part at lower temperature—that is, within the system. If the system is completely isolated, no energy is transferred into or out of it. So the *conservation of energy* again plays an important role for us: the heat lost by one part of the system is equal to the heat gained by the other part:

Energy conservation

$$\text{heat lost} = \text{heat gained}$$

or

$$\text{energy out of one part} = \text{energy into another part.}$$

These simple relations are very useful. Let us take an Example.

EXAMPLE 14–4 **The cup cools the tea.** If 200 cm^3 of tea at 95°C is poured into a 150-g glass cup initially at 25°C (Fig. 14–3), what will be the common final temperature T of the tea and cup when equilibrium is reached, assuming no heat flows to the surroundings?

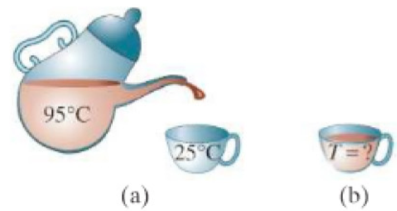

FIGURE 14–3 Example 14–4.

APPROACH We apply conservation of energy to our system of tea plus cup, which we are assuming is isolated: all of the heat that leaves the tea flows into the cup. We can use the specific heat equation, Eq. 14–2, to determine how the heat flow is related to the temperature changes.

SOLUTION Since tea is mainly water, its specific heat is 4186 J/kg·C° (Table 14–1), and its mass m is its density times its volume $(V = 200\,\text{cm}^3 = 200 \times 10^{-6}\,\text{m}^3)$: $m = \rho V = (1.0 \times 10^3\,\text{kg/m}^3)(200 \times 10^{-6}\,\text{m}^3) =$ 0.20 kg. We use Eq. 14–2, apply conservation of energy, and let T be the as yet unknown final temperature:

$$\text{heat lost by tea} = \text{heat gained by cup}$$

$$m_{\text{tea}}\, c_{\text{tea}}(95^\circ\text{C} - T) = m_{\text{cup}}\, c_{\text{cup}}(T - 25^\circ\text{C}).$$

Putting in numbers and using Table 14–1 ($c_{\text{cup}} = 840\,\text{J/kg}\cdot\text{C}^\circ$ for glass), we solve for T, and find

$$(0.20\,\text{kg})(4186\,\text{J/kg}\cdot\text{C}^\circ)(95^\circ\text{C} - T) = (0.15\,\text{kg})(840\,\text{J/kg}\cdot\text{C}^\circ)(T - 25^\circ\text{C})$$

$$79{,}500\,\text{J} - (837\,\text{J/C}^\circ)T = (126\,\text{J/C}^\circ)T - 3150\,\text{J}$$

$$T = 86^\circ\text{C}.$$

The tea drops in temperature by 9 C° by coming into equilibrium with the cup.

NOTE The cup increases in temperature by $86^\circ\text{C} - 25^\circ\text{C} = 61\,\text{C}^\circ$. Its much greater change in temperature (compared with that of the tea water) is due to its much smaller specific heat compared to that of water.

NOTE In this calculation, the ΔT (of Eq. 14–2, $Q = mc\,\Delta T$) is a positive quantity on both sides of our conservation of energy equation. On the left is "heat lost" and ΔT is the initial minus the final temperature $(95^\circ\text{C} - T)$, whereas on the right is "heat gained" and ΔT is the final minus the initial temperature. But consider this alternate approach.

CAUTION
When using heat lost = heat gained, ΔT is positive on both sides

Alternate Solution We can set up this Example (and others) by a different approach. We can write that the total heat transferred into or out of the isolated system is zero:

PROBLEM SOLVING
Alternate approach: $\Sigma Q = 0$

$$\Sigma Q = 0.$$

Then each term is written as $Q = mc(T_f - T_i)$, and $\Delta T = T_f - T_i$ is always the final minus the initial temperature, and each ΔT can be positive or negative. In the present Example:

$$\Sigma Q = m_{\text{cup}}\, c_{\text{cup}}(T - 25^\circ\text{C}) + m_{\text{tea}}\, c_{\text{tea}}(T - 95^\circ\text{C}) = 0.$$

The second term is negative because T will be less than 95°C. Solving the algebra gives the same result.

The exchange of energy, as exemplified in Example 14–4, is the basis for a technique known as **calorimetry**, which is the quantitative measurement of heat