Name **Section #**

Heat Exchange and Specific Heat

Introduction

You may have noticed while walking barefoot from a carpet to the tiles of your bathroom that the tiles seems to be much colder than the carpet when, in truth, they are both at the same temperature. When different substances are in thermal contact their final temperature at equilibrium will depend upon their original temperature difference, their masses, and the very nature of the substances themselves which we shall define as their specific heats. (A substance's specific heat is related to its conductivity.) You will immerse a metal at high temperature into cold water and, by examining the heat exchanged between them, determine the metal's specific heats.

Theory

The amount of heat ΔQ exchanged by a substance of mass m with its environment is $\Delta Q = m\,c\,\Delta T$ where c is its specific heat and $\Delta T\ (= T_f - T_i)$ is its temperature change. If $\Delta T > 0$ then $\Delta Q > 0$ and the substance will have gained heat. Heat will have been lost if $\Delta T < 0$.

A pot of boiling water containing samples of different metals will be situated at the front of the room. You will take one of these samples (mass m_m) and immerse it into cold water (of mass m_w) and then determine their individual temperature changes ΔT_w and ΔT_m. Because of conservation of energy $\Delta Q_w + \Delta Q_m = 0$. The heat gained by the metal is negative, having lost heat in cooling down, $\Delta T_m < 0$. Hence $m_w c_w \Delta T_w + m_m c_m \Delta T_m = 0$. From which $c_m = -\dfrac{m_w c_w \Delta T_w}{m_m \Delta T_m}$,

but for water, $c_w = 4.19 \dfrac{\text{kJ}}{\text{kg}\,^\circ\text{C}}$. Therefore the metal's specific heat

can be calculated as being $c_m = \left(-4.19 \dfrac{\text{kJ}}{\text{kg}^\circ\text{C}}\right)\dfrac{m_w \Delta T_w}{m_m \Delta T_m}$.

Procedure

- Determine the mass of an empty Styrofoam cup then pour in cold water until the cup is ¾ full, remeasure the mass and subtract the mass of the cup. Enter your result in kilograms in the table below under the column marked m_W (for the water's mass.) For example, a number such as 290 g should be entered as 0.290 kg. Carefully measure the water's original temperature T_{i_w} and enter it in the appropriate column.
- Remove one of the metal samples from the pot and transfer it to your cup of cold water. Do this quickly to minimize heat transfer from the metal to the room. For the metal's initial temperature T_{i_m} , note the pot's temperature. If the water in the pot is boiling, you can assume that the metal's initial temperature was 100°C. Stir the contents of your cup with the thermometer until the temperature has reached a maximum. This will be the final temperature T_f of both the metal and the water. (It is a good idea to cover the cup with a piece of paper to minimize heat exchange with the room. Punch a hole

through the paper for the thermometer.) Measure the mass of your sample *after* you determined the final temperature. Record all your measurements in the table below.

- Repeat the above procedure for four additional samples and record your data in the table below. Use fresh cold water and different metals for each case. Try to identify the metal tested by comparing your experimental value for its specific heat with those listed in the *Reference Table for Physics* under the table labeled *Heat Constants*.

m_w (kg)	m_m (kg)	T_{i_w} (°C)	T_{i_m} (°C)	T_f (°C)	ΔT_w (°C)	ΔT_m (°C)	c_m $\left(\frac{\text{kj}}{\text{kg°C}}\right)$	Metal's Identity

Questions

Did each metal sample transfer an equal amount of heat to your cold water? Support your answer from your data.

Which substance has a higher specific heat–beach sand or ocean water? Justify your answer.

List factors which might have caused errors in your determination of each sample's specific heat. For each factor, state whether the error caused your values to be too large or too small.

Why is it important that fresh cold water be used for each new trial?