# Experiment 5

# Determining the Specific Heat Capacity of Solids

## 1- Objects of the experiments

- Mixing cold water with heated copper, lead or glass shot and measuring the mixture temperature.
- Determining the specific heat capacity of copper, lead and glass.

## 2- Principles

The heat quantity $Q$ that is absorbed or evolved when a body is heated or cooled is proportional to the change of temperature $\Delta T$ and to the mass *m*:

$$Q = c\, m\, \Delta T \qquad (1)$$

The factor of proportionality *c*, the specific heat capacity of the body, is a quantity that depends on the material.

In this experiment, the specific heat capacities of different substances, which are available as shot, are determined. In each case the shot is weighed, heated with steam to the temperature $T_1$ and then poured into a quantity of water that has been weighed out and that has the temperature $T_2$. After the mixture has been carefully stirred, the pellets and the water reach the common temperature $T_M$ through heat exchange.

The heat quantity evolved by the shot

$$Q_1 = c_1\, m_1 \left(T_M - T_1\right) \qquad (2)$$

where $m_1$: mass of the shot,

$c_1$: specific heat capacity of the shot,

$T_1$: temperature of the shot ($T_1 = 373.15K$)

The heat quantity absorbed by the water

$$Q_2 = c_2 m_2 (T_M - T_2) \qquad (3)$$

where $m_2$: mass of the water

$c_2$: The specific heat capacity of water ($c_2 = 4.19kJ \cdot K^{-1} \cdot kg$)

The calorimeter vessel too absorbs part of the heat evolved by the shot. Therefore, the heat capacity

$$C_K = c_2 m_K \qquad (4)$$

Where

$m_k$: water equivalent of the calorimeter vessel ($m_k = 23g$)

The absorbed heat quantity calculated in Eq. (3) is thus more precisely

$$Q_2' = c_2 (m_2 + m_K)(T_M - T_2) \qquad (5)$$

The unknown quantity $c_1$ can therefore be calculated from the measured quantities $T_2$, $T_M$, $m_1$ and $m_2$:

$$-Q_1 = Q_2' \quad \Rightarrow \quad c_1 = c_2 \frac{(m_2 + m_K)(T_M - T_2)}{m_1 (T_1 - T_M)} \qquad (6)$$

**3- List of Equipments**

| | Catalogue Number |
|---|---|
| 1 Dewar vessel | 386 48 |
| 1 cover for Dewar vessel | 384 161 |
| 1 copper shot, 200 g | 384 35 |
| 1 glass shot, 100 g | 348 36 |

| | |
|---|---|
| 1 lead shot, 200 g | 315 76 |
| 1 Balance | 315 23 |
| 1 thermometer –10°C to +110°C | 382 34 |
| 1 steam generator, 550 W / 220 V | 303 281 |
| 1 heating apparatus | 384 34 |
| 1 beaker, 400 ml | 664 104 |
| 1 stand base, V-shape, 20 cm | 300 02 |
| 1 stand rod, 47 cm | 300 42 |
| 1 multiclamp | 301 01 |
| 1 universal clamp, 0 … 80 mm dia. | 666 555 |
| 1 silicone tubing int. dia. 7 × 1.5 mm, 1 m | 667 194 |

## 4- Setup and carrying out the experiment

The experimental setup is illustrated in Fig. 1.

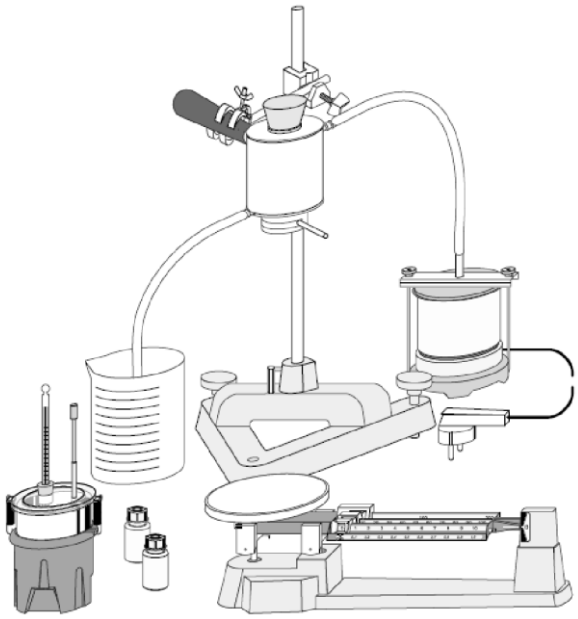

**Figure 1**. Experimental setup for determining the specific heat capacity of solids.

- Mount the heating apparatus in the stand material.
- Fill water into the steam generator, close the device cautiously, and connect it to the top hose connection of the heating apparatus (steam inlet) with silicone tubing.
- Attach silicone tubing to the bottom hose connection of the heating apparatus (steam outlet), and hang the other end in the beaker. See to it that the silicone tubings are securely seated at all connections.
- Fill the sample chamber of the heating apparatus as completely as possible with lead shot, and seal it with the stopper.
- Connect the steam generator to the mains, and heat the shot for about 20-25 minutes in the heating apparatus flowed through by steam.

In the meantime:
- Determine the mass of the empty Dewar vessel, and fill in about 180 g of water.
- Mount the cover for the Dewar vessel and insert the thermometer.
- Measure the temperature $T_2$ of the water.
- Open the cover of the Dewar vessel and shift it aside; leave the mesh for samples of the cover in the Dewar vessel.

- Drop the shot with the temperature of 100ºC into the mesh for samples, close the cover, and thoroughly mix the water with the shot.
- Read the mixture temperature when the temperature of the water stops rising.
- Determine the additional mass *m* of the shot.
- Repeat the experiment with copper and glass shot.

Mass of the water: $m_2$ = 180g

Temperature of the shot: $T_1 = 373{,}15K$

- Complete the following table.

| Substance | $m_1$ (kg) | $T_2$ (K) | $T_M$ (K) |
|---|---|---|---|
| Lead | 0.070 | | |
| Copper | 0.070 | | |
| Glass | 0.020 | | |

Water equivalent of the calorimeter: $m_K$ = 23g

specific heat capacity of water: $c_2 = 4.19\ kJ/K.kg$

- Determine the specific heat capacities by using Eq. (6).

| Substance | c (*kJ/K.kg*) | c (*kJ/K.kg*) |
|---|---|---|
| | experiment | literature |
| Lead | | 0.1295 |
| Copper | | 0.385 |
| Glass | | 0.746 |

- Compare the specific heat capacities determined experimentally and the corresponding values quoted in the literature.

- Conclusion.