17. (II) When a 290-g piece of iron at 180°C is placed in a 95-g aluminum calorimeter cup containing 250 g of glycerin at 10°C, the final temperature is observed to be 38°C. Estimate the specific heat of glycerin.

18. (II) The 1.20-kg head of a hammer has a speed of 6.5 m/s just before it strikes a nail (Fig. 14–17) and is brought to rest. Estimate the temperature rise of a 14-g iron nail generated by 10 such hammer blows done in quick succession. Assume the nail absorbs all the energy.

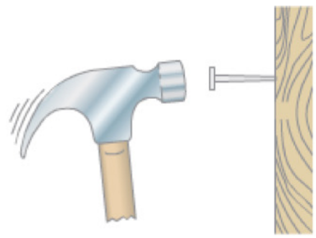

FIGURE 14–17 Problem 18.

19. (II) A 0.095-kg aluminium sphere is dropped from the roof of a 45-m-high building. If 65% of the thermal energy produced when it hits the ground is absorbed by the sphere, what is its temperature increase?

20. (II) The *heat capacity, C*, of an object is defined as the amount of heat needed to raise its temperature by 1 C°. Thus, to raise the temperature by ΔT requires heat Q given by

$$Q = C\,\Delta T.$$

(*a*) Write the heat capacity C in terms of the specific heat, c, of the material. (*b*) What is the heat capacity of 1.0 kg of water? (*c*) Of 25 kg of water?

14–5 Latent Heat

21. (I) How much heat is needed to melt 16.50 kg of silver that is initially at 20°C?

22. (I) During exercise, a person may give off 180 kcal of heat in 30 min by evaporation of water from the skin. How much water has been lost?

23. (I) If 2.80×10^5 J of energy is supplied to a flask of liquid oxygen at −183°C, how much oxygen can evaporate?

24. (II) A 30-g ice cube at its melting point is dropped into an insulated container of liquid nitrogen. How much nitrogen evaporates if it is at its boiling point of 77 K and has a latent heat of vaporization of 200 kJ/kg? Assume for simplicity that the specific heat of ice is a constant and is equal to its value near its melting point.

25. (II) A cube of ice is taken from the freezer at −8.5°C and placed in a 95-g aluminum calorimeter filled with 310 g of water at room temperature of 20.0°C. The final situation is observed to be all water at 17.0°C. What was the mass of the ice cube?

26. (II) An iron boiler of mass 230 kg contains 830 kg of water at 18°C. A heater supplies energy at the rate of 52,000 kJ/h. How long does it take for the water (*a*) to reach the boiling point, and (*b*) to all have changed to steam?

27. (II) In a hot day's race, a bicyclist consumes 8.0 L of water over the span of four hours. Making the approximation that all of the cyclist's energy goes into evaporating this water as sweat, how much energy in kcal did the rider use during the ride? (Since the efficiency of the rider is only about 20%, most of the energy consumed does go to heat, so our approximation is not far off.)

28. (II) What mass of steam at 100°C must be added to 1.00 kg of ice at 0°C to yield liquid water at 20°C?

29. (II) The specific heat of mercury is 138 J/kg·C°. Determine the latent heat of fusion of mercury using the following calorimeter data: 1.00 kg of solid Hg at its melting point of −39.0°C is placed in a 0.620-kg aluminum calorimeter with 0.400 kg of water at 12.80°C; the resulting equilibrium temperature is 5.06°C.

30. (II) A 70-g bullet traveling at 250 m/s penetrates a block of ice at 0°C and comes to rest within the ice. Assuming that the temperature of the bullet doesn't change appreciably, how much ice is melted as a result of the collision?

31. (II) A 54.0-kg ice-skater moving at 6.4 m/s glides to a stop. Assuming the ice is at 0°C and that 50% of the heat generated by friction is absorbed by the ice, how much ice melts?

32. (II) At a crime scene, the forensic investigator notes that the 8.2-g lead bullet that was stopped in a doorframe apparently melted completely on impact. Assuming the bullet was fired at room temperature (20°C), what does the investigator calculate as the *minimum* muzzle velocity of the gun?

14–6 to 14–8 Conduction, Convection, Radiation

33. (I) One end of a 33-cm-long aluminum rod with a diameter of 2.0 cm is kept at 460°C, and the other is immersed in water at 22°C. Calculate the heat conduction rate along the rod.

34. (I) Calculate the rate of heat flow by conduction in Example 14–10, assuming that there are strong gusty winds and the external temperature is −5°C.

35. (I) (*a*) How much power is radiated by a tungsten sphere (emissivity $e = 0.35$) of radius 22 cm at a temperature of 25°C? (*b*) If the sphere is enclosed in a room whose walls are kept at −5°C, what is the *net* flow rate of energy out of the sphere?

36. (II) *Heat conduction to skin.* Suppose 200 W of heat flows by conduction from the blood capillaries beneath the skin to the body's surface area of 1.5 m^2. If the temperature difference is 0.50 C°, estimate the average distance of capillaries below the skin surface.

37. (II) Two rooms, each a cube 4.0 m per side, share a 12-cm-thick brick wall. Because of a number of 100-W lightbulbs in one room, the air is at 30°C, while in the other room it is at 10°C. How many of the 100-W bulbs are needed to maintain the temperature difference across the wall?

38. (II) How long does it take the Sun to melt a block of ice at 0°C with a flat horizontal area 1.0 m^2 and thickness 1.0 cm? Assume that the Sun's rays make an angle of 30° with the vertical and that the emissivity of ice is 0.050.

39. (II) A copper rod and an aluminum rod of the same length and cross-sectional area are attached end to end (Fig. 14–18). The copper end is placed in a furnace maintained at a constant temperature of 250°C. The aluminum end is placed in an ice bath held at constant temperature of 0.0°C. Calculate the temperature at the point where the two rods are joined.

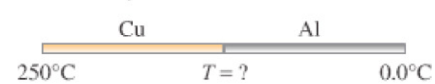

FIGURE 14–18 Problem 39.