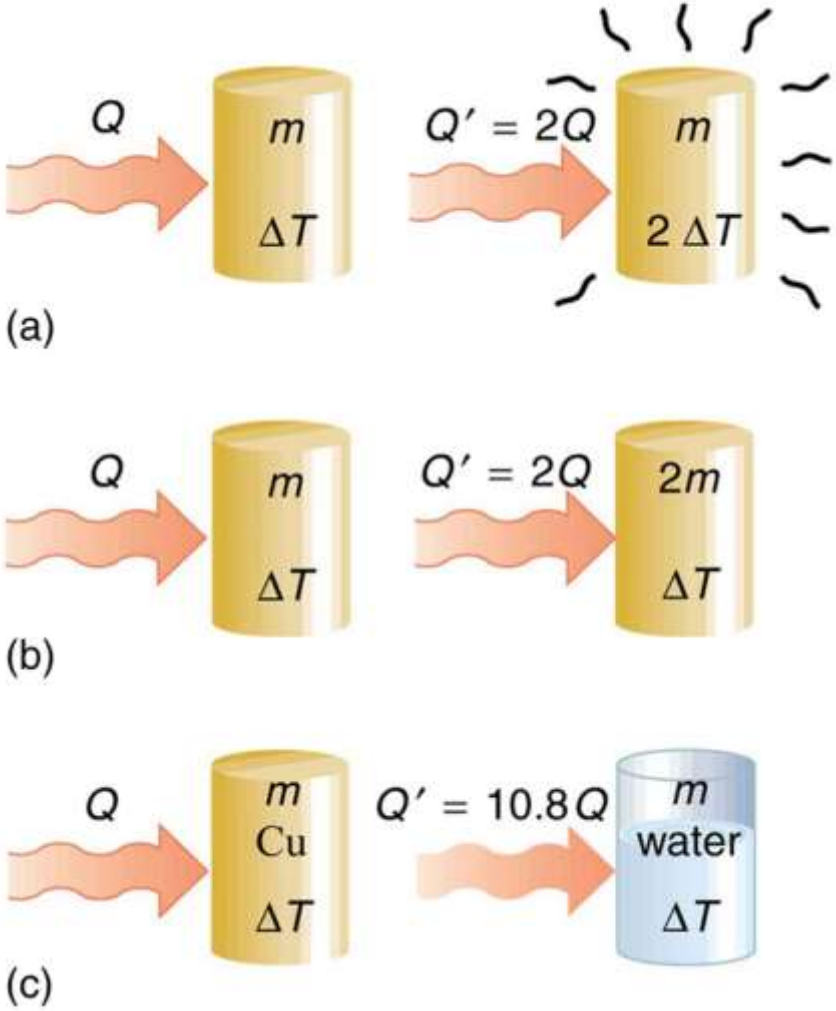
AP2 Ch14
Heat & Heat Transfer
EZ PZ

14.2 Temperature Change and Heat Capacity

$$Q \propto \Delta T$$

Heat transfer : Fig 14-4



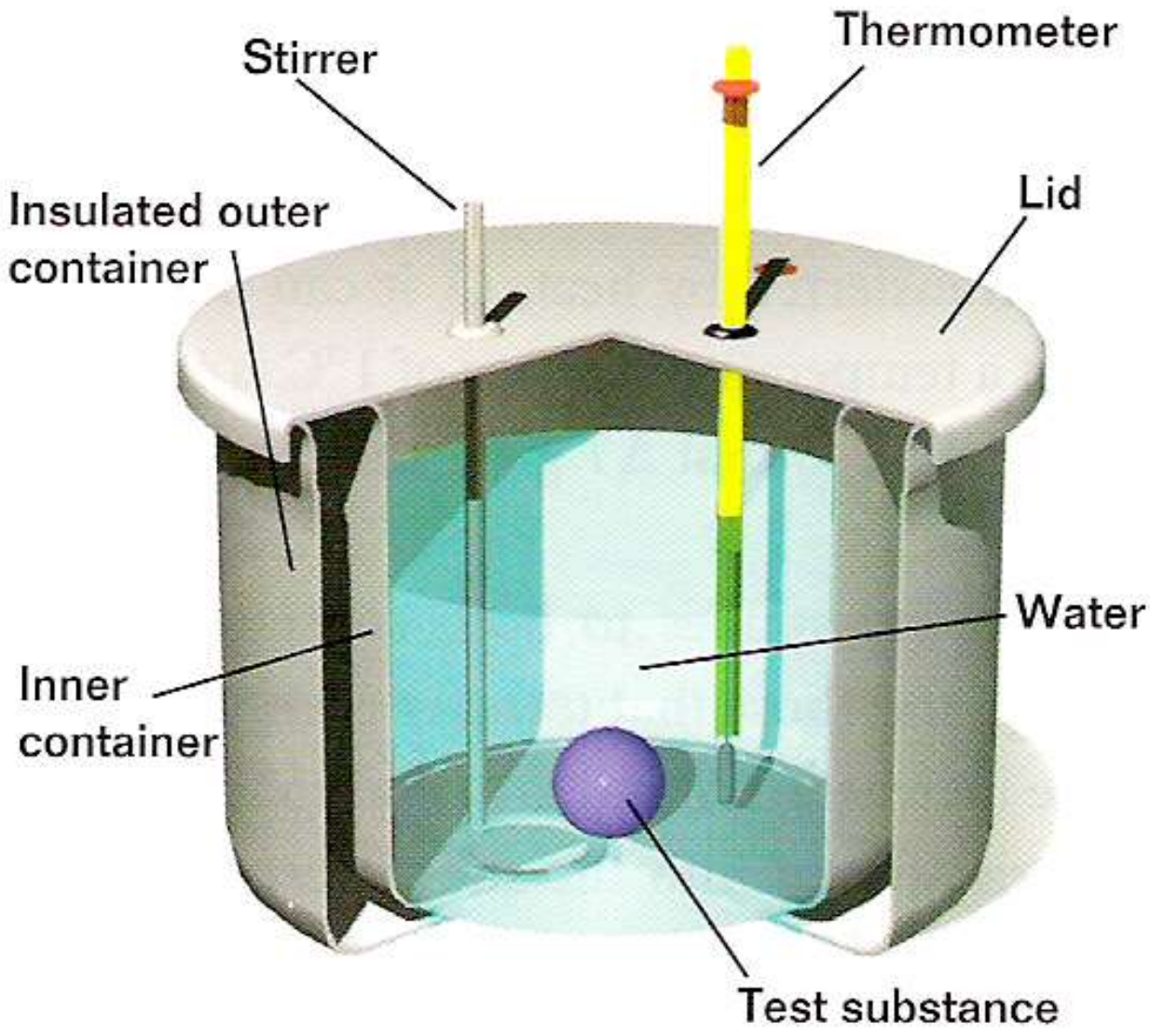
$$Q \propto m$$

$$Q \propto c$$

Calorimetry

- Since heat, Q, is a form of E…
  - $Q_L = Q_G$
  - $\Delta Q_{Total} = 0 = mc\Delta T$
- So,

$$m_1 c_1 \Delta T_1 = m_2 c_2 \Delta T_2$$


Stirrer
Thermometer
Insulated outer container
Lid
Water
Inner container
Test substance

Prob #1

How much heat energy, in joules, must be supplied to change 100g of ice at -20° to steam at 120°?

Ask yourself, “Self…?”

- “What exactly has to happen?”
  - Ice must heat up to 0° in order to melt.
  - Ice must then melt to water at 0°.
  - Water must heat up to 100° to turn to steam.
  - Water has to turn to steam.
  - Steam has to heat up to 120°.
- Note: 5 STEPS!

Step 1

$$Q_1 = mc_{ice}\Delta T$$

$$Q_1 = (100g)\left(2090\frac{J}{kg \bullet C^o}\right)(20^o C)$$

$$Q_1 = 4180J$$

Step 2

$$Q_2 = m_{ice} L$$

$$Q_2 = (100g)\left(33.5x10^4 \frac{J}{kg}\right)$$

$$Q_2 = 33.5x10^3 J$$

Step 3

$$Q_3 = mc_{water}\Delta T$$

$$Q_3 = (100g)\left(4186\frac{J}{kg \bullet C^o}\right)(100^o C)$$

$$Q_3 = 41860J$$

Step 4

$$Q_4 = m_{water} L$$

$$Q_4 = (100g)\left(22.6x10^5 \frac{J}{kg}\right)$$

$$Q_4 = 22.6x10^4 J$$

Step 5

$$Q_5 = mc_{steam}\Delta T$$

$$Q_5 = (100g)\left(2010\frac{J}{kg \bullet C^o}\right)(20^o C)$$

$$Q_5 = 4020J$$

Step 6 - Solution

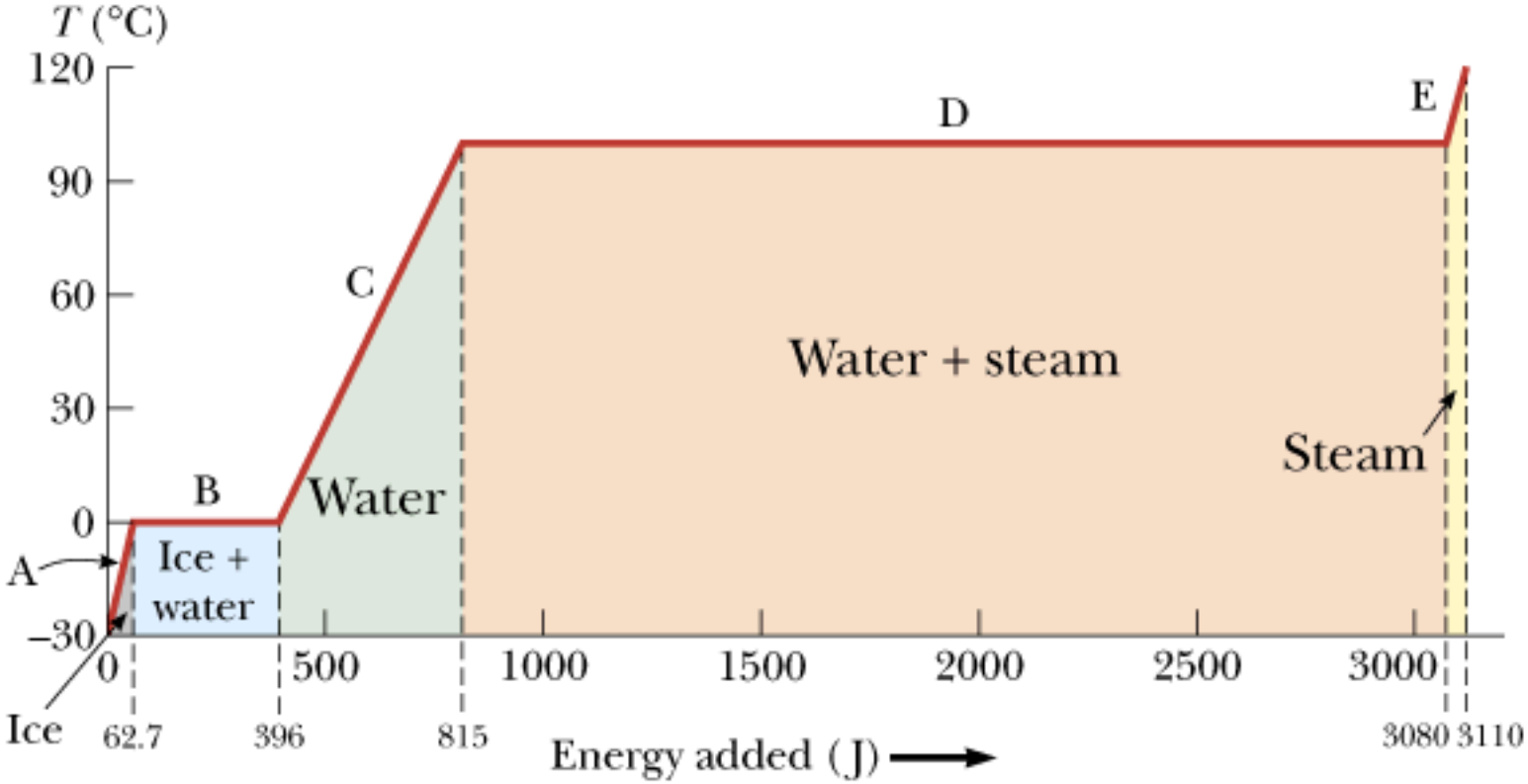
$$\boxed{Q_{total} = 309,560\,J}$$

First law of thermodynamics

From Wikipedia, the free encyclopedia

The **first law of thermodynamics** is you do NOT talk about thermodynamics

Serway, Physics for Scientists and Engineers, 5/e
Figure 20.2



Harcourt, Inc.

Calorimetry

- $Q_L = Q_G$
- Phase Change
- So,

$$Q = mL$$

Serway, Physics for Scientists and Engineers, 5/e
Figure 20.2

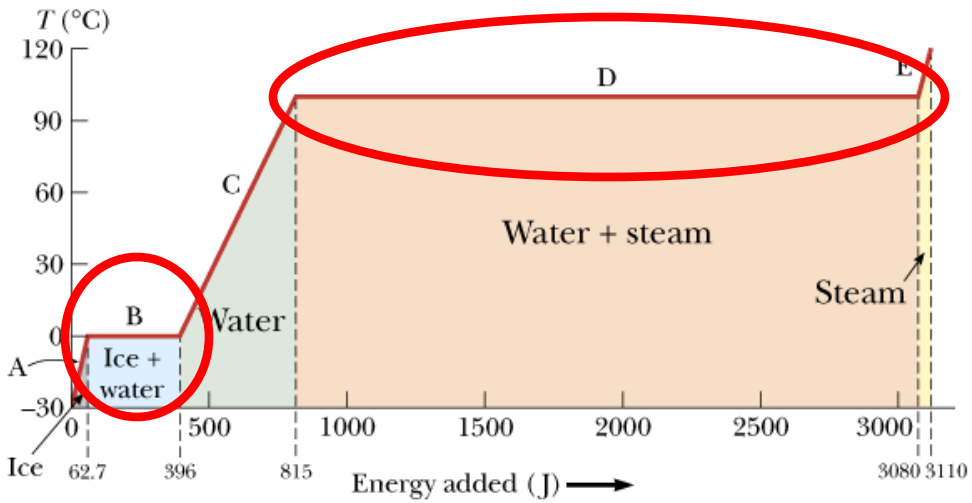


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FIGURE 14.5

The smoking brakes on this truck are a visible evidence of the mechanical equivalent of heat.

EXAMPLE 14-2, p477

Step 1. Calculate the change in gravitational potential energy as the truck goes downhill.

Calculate the temperature increase of 100 kg of brake material with an average specific heat of 800 J/kg · ºC if the material retains the energy from a 10,000-kg truck descending 75.0 m (in vertical displacement) at a constant speed.

$$PE = mgh$$
$$= (10{,}000kg)(10)(75)$$
$$= 7.5x10^6\ J$$

FIGURE 14.5

The smoking brakes on this truck are a visible evidence of the mechanical equivalent of heat.

EXAMPLE 14-2, p477

Step 2. Calculate the temperature from the heat transferred using ΔQ=Mgh.

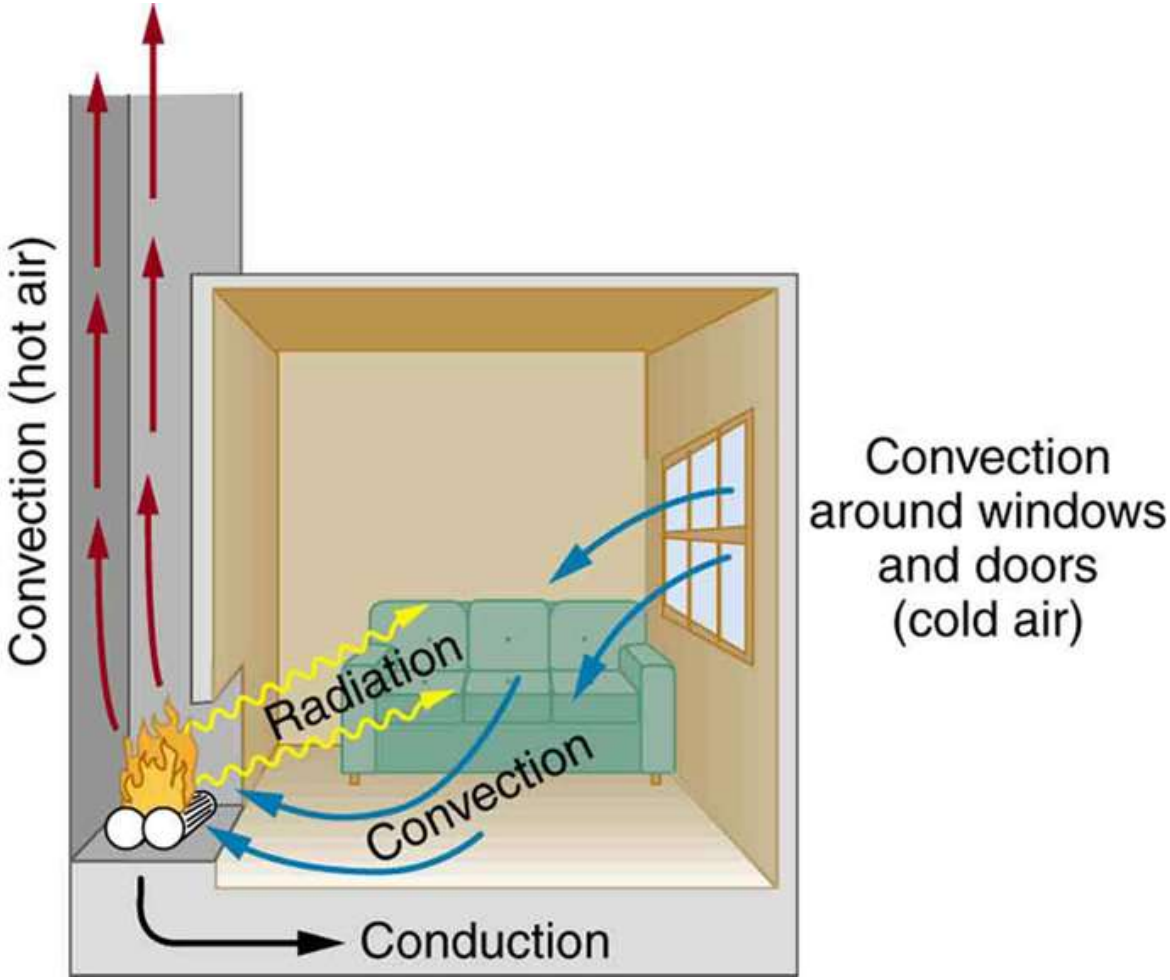
Calculate the temperature increase of 100 kg of brake material with an average specific heat of 800 J/kg · ºC if the material retains the energy from a 10,000-kg truck descending 75.0 m (in vertical displacement) at a constant speed.

$$Q = mc\Delta T = mgh$$

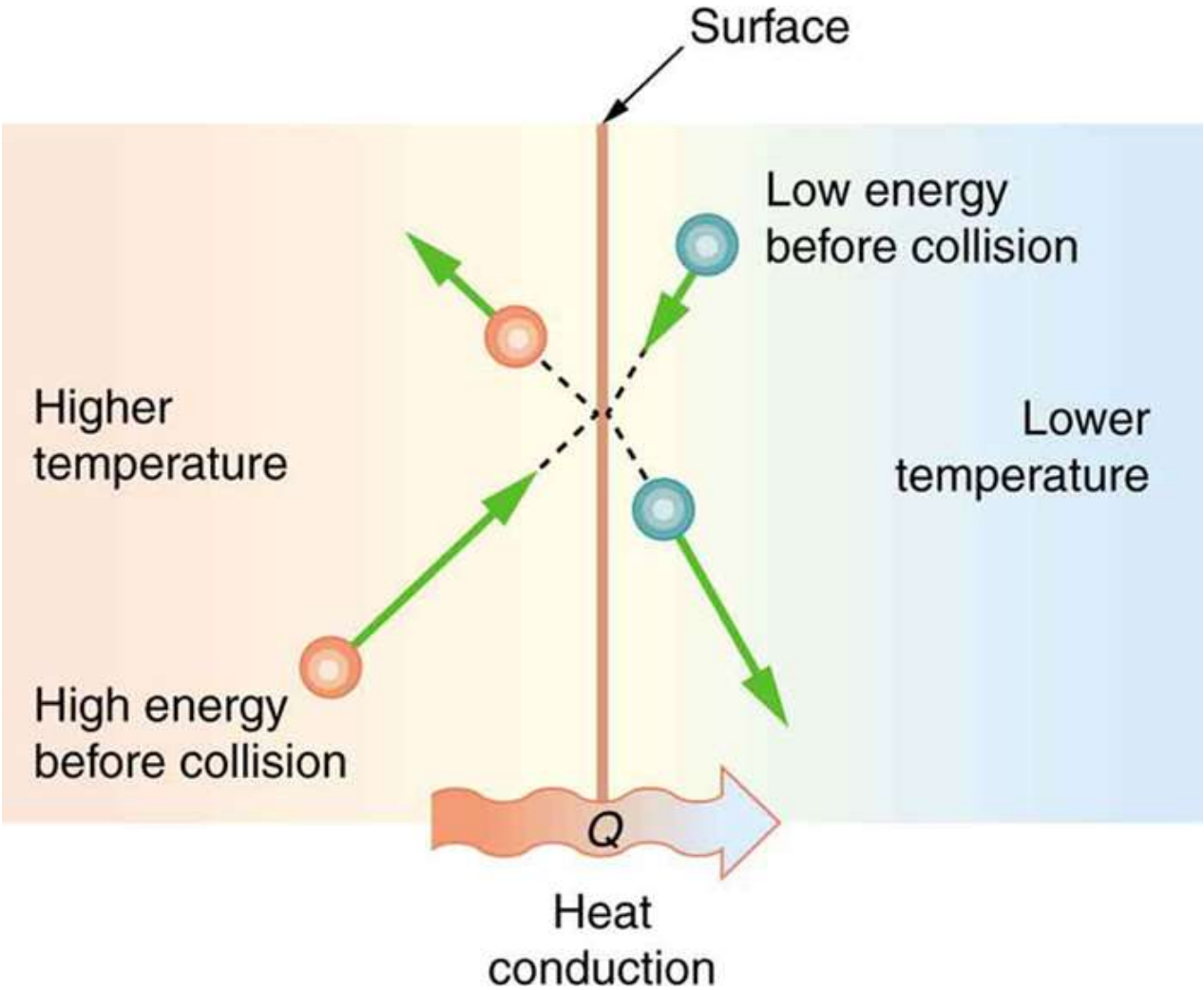
$$\Delta T = \frac{mgh}{mc} = \frac{7.5x10^6\ J}{(100kg)\left(800\ {}^{J}\!/_{kg \cdot K}\right)}$$

$$\Delta T = 93.75K$$

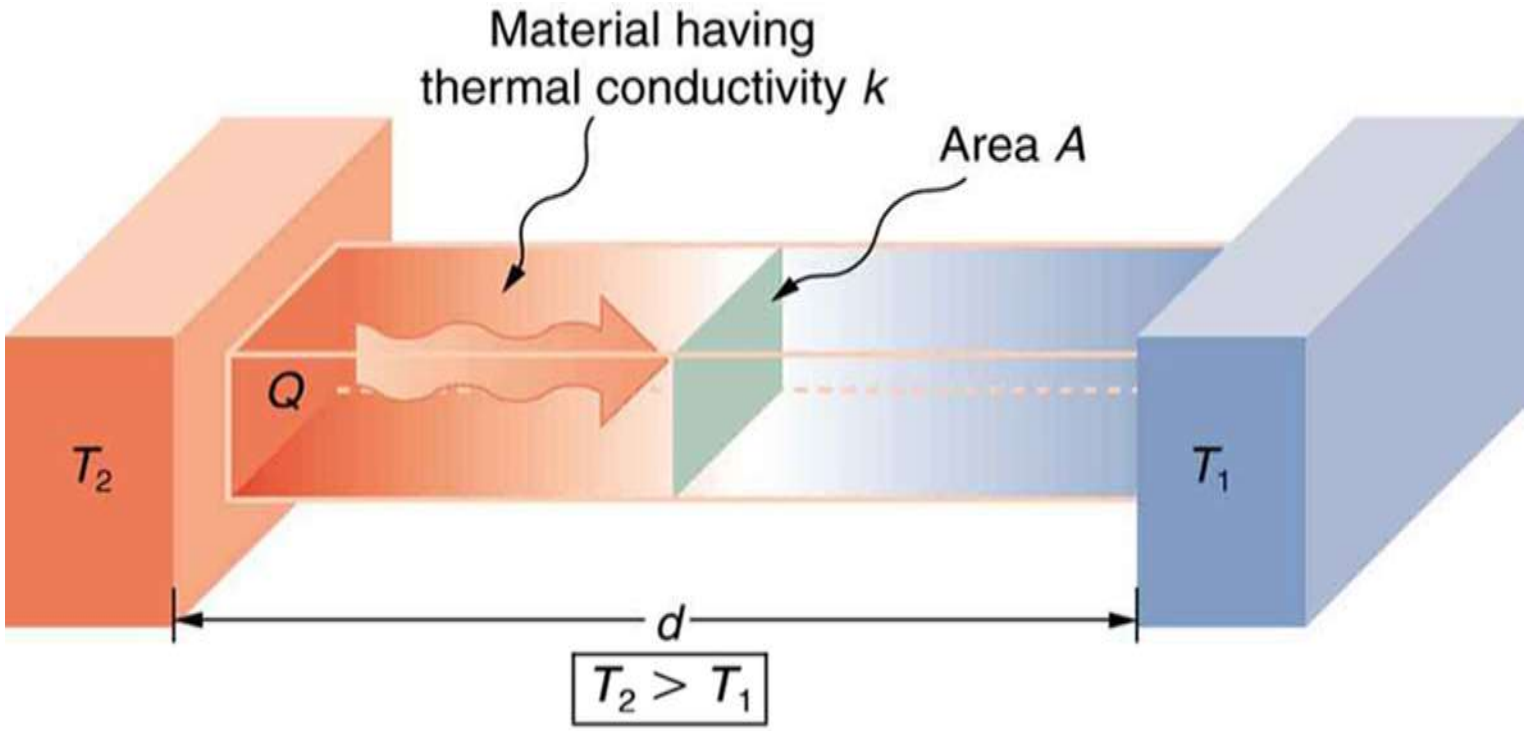
14.4: Heat Transfer Methods



14.4: Heat Transfer Methods



14.4: Heat Transfer Methods



$$\frac{Q}{t} = \frac{kA\Delta T}{d}$$

Example 14.5 Calculating Heat Transfer Through Conduction: Conduction Rate Through an Ice Box

A Styrofoam ice box has a total area of $0.950\ \mathrm{m}^2$ and walls with an average thickness of 2.50 cm. The box contains ice, water, and canned beverages at $0^\circ\mathrm{C}$. The inside of the box is kept cold by melting ice. How much ice melts in one day if the ice box is kept in the trunk of a car at $35.0^\circ\mathrm{C}$? k_{styro}=0.01 J/s

Strategy

$$\frac{Q}{t} = \frac{kA\Delta T}{d}$$

Solution

Example 14.7 Calculating Heat Transfer by Convection: Convection of Air Through the Walls of a House

Most houses are not airtight: air goes in and out around doors and windows, through cracks and crevices, following wiring to switches and outlets, and so on. The air in a typical house is completely replaced in less than an hour. Suppose that a moderately-sized house has inside dimensions $12.0\text{m} \times 18.0\text{m} \times 3.00\text{m}$ high, and that all air is replaced in 30.0 min. Calculate the heat transfer per unit time in watts needed to warm the incoming cold air by 10.0°C, thus replacing the heat transferred by convection alone.

Strategy

Solution