

Specific Heats

1 Object

To determine the specific heats of various objects.

2 Apparatus

Balance, plastic cup, calorimeter, hot plate, pot, rubber stopper, thermometers, unknowns, water.

3 Theory

It is a fairly well-known fact that objects can absorb heat in varying amounts and at different rates. There are many physical characteristics that determine this. One such macroscopic quantity is the specific heat of an object.

For reasonable temperatures and temperature changes it is an empirical observation that this specific heat of an object depends only on the material to be found in the object. The accepted definition of the specific heat is

$$c = \frac{Q}{m\Delta T} \quad (1)$$

where c is the specific heat of the object in $cal/g^\circ C$, Q the amount of heat added or released, m the mass of the object in g , and ΔT is the change in temperature of the object in $^\circ C$. Thus, in essence, what the specific heat of an object does is to relate the change in temperature to the heat loss or gain for that particular object.

In this experiment a calorimeter is used in an attempt to produce an isolated system. It is hoped that by transferring the objects quickly and by using the double walled container that heat exchange with the environment will be minimal. In the calculations it is assumed that there is no heat loss and then one has

$$Q_{loss} = Q_{gain} \quad (2)$$

as an expression of the conservation of energy. More explicitly, this becomes:

$$m_1c_1\Delta T_1 = m_2c_2\Delta T_2 + m_3c_3\Delta T_3 + m_4c_4\Delta T_4 \quad (3)$$

where the subscripts refer to

1. the unknown
2. the cold water
3. the inner cup of the calorimeter
4. the stirrer

and m is the mass, c specific heat, and ΔT the *positive* temperature change of the appropriate objects; c_1 is the experimental unknown in this equation.

Below in the table are accepted values of specific heats for various materials.

Material	Specific heat ($cal/g^{\circ}C$)
Aluminum	.215
Copper	.0923
Lead	.031
Tin	.054
Zinc	.0927
Steel	.11
Brass	.094

4 Procedure

Record the mass of the three unknowns and room temperature. Record the mass and specific heat of the inner cup of the calorimeter. Record the mass and the specific heat of the stirrer. Fill the pot approximately 3/4 full of water and put it on the hot plate and heat it. For the induction hot plates, press the “Max” button to heat at 1800 Watts. The display will show 1800 at this power setting. Place the unknowns in the pot.

While the water heats up, fill the inner cup of the calorimeter with water about 1/2 to 2/3 full and weigh the cup and water. The temperature of this water should be about $4^{\circ}C$ below room temperature.

Now prepare to move an unknown from the pot to calorimeter by doing the following: after the hot water is boiling rapidly, turn the hot plate down to 1000 watts (or less). Then, place a thermometer into the water and wait until the temperature of the pot, hot water, and unknowns has stabilized. This should only take a minute or two and should result in a temperature near $98^{\circ}C$. Once the boiling water’s temperature is stable, record it along with the temperature of the calorimeter; then immediately move your chosen unknown into the calorimeter. Record the temperature of this water just before the unknown is put into it.

Immediately after the unknown is dumped into the calorimeter, cover it and record the highest temperature reached by the contents (unknown, calorimeter, and cold water).

Repeat this process three times and then change the unknown and obtain four different readings for it. Obtain four similar results for a third unknown, but in this case for each trial use four fairly different temperatures for the unknown and hot water.

In all parts of this experiment the calorimeter should be as tightly sealed as possible so that little heat can be exchanged between it and the environment. Further, in all parts of this experiment, the temperature change of the calorimeter should be centered around room temperature. That is, if the calorimeter starts $4^{\circ}C$ below room temperature, after mixing its temperature should be somewhere in the neighborhood of $4^{\circ}C$ above room temperature. To do this you may have to adjust your starting temperature on subsequent trials for each unknown.

5 Calculations

Using equation 3, calculate the specific heat for each unknown, for each trial. Compare to the accepted values by using a mean and error. Do this for all of the unknowns.

6 Questions

1. How do specific heat and thermal conductivity differ?

2. If your values for specific heat are consistently too low, what is the most probable source of error?
3. Why is it preferable to have the changes in temperature be around room temperature?