OPERATING INSTRUCTIONS

AND SUGGESTED ACTIVITIES

DOUBLE-WALL CALORIMETER

CLRM01

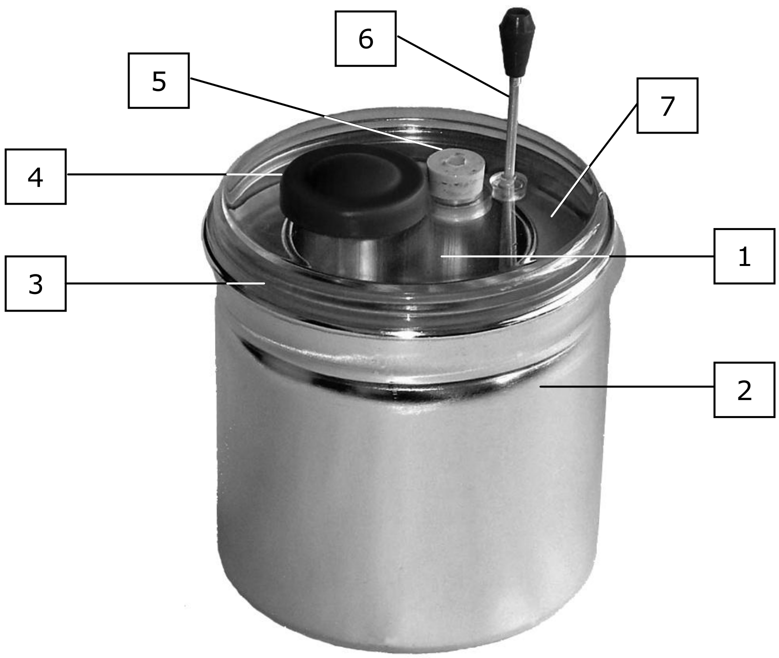

Figure 1

DESCRIPTION

Double-Wall Calorimeter CLRM01 is designed for students to investigate heat transfer, thermal equilibrium and phase transitions in the temperature range 0°C to 100°C. Popular experiments include determining the specific heat of various metals, the latent heat of fusion of ice, and the latent heat of vaporization of water.

PARTS OF THE CALORIMETER (See *Figure 1*)

1. Inner can – aluminum, 60 mm diameter, 65 mm high, useable capacity: 150 ml
2. Outer can – aluminum, 100 mm diameter
3. Clear molded plastic lid
4. Plastic filler cap
5. One-hole rubber stopper for thermometer
6. Aluminum stirrer
7. Inner can insulation – Styrofoam, with hard plastic inner can support ring

BACKGROUND

The calorimeter is an insulated volume that is sufficiently isolated from the external environment to allow heat exchange measurements to be made without having to consider heat exchange with the surroundings, which is difficult to measure. The metal inner can and stirrer ensure that the temperature of a measured quantity of water placed in the can may be kept uniform. Heat gained or lost by the inner can and stirrer when an object at a different temperature is added must be taken into account in measurements. Similarly heat gained or lost by a thermometer affects the measurement, but is small and often ignored. Alternatively, a preliminary experiment to determine the combined heat capacity of the inner can, stirrer, and thermometer may be carried out. To minimize errors caused by excessive evaporation of water which re-condenses on the lid and is not measured, it is advantageous to limit the expected temperature change in an experiment to about 10°C or less, provided that the resolution of the thermometer or temperature probe is adequate to give the required precision in the result.

Determining the Specific Heat of a Metal

The Specific Heat of a material, c, is the amount of heat energy absorbed or given up by the substance, ΔQ, per unit mass for one degree of temperature change. If a mass m of the substance is changed in temperature by ΔT, then

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

In the experiment to determine the specific heat of a metal, a known mass of the metal at a known high temperature is mixed with a known mass of water contained in a calorimeter at a known lower temperature. As the metal and water come to a single final temperature, the amount of heat lost by the metal is equal to the amount of heat gained by the water and calorimeter:

$$c_m.m_m.(T_{mi} - T_f) = c_w.m_w.(T_f - T_{wi}) + c_c.m_c.(T_f - T_{wi}) \qquad (2)$$

Where:
- c_m is the specific heat of the metal
- c_w is the specific heat of water (1.00cal/g/°C)
- c_c is the specific heat of the inner can and stirrer (aluminum, 0.217cal/g/°C)
- m_m is the mass of the metal
- m_w is the mass of water
- m_c is the combined mass of the inner can and stirrer
- T_f is the final temperature of the mixture
- T_{mi} is the initial temperature of the metal
- T_{wi} is the initial temperature of the water

By rearranging equation (2), we obtain an equation for the specific heat of the metal:

$$c_m = [(c_w.m_w + c_c.m_c)(T_f - T_{wi})]/[m_m\ (T_{mi} - T_f)] \qquad (3)$$

If a preliminary experiment is performed where hot and cold water are mixed in the calorimeter, a measured value for $c_c.m_c$ can be found, and this value can also include any thermometer contribution. This number is sometimes called the *calorimeter constant*.
If the calorimeter starts at a temperature T_{w1} with a mass of water m_{w1} and a mass m_{w2} of water at a higher temperature T_{w2} is added, resulting in a final combined temperature T_f, then the heat balance equation becomes: