6.5.3 Specific heat capacity

videos

Specific heat capacity (c) is defined as the energy required to raise the temperature of 1kg of a material by 1K (or 1°C).

$$c = \frac{\Delta E}{m\Delta T}$$

where ΔE=energy supplied, ΔT=change in temperature, m=mass of material

(1) Two litres of water (m=2kg) is heated for 2minutes using a 1000W heater. The temperature increases by 14°C. Assuming that the heating system is 100% efficient, work out the specific heat capacity of the water.

Using an electric heater

A common practical is to use an electric (immersion) heater to heat a material. The energy supplied can be determined from the power (P) of the heater and the time (t) it is switched on:

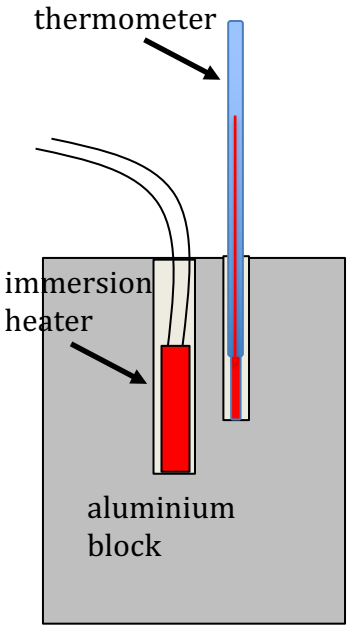
$$\Delta E = P\Delta t$$

The power is usually monitored by measuring the current (I) supplied to the heater and the potential difference (V) dropped across the heater:

$$P = IV$$

(2) Substitute for P in the first equation to get an expression for the energy supplied.

(3) Draw a circuit diagram to show the position of the voltmeter and ammeter. What device could be used to adjust the power supplied to the heater? Show this in your circuit diagram.



In the experiment, left, an immersion heater is inserted into a 1kg block of aluminium. A thermometer is inserted into an adjacent slot to monitor the temperature at different times after the heater has been switched on. The following results were obtained:

time (s)	potential difference (V)	current (A)	temperature (°C)
0	12.0	2.0	21.0
60	12.0	2.0	22.5
120	12.0	2.0	24.0
180	12.0	2.0	26.0
240	12.0	2.0	27.5
300	12.0	2.0	29.0

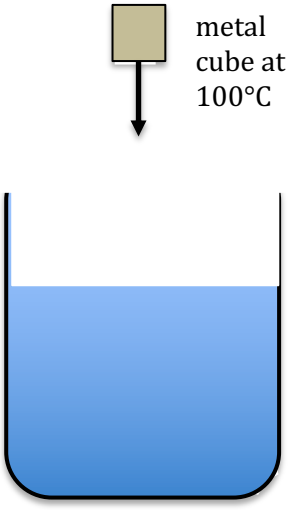
(4) From the data in the table, determine the specific heat capacity of aluminium.

(5) Why is the value obtained using this method likely to be an over estimate of the true value?

Method of mixtures

If we know the specific heat capacity of one material, we can use this to determine the specific heat capacity of a second material using the method of mixtures.

Consider the following experiment:



A metal cube, of known mass (m_m), is heated by placing it in boiling water. It is then transferred quickly to a beaker of water, of known mass (m_w) and initial temperature (T_i). The specific heat capacity of the water (c_w) is also known. There is a transfer of thermal energy from the metal block to the water, until they reach an equilibrium, final temperature (T_f). This final temperature is measured using a thermometer.

We can write:

$$heat\ energy\ supplied\ to\ water\ = heat\ energy\ lost\ by\ metal\ cube$$
$$m_w c_w\left(T_f - T_i\right) = m_m c_m (100 - T_f)$$

(where all temperatures are in °C)

(6) Rearrange the equation above to make c_m the subject.

(7) The method, above, was used for a 20g cube of iron. The temperature rise of 100g of water (start temperature = 21°C) was observed to be 2°C. The heat capacity of water is $4200 J kg^{-1} K^{-1}$. Determine the specific heat capacity of iron.