# Specific heat of solids

## Motivation and Aim

The change in temperature ($\Delta T$) of a material when supplied with a certain (fixed) amount of heat ($\Delta Q$) depends on the type of material and is inversely proportional to the the mass $m$ of the material. The material dependence is given the quantity called the specific heat $c$ of the substance. The interdependence of these quantities is summarised by the equation

$$\Delta Q = cm\Delta T$$

To measure the specific of a substance we supply a fixed amount of heat and measure the rise in its temperature.

## Apparatus

1. Dewar
2. Thermometers
3. Weighing Balance
4. Shots of various materials
5. Steam Generator

## Procedure

Measure the mass of the shots of each material. Place as many shots of a given material into the steam chamber and leave them there long enough for them to come to equilibrium with steam temperature (20 min). Then drop the shots (which are now at 100 °C) into the transfer mesh and insert them in the Dewar that has about 180 g water at room temperature. Keep the Dewar closed. Thoroughly mix the water and observe the maximum rise in temperature of the water. Repeat with shots of different materials and measure the temperature change in each case.

## Theory

The amount of heat required to raise the temperature of a unit mass of a substance by 1 degree is called the specific heat of the substance. The SI unit of specific heat is [J/kg/K]. The specific heat of water is among the highest of all substances. Historically the specific heat of water is arbitrarily set as 1 cal/g/ °C. The equivalent SI value is 4184 J/kg/K. A related quantity is the molar specific heat, which is the specific heat for 1 mol of a substance. Metals have very low specific heats, in comparison. At room temperature the molar heat capacity of all crystalline solids is more or less the same. This is because the vibrational energy levels in a solid are more or less similar and the main contribution to the specific heats are from vibrations of the atoms in a solid. Exceptions to this are for instance diamond, which has extremely low specific heat.

## Analysis

Heat lost by the shots is

$$\Delta Q_s = c_s m_s(\theta_s - \theta_m)$$

where $\theta_s$ is the initial temperature of the shots, $\theta_m$ is the final temperature of the mixture of water and shots.

Heat gained by the water is

$$\Delta Q_w = c_w m_w(\theta_w - \theta_m),$$

assuming that no heat is absorbed by the flask. However, this is not correct, and we make a correction by replacing $m_w$ by $m_w + m_f$, where $m_f$ is the equivalent mass of water that would have absorbed the same amount of heat as the flask. Since $Q_1 = Q_2$, and $c_w = 1$, we have

$$c_s = \frac{(m_w + m_f)(\theta_w - \theta_m)}{m_s(\theta_s - \theta_m)}$$

## Points to Ponder

1. How would you determine the water equivalent of the Dewar, if it were not given to you?