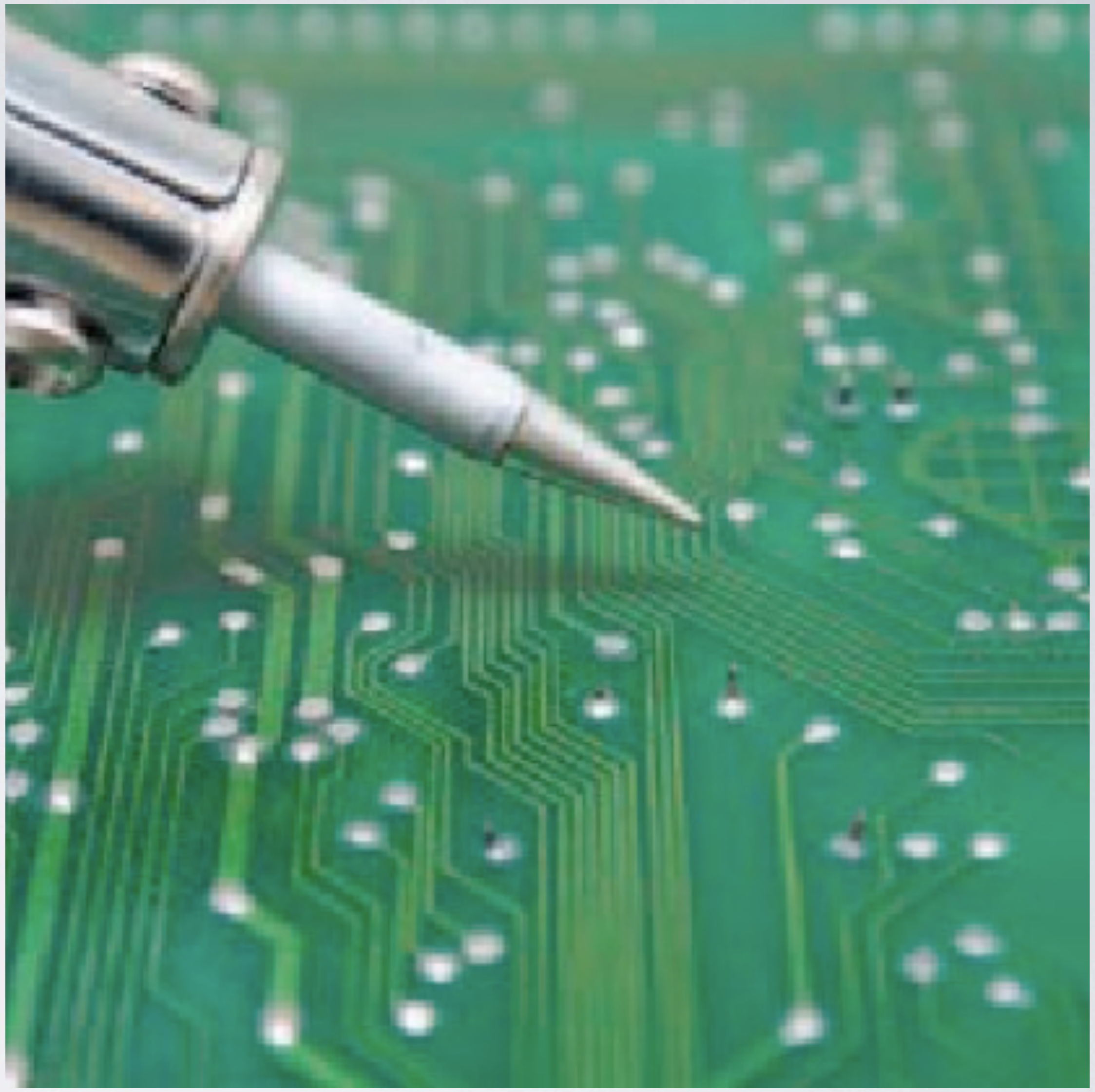
# ENERGY TRANSFER MECHANISMS

When two objects are in direct contact, such as the soldering iron and the circuit board, heat is transferred by *conduction*.



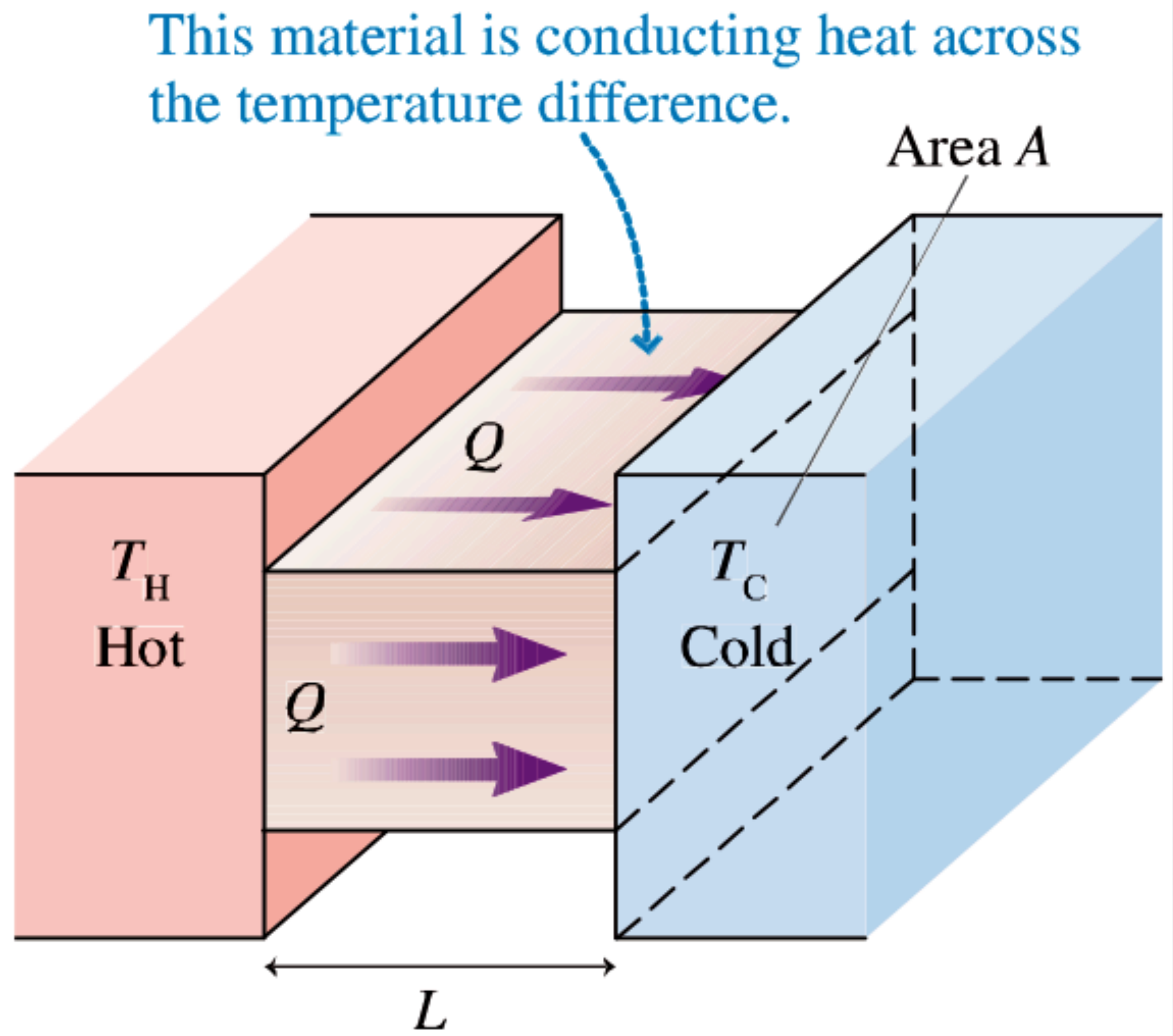
Air currents near a warm glass of water rise, taking thermal energy with them in a process known as *convection*.

The lamp at the top shines on the lambs huddled below, warming them. The energy is transferred by *radiation*.

Blowing on a hot cup of tea or coffee cools it by *evaporation*.

# Thermal conduction

$$\frac{Q}{\Delta t} = k\frac{A}{L}\Delta T$$




Conduction of heat through a solid.

# Thermal conduction

$$\frac{Q}{\Delta t} = k\frac{A}{L}\Delta T$$

**TABLE 20.3 Thermal Conductivities**

| Substance | Thermal Conductivity (W/m·°C) |
|---|---|
| **Metals (at 25°C)** | |
| Aluminum | 238 |
| Copper | 397 |
| Gold | 314 |
| Iron | 79.5 |
| Lead | 34.7 |
| Silver | 427 |
| **Nonmetals (approximate values)** | |
| Asbestos | 0.08 |
| Concrete | 0.8 |
| Diamond | 2 300 |
| Glass | 0.8 |
| Ice | 2 |
| Rubber | 0.2 |
| Water | 0.6 |
| Wood | 0.08 |
| **Gases (at 20°C)** | |
| Air | 0.023 4 |
| Helium | 0.138 |
| Hydrogen | 0.172 |
| Nitrogen | 0.023 4 |
| Oxygen | 0.023 8 |

# Thermal conduction

$$\frac{Q}{\Delta t} = k\frac{A}{L}\Delta T$$

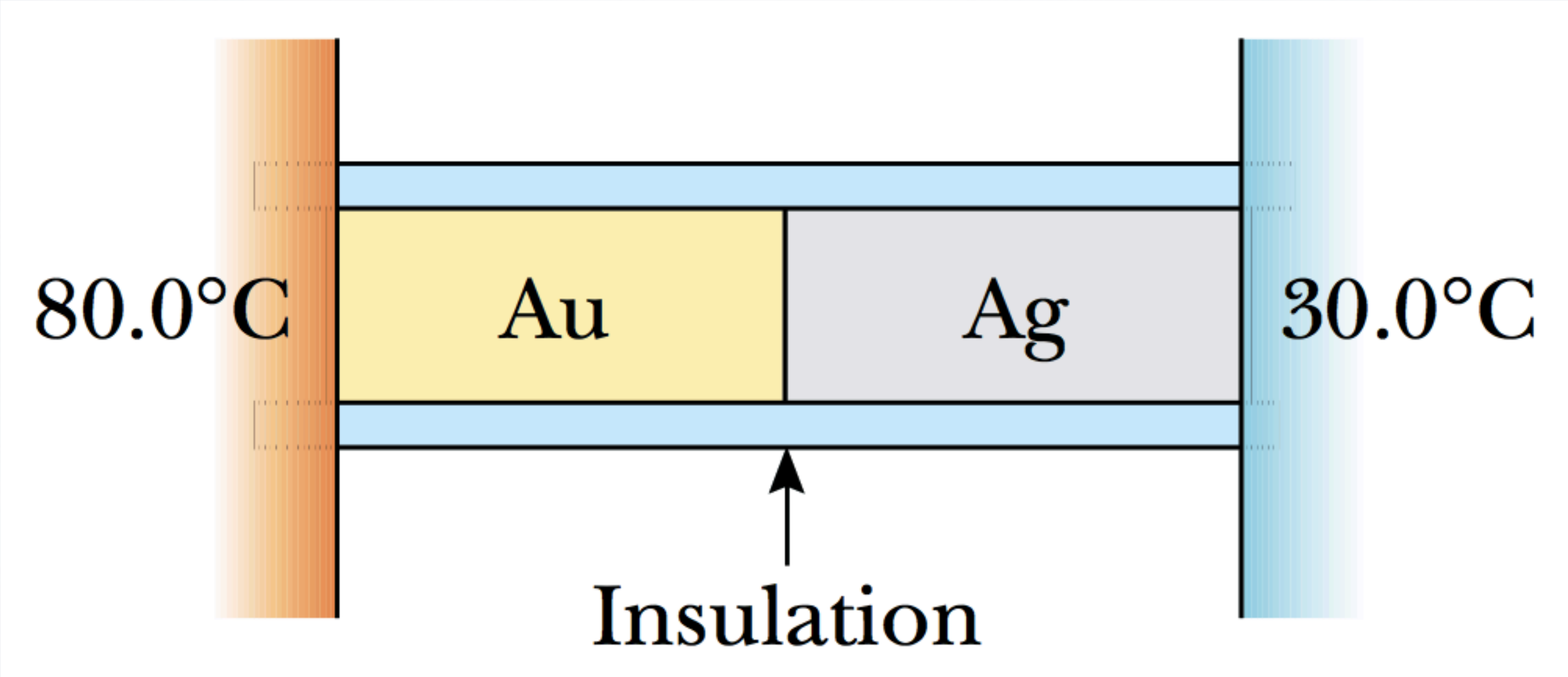
$$\mathcal{P} = \frac{A(T_2 - T_1)}{\sum_i R_i}$$

**TABLE 20.4** ***R*** **Values for Some Common Building Materials**

| Material | *R* value ($ft^2 \cdot °F \cdot h/Btu$) |
|---|---|
| Hardwood siding (1 in. thick) | 0.91 |
| Wood shingles (lapped) | 0.87 |
| Brick (4 in. thick) | 4.00 |
| Concrete block (filled cores) | 1.93 |
| Fiberglass batting (3.5 in. thick) | 10.90 |
| Fiberglass batting (6 in. thick) | 18.80 |
| Fiberglass board (1 in. thick) | 4.35 |
| Cellulose fiber (1 in. thick) | 3.70 |
| Flat glass (0.125 in. thick) | 0.89 |
| Insulating glass (0.25-in. space) | 1.54 |
| Air space (3.5 in. thick) | 1.01 |
| Stagnant air layer | 0.17 |
| Drywall (0.5 in. thick) | 0.45 |
| Sheathing (0.5 in. thick) | 1.32 |

**20.45**

A bar of gold is in thermal contact with a bar of silver of the same length and area. One end of the compound bar is maintained at 80.0°C, while the opposite end is at 30.0°C. When the rate of energy transfer by conduction reaches steady state, what is the temperature at the junction?



**Radiation**

Stefan's Law

$$\mathcal{P} = \sigma A e T^4$$

$$\mathcal{P}_{\text{net}} = \sigma A e (T^4 - T_0{}^4)$$

# Example

The radius of the sun is $6.96 \times 10^8$ m. At the distance of the earth, $1.50 \times 10^{11}$ m, the intensity of solar radiation (measured by satellites above the atmosphere) is 1370 W/m$^2$. What is the temperature of the sun's surface?