Heat Capacity

Goal: To determine the composition of two unknown metal cylinder by determining the cylinder's specific heat capacity.

Equipment List:

Pasco steam generator
styrofoam "calorimeter"
2 metal cylinders (one at a time)
thermometer (two if desired)
paper towels for cleaning up
beaker
triple beam balance
string

Background:
Conservation of energy is an extremely important aspect of physics and it may be demonstrated in many different ways. This laboratory uses the concept of conservation of heat energy along with specific heat capacity in order to determine the type of metal of which a cylinder is composed.

Procedure:

- Fill the steam generator about 2/3 full and turn it on to warm it up. Start with the setting at 7, which should heat the water to a temperature around 90^{o} C.
- Measure the cylinder and record this in a data table as m_{cyl}.
- Measure the mass of the styrofoam cup.
- Measure the mass of approximately 100 - 200 mL of water (enough to cover the cylinder - smaller amount yeilds higher temperature rise) of water in the styrofoam cup calorimeter. Record the initial temperature To (cal) of the calorimeter water.

- Using the string (securely tied to the cylinder to keep the cylinder off of the bottom of the steam generator), immerse the cylinder into the water bath in the steam generator. Use the chopstick to stir the water and get the bath temperature uniform. Let the cylinder sit in the water for approximately 5 – 6 minutes, then record the temperature of the water bath. Take care not to let the thermometer touch the bottom of the steam generator as the temperature of the bottom of the generator is the top of the heater element and not necessarily the best measurement of the bath temperature.This temperature will also be the temperature of the metal cylinder T_0 (cyl).
- Carefully remove the cylinder from the water bath and quickly immerse it into the calorimeter water.
- Monitor the temperature of the calorimeter. After a very short time (monitor constantly for several minutes), you will observe that the temperature has risen. Record the highest temperature attained by the calorimeter water. This final calorimeter temperature T_f (cal) is also the final temperature of the metal cylinder T_f (cyl). Also record the difference between the final temperature and the initial temperature of both the metal cylinder and the calorimeter water.
- Trade cylinders with another group and repeat the experiment using a different material.

Analysis:

Assuming that all of the heat acquired by the metal cylinder while in the water bath was effectively transferred to the calorimeter water and the aluminum cup, it is now possible to calculate the specific heat of the metal cylinder.

$$\Delta Q \text{ of the calorimeter water and cup} = \Delta Q \text{ of the metal cylinder} \qquad (1)$$

or

Heat gained by the calorimeter water and cup is equal to the heat lost by the cylinder.

Since

$$\Delta Q = mc\Delta T \qquad (2)$$

$$m_w c_w \Delta T_w = m_{cyl} c_{cyl} \Delta T_{cyl} \qquad (3)$$

Then, manipulate the above equation to solve for the Specific Heat of the cylinder:

$$c_{cyl} = \frac{m(w)c(w)\,\Delta T\,(w)}{m_{cyl}\Delta T_{cyl}} \qquad (4)$$

Determine the composition of your two cylinders by determining the specific heat capacity. Use error propagation to determine if your result is within uncertainty of the accepted values:

$c_w = 1$ cal/g C^o = 1kcal/kg C^o

$c_{al} = 0.215$ kcal/kg C^o

$c_{cu} = 0.0923$ kcal/kg C^o

$c_{pb} = 0.0305$ kcal/kg C^o

$c_{zn} = 0.0925$ kcal/kg C^o

$c_{sn} = 0.0540$ kcal/kg C^o

Conclusion: Review your results.