3B SCIENTIFIC® PHYSICS

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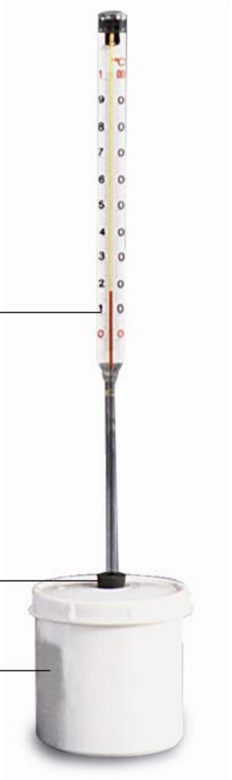
Calorimeter – 200 ml 1000823

Instruction Sheet

10/15 SP/ALF



1 Thermometer (not included)
2 Opening for the thermometer
3 Container

1. Safety instructions

Experiments are conducted with hot liquid. Caution: danger of burns and scalding!

- In schools and educational institutions, operation of the apparatus must always be supervised by qualified personnel.
- Set up the experiment on an even surface.
- Take extreme care while emptying the calorimeter of its contents after conducting the experiment.

2. Description

The calorimeter is used to determine the specific heat capacity, latent heat of substances, mixing temperatures as well as the specific latent heat of fusion of ice. The calorimeter consists of a double-walled plastic container with a polystyrene insert.

3. Technical data

Contents of insulated container:	200 ml
Weight:	80 g approx.

4. Sample experiments

Recommended apparatus:

1 Tube thermometer	1003526
Aluminium shot, 100 g	1000832
Copper shot, 200 g	1000833
Glass shot, 100 g	1000834

4.1 Heat capacity of calorimeter

- First measure the temperature of 500 ml cold water, then pour it into the calorimeter.
- Pour 90 ml of warm water at a temperature of approx. 60°C into the calorimeter. Cover the calorimeter with the lid. Cover the calorimeter with the lid. Insert the thermometer into the opening provided. Carefully stir the contents and measure the resulting temperature.
- Pour 90 ml warm water with a temperature of approx. 60°C into the calorimeter. Insert the thermometer into the opening provided. Carefully stir the contents and measure the resulting mixing temperature.
- Read the temperature for approx. 5 minutes and wait till the temperature of the mixture remains constant.

If the heat capacity of the calorimeter C_K is not known, it can be determined in the form of the water equivalent:

$$W = C_K = m_K \cdot c_K$$

The water equivalent W is not a constant for the apparatus. It depends on the liquid level of the calorimeter. The calorimeter is filled with hot water, the temperature ϑ_1 and mass m_1 of which are known values. Subsequently, cold water with mass m_2 and temperature ϑ_2 is poured into the calorimeter. After a certain period, the mixture attains a temperature ϑ_m. The amount of heat lost by the hot water and the calorimeter can be determined by the following equation:

$$Q_1 = (c_W \cdot m_1 + W) \cdot (\vartheta_1 - \vartheta_m)$$

The amount of heat absorbed by the cold water can be determined by the equation:

$$Q_2 = c_W \cdot m_2 \cdot (\vartheta_m - \vartheta_2)$$

Due to conservation of energy, the amount of heat released Q_1 should be equal to the amount of heat absorbed Q_2.

The heat capacity of the calorimeter is determined from the equation:

$$C_K = \frac{c_W [m_2 \cdot (\vartheta_m - \vartheta_2) - m_1(\vartheta_1 - \vartheta_m)}{(\vartheta_1 - \vartheta_m)}$$

4.2 Specific heat capacity of solids

- Pour 190 ml cold water into the calorimeter and measure its temperature.
- Heat up the solid in boiling water then suspend the solid in the calorimeter and cover the calorimeter with the lid. Measure the resulting temperature.

In the interior of the calorimeter, there is a liquid of known mass m_1, temperature ϑ_1 and specific heat capacity c_1 (water). The solid body being investigated in the experiment has a known mass m_2 and temperature ϑ_2 and is then introduced into the calorimeter. The solid body should be at a higher temperature than the liquid in the calorimeter (so that $\vartheta_2 > \vartheta_1$). The hotter solid loses an amount of heat determined by the following equation:

$$Q_2 = m_2 \cdot c_2 \cdot (\vartheta_2 - \vartheta_m)$$

The heat absorbed by the water in the calorimeter is determined by the equation:

$$Q_1 = m_1 \cdot c_W \cdot (\vartheta_m - \vartheta_1)$$

In equating the energies, the heat capacity C_K of the calorimeter should also be taken into account since the temperature of the container also changes during the process. The heat absorbed by the calorimeter is determined by the equation:

$$Q_K = C_K \cdot (\vartheta_m - \vartheta_1)$$

Specific heat capacity of water: $4{,}182 \frac{\text{kJ}}{\text{kg} \cdot \text{K}}$

4.3 Specific latent heat of fusion of ice

- Pour 190 ml water into the calorimeter and measure its temperature (The temperature can also be room temperature).
- Introduce ice of a known mass into the calorimeter. The temperature of the ice will be 0°C. The mass should have been determined previously.
- Cover the calorimeter with the lid. Measure the temperature for approx. 5 minutes.

In order to determine the specific latent heat of fusion of ice q, ice cubes with a melting point ϑ_S (0°C) and total mass m_E are melted in a calorimeter with specific heat C_K, filled with water of mass m_W and specific heat capacity c_W. The temperature should be measured throughout the entire process. The temperature inside the calorimeter is ϑ_1 and the temperature after the ice has melted is ϑ_m.

Since the calorimeter is a closed system, the following holds true:

$$Q_2 + Q_1 = 0$$

The specific latent heat of fusion of ice can therefore be determined by using the following equation:

$$q = \frac{(C_K + m_W \cdot c_W) \cdot (\vartheta_1 - \vartheta_m)}{m_E} - c_W \cdot (\vartheta_m - \vartheta_S)$$