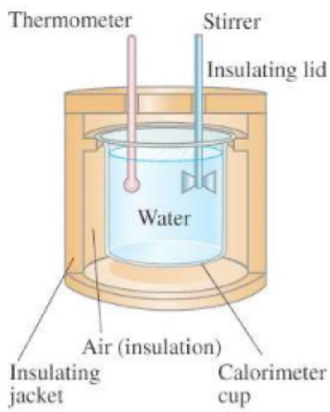

FIGURE 14–4 Simple water calorimeter.

exchange. To make such measurements, a **calorimeter** is used; a simple water calorimeter is shown in Fig. 14–4. It is very important that the calorimeter be well insulated so that almost no heat is exchanged with the surroundings. One important use of the calorimeter is in the determination of specific heats of substances. In the technique known as the "method of mixtures," a sample of a substance is heated to a high temperature, which is accurately measured, and then quickly placed in the cool water of the calorimeter. The heat lost by the sample will be gained by the water and the calorimeter cup. By measuring the final temperature of the mixture, the specific heat can be calculated, as illustrated in the following Example.

EXAMPLE 14–5 **Unknown specific heat determined by calorimetry.** An engineer wishes to determine the specific heat of a new metal alloy. A 0.150-kg sample of the alloy is heated to 540°C. It is then quickly placed in 400 g of water at 10.0°C, which is contained in a 200-g aluminum calorimeter cup. (We do not need to know the mass of the insulating jacket since we assume the air space between it and the cup insulates it well, so that its temperature does not change significantly.) The final temperature of the system is 30.5°C. Calculate the specific heat of the alloy.

APPROACH We apply conservation of energy to our system, which we take to be the alloy sample, the water, and the calorimeter cup. We assume this system is isolated, so the energy lost by the hot alloy equals the energy gained by the water and calorimeter cup.

SOLUTION The heat lost equals the heat gained:

$$\begin{pmatrix}\text{heat lost}\\ \text{by alloy}\end{pmatrix} = \begin{pmatrix}\text{heat gained}\\ \text{by water}\end{pmatrix} + \begin{pmatrix}\text{heat gained by}\\ \text{calorimeter cup}\end{pmatrix}$$

$$m_a c_a \,\Delta T_a = m_w c_w \,\Delta T_w + m_{cal} c_{cal} \,\Delta T_{cal}$$

where the subscripts a, w, and cal refer to the alloy, water, and calorimeter, respectively, and each $\Delta T > 0$. When we put in values and use Table 14–1, this equation becomes

$$\begin{aligned}(0.150\,\text{kg})(c_a)(540°\text{C} - 30.5°\text{C}) &= (0.40\,\text{kg})(4186\,\text{J/kg}\cdot\text{C}°)(30.5°\text{C} - 10.0°\text{C})\\ &\quad + (0.20\,\text{kg})(900\,\text{J/kg}\cdot\text{C}°)(30.5°\text{C} - 10.0°\text{C})\\ 76.4\,c_a &= (34{,}300 + 3700)\,\text{J/kg}\cdot\text{C}°\\ c_a &= 500\,\text{J/kg}\cdot\text{C}°.\end{aligned}$$

In making this calculation, we have ignored any heat transferred to the thermometer and the stirrer (which is used to quicken the heat transfer process and thus reduce heat loss to the outside). It can be taken into account by adding additional terms to the right side of the above equation and will result in a slight correction to the value of c_a (see Problem 14).

PROBLEM SOLVING
Be sure to consider all possible sources of energy transfer

In all Examples and Problems of this sort, be sure to include *all* objects that gain or lose heat (within reason). On the "heat loss" side here, it is only the hot metal alloy. On the "heat gain" side, it is both the water and the aluminum calorimeter cup. For simplicity, we have ignored very small masses, such as the thermometer and the stirrer, which will affect the energy balance only very slightly.

PHYSICS APPLIED
Measuring Calorie content

A **bomb calorimeter** is used to measure the thermal energy released when a substance burns. Important applications are the burning of foods to determine their Calorie content, and the burning of seeds and other substances to determine their "energy content," or heat of combustion. A carefully weighed sample of the substance, together with an excess amount of oxygen at high pressure, is placed in a sealed container (the "bomb"). The bomb is placed in the water of the calorimeter and a fine wire passing into the bomb is then heated briefly, which causes the mixture to ignite. The energy released in the burning process is gained by the water and the bomb.