TAP 607- 3: Measurement of specific heat capacities

There are several simple methods for measuring the specific heat capacities of both solids and liquids, such as the method of mixtures, but we will consider here only electrical methods. Since the specific heat capacity varies with temperature, we have seen it is important to record the mean temperature at which the measurement is made.

Electrical calorimeters

Figure 1(a) and 1(b) show possible arrangements for electrical calorimeters for a solid and a liquid specimen.

solid block

lagging

immersion heater

thermometer

immersion heater

thermometer

calorimeter

stirrer

shield

lid

Figure 1(a)

Figure 1(b)

The material under investigation is heated by an electrical immersion heater and the input energy (Q) and the rise in temperature that this produces are measured. If the mass of the specimen (solid or liquid) is m and its specific heat capacity C, then:

Q = m C (1 - o) + q

where θ0 and θ1 are the initial and final temperatures of the specimen and q is the heat loss. Using the cooling correction, the value of q may be found. This simple method can be used for liquids or solids, although in the case of a liquid, allowance has to be made for the thermal capacity of the container, and the liquid should also be stirred to allow an even distribution of the heat energy throughout its volume. This is necessary since liquids are such poor thermal conductors.

The continuous-flow calorimeter

This was first developed by Callender and Barnes in 1902 for the measurement of the specific heat capacity of a liquid, and is shown in diagram below. Its main advantage is that the thermal capacity of the apparatus itself need not be known.

Continuous-flow calorimeter

**V**

V

## A

platinum resistance thermometer

liquid in

liquid out

platinum resistance thermometer

heater

Liquid flows in from a constant-head apparatus at a constant rate past a thermometer (θ 0). It then flows around the heater coil and out past a second thermometer where the outlet temperature (θ1) may be measured. When steady-state conditions have been reached (a temperature difference between inlet and outlet points of 50C is reasonable) the temperatures and the flow rate of the liquid (m) are measured. A vacuum jacket round the heater coil reduces heat losses.

The electrical energy supplied to the heater coil (E = V I t) may be found readily with a joulemeter or with an ammeter and voltmeter.

Two sets of measurements are carried out.

For a first experiment we have:

Electrical energy supplied (E1) = V1 I1 t1 = m1 C (θ1 – θ0) + q

C is the specific heat capacity of the liquid and q the heat loss to the surroundings and to the apparatus.

The flow rate and rate of energy input are now altered to give a second set of results. However, if the inlet and outlet temperatures are the same as in the first experiment the heat loss will also be the same. Therefore:

Electrical energy supplied (E2) = = V2 I2 t2 = m2 C (θ1 - θO) + q

Eliminating the heat loss (q) gives

Specific heat capacity of the liquid (C) = [E2 – E1]/ (m2 – m1)(1 – o)

Practical advice

A smaller amount of water could be heated in a polystyrene cup than in a calorimeter; this reduces the heating time needed and provides insulation. *The heater must be covered by the water*. The heat absorbed by the polystyrene is also small compared to that absorbed by the calorimeter. However take care that the heater does not touch the cup or it will melt. Thermometers can also overbalance the cup. Always stir liquids before taking a temperature.

It is better to choose an immersion heater that fits all the way into the solid material rather than having part of it in the air. The top of the block should also be lagged. Take the highest temperature reached by the block after the heater has been switched off.

External reference

This activity is taken from Resourceful Physics