroundings, because no heat flows into or out of the calorimeter. Which means that the thermal energy that flows into the cooler object in the calorimeter, Q_C, is equal to the negative of the thermal energy that flowed out of the hotter object in the calorimeter Q_H.

$$Q_C = -Q_H \qquad \text{eq(2)}$$

Experiment

Note: Under no circumstance do you use the thermometers to take the temperature of the boiling water. Doing so will break the thermometers. We know that water boils at 100^o C, so there is no need to measure the temperature of boiling water because we already know it is 100^0 C.

1. Measure the masses of the aluminum, copper, and tungsten, M_s, samples, and then record them in table 2.
2. If there is not a string already attached, then tie a long piece of string to each of the metal samples.
3. Fill up a glass beaker about half way with water, turn on the heating pad, place the beaker on the heating pad. Carefully place the metal samples in the water. No need to wait for the water to be boiling before doing so. Make sure the attached strings are hanging over the sides of the beaker so you can pull the metal samples out of the water when the time comes to do so. While waiting for the water to boil, complete steps 4 through 7.
4. **Since water boils at *100^{o}C* record T_H as 100^{o}C in Table 1.**
5. Measure the mass of the empty dry calorimeter, with its lid, $M_{cal,}$ and record the mass in Table 1. If it's not dry, get a paper towel and dry it off before measuring its mass.
6. Then fill your calorimeter up about half way with cold water, then measure the combined mass of your calorimeter and the water, M_{cal+W}, and record in table 1.
7. Then put the cover on the calorimeter, insert the thermometer through the hole in the lid. Wait a couple of minutes, then record the water's initial temperature, T_w, in table 1.
8. Wait for at least about five minutes after your water starts to boil, then using the string, pull one of the metal samples out of the boiling water. Using a paper towel, quickly dry the sample off and put the sample into the cold water in your calorimeter. Then put the lid back on the calorimeter and reinsert the thermometer.
9. Watch the thermometer's temperature reading. When it stops moving, record the temperature, T, in table 1. We will assume our sample was first in thermal equilibrium with the boiling water, so record its initial temperature, T_s, to be *100^{o}C*.

10. Next cool down the thermometer by running it under cool water for a minute. Then repeat steps for the other two samples.
11. Look up the Specific Heats, C_s, of the three sample metals and record them in table 1.

Analysis of Specific Heat Lab

Name____ Group#________

Course/Section____

Instructor____

Table 1 (20 points)

		Aluminum	*Copper*	*Tungsten*
M_{cal}				
$M_{cal + W}$				
M_w				
T_w				
T_s				
T				
C_s				

Calculations

Using the values in Table 1 make the necessary calculations to determine the following: the mass of the water, M_w, the temperature change of the water, ΔT_w, and the temperature change of the metal sample, ΔT_s. Enter all these values into Table 2. Show calculations in the space provide below. (20 points)

Table 2 (10 points)

		Aluminum	*Copper*	*Tungsten*
M_w				
M_s				
ΔT_w				
ΔT_s				

1. Combining eq(1) with eq(2) we see that;

$$\Delta Q_w = -\Delta Q_s$$

$$M_w C_w \Delta T_w = -M_s C_s \Delta T_s$$

Solving this for C_s gives;

$$C_s = -\frac{M_w C_w \Delta T_w}{M_s \Delta T_s} \qquad \text{eq(3)}$$

Now using eq(3) calculate your experimental values of the Specific Heat for each of the three metal samples. Show work in the space provided. (20 points)

2. For each sample calculate the % error between its accepted value of the Specific Heat, and your experimental value of its Specific Heat. Show work in the space provided. (10 Points)

3. State at least <u>two</u> possible 'physics' sources of our percent error (*do not include rounding errors, calculation errors, human errors or equipment malfunction*). (10 points)

4. Did our experiments confirm the theory? Explain your answer. (10 points)