

CHAPTER 11

1. A 10-kg piece of aluminum (which has a specific heat of $900 \text{ J/kg}\cdot^\circ\text{C}$) is warmed so that its temperature increases by 5.0°C . How much heat was transferred into it?
 - a. $4.5 \times 10^4 \text{ J}$
 - b. $9.0 \times 10^4 \text{ J}$
 - c. $1.4 \times 10^5 \text{ J}$
 - d. $2.0 \times 10^5 \text{ J}$
2. In a greenhouse, electromagnetic energy in the form of visible light enters the glass panes and is absorbed and then reradiated. What happens to this reradiated electromagnetic radiation from within the greenhouse?
 - a. 100% returns to the atmosphere.
 - b. It's blocked by glass.
 - c. It's transformed into ultraviolet upon striking the glass.
 - d. It's reflected as visible light upon striking the glass.
3. Which of the following best describes a substance in which the temperature remains constant while at the same time it is experiencing an inward heat flow?
 - a. gas
 - b. liquid
 - c. solid
 - d. substance undergoing a change of state
4. Carly places one end of a steel bar in a Bunsen flame and the other end in an ice cube. By what factor is the rate of heat flow changed when the bar's cross-sectional area is doubled?
 - a. 2
 - b. $1/2$
 - c. 4.0
 - d. $1/4$
5. Dmitri places one end of a copper rod in a heat reservoir and the other end in a heat sink. By what factor is the rate of heat flow changed when the temperature difference between the reservoir and sink is tripled?
 - a. 0.33
 - b. $1/9$
 - c. 3.0
 - d. 9.0

6. If one's hands are being warmed by holding them to one side of a flame, the predominant form of heat transfer is what process?
 - a. conduction
 - b. radiation
 - c. convection
 - d. vaporization
7. The surfaces of a Dewar flask are silvered for the purpose of minimizing heat transfer by what process?
 - a. conduction
 - b. radiation
 - c. convection
 - d. vaporization
8. The use of fiberglass insulation in the outer walls of a building is intended to minimize heat transfer through what process?
 - a. conduction
 - b. radiation
 - c. convection
 - d. vaporization
9. A hot (70°C) lump of metal has a mass of 250 g and a specific heat of $0.25 \text{ cal/g}\cdot^{\circ}\text{C}$. John drops the metal into a 500-g calorimeter containing 75 g of water at 20°C . The calorimeter is constructed of a material that has a specific heat of $0.10 \text{ cal/g}\cdot^{\circ}\text{C}$. When equilibrium is reached, what will be the final temperature? $c_{\text{water}} = 1.00 \text{ cal/g}\cdot^{\circ}\text{C}$.
 - a. 114°C
 - b. 72°C
 - c. 64°C
 - d. 37°C
10. Heat flow occurs between two bodies in thermal contact when they differ in what property?
 - a. mass
 - b. specific heat
 - c. density
 - d. temperature
11. Who demonstrated that when heat is gained or lost by a system during some process, the gain or loss can be accounted for by an equivalent quantity of mechanical work done on the system?
 - a. Joule
 - b. Boltzmann
 - c. Thompson, Count Rumford
 - d. Kelvin

12. The first experiment, which systematically demonstrated the equivalence of mechanical energy and heat, was performed by:
 - a. Joule
 - b. Boltzmann
 - c. Thompson, Count Rumford
 - d. Kelvin
13. Sea breezes that occur near the shore are attributed to a difference between land and water with respect to what property?
 - a. mass density
 - b. coefficient of volume expansion
 - c. specific heat
 - d. emissivity
14. How does the heat energy from the sun reach us through the vacuum of space?
 - a. conduction
 - b. radiation
 - c. convection
 - d. none of the above choices are valid
15. Which one of the following processes of heat transfer requires the presence of a fluid?
 - a. conduction
 - b. radiation
 - c. convection
 - d. none of the above choices are valid
16. If cooking is done using an aluminum pan over an electric burner, which of the following will not promote the rate of heat flow from burner to food?
 - a. increase pan bottom thickness
 - b. increase pan bottom area
 - c. increase burner temperature
 - d. decrease height of pan sides
17. On a sunny day at the beach, the reason the sand gets so hot and the water stays relatively cool is attributed to the difference in which property between water and sand?
 - a. mass density
 - b. specific heat
 - c. temperature
 - d. thermal conductivity

18. Marc attaches a falling 500-kg object with a rope through a pulley to a paddle wheel shaft. He places the system in a well-insulated tank holding 25 kg of water. When the object falls, it causes the paddle wheel to rotate and churn the water. If the object falls a vertical distance of 100 m at constant speed, what is the temperature change of the water? (1 kcal = 4 186 J, the specific heat of water is 4 186 J/kg·°C, and $g = 9.8 \text{ m/s}^2$)
- a. 19 600 C°
 - b. 4 700 C°
 - c. 4.7 C°
 - d. 0.8 C°
19. An inventor develops a stationary cycling device by which an individual, while pedaling, can convert all of the energy expended into heat for warming water. How much mechanical energy is required to increase the temperature of 300 g of water (enough for 1 cup of coffee) from 20°C to 95°C? (1 cal = 4.186 J, the specific heat of water is 4 186 J/kg·°C)
- a. 94 000 J
 - b. 22 000 J
 - c. 5 400 J
 - d. 14 J
20. An inventor develops a stationary cycling device by which an individual, while pedaling, can convert all of the energy expended into heat for warming water. What minimum power must be generated if 300 g water (enough for 1 cup of coffee) is to be heated in 10 min from 20°C to 95°C? (1 cal = 4.186 J, the specific heat of water is 4 186 J/kg·°C)
- a. 9 400 W
 - b. 590 W
 - c. 160 W
 - d. 31 W
21. A 3.00-g lead bullet is traveling at a speed of 240 m/s when it embeds in a wood post. If we assume that half of the resultant heat energy generated remains with the bullet, what is the increase in temperature of the embedded bullet? (specific heat of lead = 0.030 5 kcal/kg·°C, 1 kcal = 4 186 J)
- a. 113°C
 - b. 137°C
 - c. 226°C
 - d. 259°C

22. A 0.003 0-kg lead bullet is traveling at a speed of 240 m/s when it embeds in a block of ice at 0°C. If all the heat generated goes into melting ice, what quantity of ice is melted? ($L_f = 80$ kcal/kg, the specific heat of lead = 0.03 kcal/kg·°C, and 1 kcal = 4 186 J)
- a. 1.47×10^{-2} kg
 - b. 5.8×10^{-4} kg
 - c. 3.2×10^{-3} kg
 - d. 2.6×10^{-4} kg
23. A puddle holds 150 g of water. If 0.50 g of water evaporates from the surface, what is the approximate temperature change of the remaining water? ($L_v = 540$ cal/g)
- a. +1.8 C°
 - b. -1.8 C°
 - c. +0.18 C°
 - d. -0.18 C°
24. A windowpane is half a centimeter thick and has an area of 1.0 m². The temperature difference between the inside and outside surfaces of the pane is 15 C°. What is the rate of heat flow through this window? (Thermal conductivity for glass is 0.84 J/s·m·°C.)
- a. 50 000 J/s
 - b. 2 500 J/s
 - c. 1 300 J/s
 - d. 630 J/s
25. A 2.0-m² Thermopane window is constructed, using two layers of glass 4.0 mm thick, separated by an air space of 5.0 mm. If the temperature difference is 20 C° from the inside of the house to the outside air, what is the rate of heat flow through this window? (Thermal conductivity for glass is 0.84 J/s·m·°C and for air 0.023 4 J/s·m·°C.)
- a. 7 700 W
 - b. 1 900 W
 - c. 547 W
 - d. 180 W
26. A swimming pool heater has to be able to raise the temperature of the 40 000 gallons of water in the pool by 10.0 C°. How many kilowatt-hours of energy are required? (One gallon of water has a mass of approximately 3.8 kg and the specific heat of water is 4 186 J/kg·°C.)
- a. 1 960 kWh
 - b. 1 770 kWh
 - c. 330 kWh
 - d. 216 kWh

27. A solar heated house loses about 5.4×10^7 cal through its outer surfaces on a typical 24-h winter day. What mass of storage rock is needed to provide this amount of heat if it is brought up to initial temperature of 62°C by the solar collectors and the house is maintained at 20°C ? (Specific heat of rock is $0.21 \text{ cal/g}\cdot^\circ\text{C}$.)
- a. 163 kg
 - b. 1 230 kg
 - c. 6 100 kg
 - d. 12 700 kg
28. A 0.2-kg aluminum plate, initially at 20°C , slides down a 15-m-long surface, inclined at a 30° angle to the horizontal. The force of kinetic friction exactly balances the component of gravity down the plane so that the plate, once started, glides down at constant velocity. If 90% of the mechanical energy of the system is absorbed by the aluminum, what is its temperature increase at the bottom of the incline? (Specific heat for aluminum is $900 \text{ J/kg}\cdot^\circ\text{C}$.)
- a. 0.16°C
 - b. 0.07°C
 - c. 0.04°C
 - d. 0.03°C
29. Iced tea is made by adding ice to 1.8 kg of hot tea, initially at 80°C . How many kg of ice, initially at 0°C , are required to bring the mixture to 10°C ? ($L_f = 3.33 \times 10^5 \text{ J/kg}$, $c_w = 4 186 \text{ J/kg}\cdot^\circ\text{C}$)
- a. 1.8 kg
 - b. 1.6 kg
 - c. 1.4 kg
 - d. 1.2 kg
30. The filament temperature of a light bulb is 2 000 K when the bulb delivers 40 W of power. If its emissivity remains constant, what power is delivered when the filament temperature is 2 500 K?
- a. 105 W
 - b. 62 W
 - c. 98 W
 - d. 50 W
31. A waterfall is 145 m high. What is the increase in water temperature at the bottom of the falls if all the initial potential energy goes into heating the water? ($g = 9.8 \text{ m/s}^2$, $c_w = 4 186 \text{ J/kg}\cdot^\circ\text{C}$)
- a. 0.16°C
 - b. 0.34°C
 - c. 0.69°C
 - d. 1.04°C

32. What is the temperature increase of 4.0 kg of water when heated by an 800-W immersion heater for 10 min? ($c_w = 4\,186 \text{ J/kg}\cdot^\circ\text{C}$)
- 56°C
 - 51°C
 - 29°C
 - 14°C
33. A solar heating system has a 25.0% conversion efficiency; the solar radiation incident on the panels is $1\,000 \text{ W/m}^2$. What is the increase in temperature of 30.0 kg of water in a 1.00-h period by a 4.00-m^2 -area collector? ($c_w = 4\,186 \text{ J/kg}\cdot^\circ\text{C}$)
- 14.3°C
 - 22.4°C
 - 28.7°C
 - 44.3°C
34. An 80.0-g piece of copper, initially at 295°C, is dropped into 250 g of water contained in a 300-g aluminum calorimeter; the water and calorimeter are initially at 10.0°C. What is the final temperature of the system? (Specific heats of copper and aluminum are 0.092 0 and 0.215 cal/g·°C, respectively. $c_w = 1.00 \text{ cal/g}\cdot^\circ\text{C}$)
- 12.8°C
 - 16.5°C
 - 28.4°C
 - 32.1°C
35. A machine gear consists of 0.10 kg of iron and 0.16 kg of copper. How much total heat is generated in the part if its temperature increases by 35 C°? (Specific heats of iron and copper are 450 and 390 J/kg·°C, respectively.)
- 910 J
 - 3 800 J
 - 4 000 J
 - 4 400 J
36. I place a 500-g ice cube (initially at 0°C) in a Styrofoam box with wall thickness 1.0 cm and total surface area 600 cm². If the air surrounding the box is at 20°C and after 4 hours the ice is completely melted, what is the conductivity of the Styrofoam material? ($L_f = 80 \text{ cal/g}$)
- $9.6 \times 10^{-5} \text{ cal/s}\cdot\text{cm}\cdot^\circ\text{C}$
 - $2.8 \times 10^{-6} \text{ cal/s}\cdot\text{cm}\cdot^\circ\text{C}$
 - $1.15 \times 10^{-2} \text{ cal/s}\cdot\text{cm}\cdot^\circ\text{C}$
 - $2.3 \times 10^{-4} \text{ cal/s}\cdot\text{cm}\cdot^\circ\text{C}$

37. A 50-g cube of ice, initially at 0.0°C , is dropped into 200 g of water in an 80-g aluminum container, both initially at 30°C . What is the final equilibrium temperature? (Specific heat for aluminum is $900\text{ J/kg}\cdot^{\circ}\text{C}$, the specific heat of water is $4186\text{ J/kg}\cdot^{\circ}\text{C}$, and $L_f = 3.33 \times 10^5\text{ J/kg}$.)
- a. 17.9°C
 - b. 9.5°C
 - c. 12.1°C
 - d. 20.6°C
38. If heat is flowing from a table to a block of ice moving across the table, which of the following must be true?
- a. The table is rough and there is friction between the table and ice.
 - b. The ice is cooler than the table.
 - c. The ice is changing phase.
 - d. All three are possible, but none is absolutely necessary.
39. As I use sandpaper on some rusty metal, the sandpaper gets hot because:
- a. Heat is flowing from the sandpaper into the metal.
 - b. Heat is flowing from the metal into the sandpaper.
 - c. Friction is creating the heat.
 - d. Heat is flowing from my hand into the sandpaper.
40. A 120-g block of copper is taken from a kiln and quickly placed into a beaker containing 300 g of water. The water temperature rises from 15°C to 35°C . Given $c_{\text{Cu}} = 0.10\text{ cal/g}\cdot^{\circ}\text{C}$, and $c_{\text{water}} = 1.00\text{ cal/g}\cdot^{\circ}\text{C}$, what was the temperature of the kiln?
- a. 500°C
 - b. 360°C
 - c. 720°C
 - d. 535°C
41. 125 g of dry ice (solid CO_2) is dropped into a beaker containing 500 g of 66°C water. The dry ice converts directly to gas, leaving the solution. When the dry ice is gone, the final temperature of the water is 29°C . What is the heat of vaporization of solid CO_2 ? ($c_{\text{water}} = 1.00\text{ cal/g}\cdot^{\circ}\text{C}$)
- a. 37 cal/g
 - b. 74 cal/g
 - c. 111 cal/g
 - d. 148 cal/g

42. A piece of copper of mass 100 g is being drilled through with a $\frac{1}{2}$ " electric drill. The drill operates at 40.0 W and takes 30.0 s to bore through the copper. If all the energy from the drill heats the copper, find the copper's increase in temperature. $c_{\text{copper}} = 387 \text{ J/kg}\cdot^\circ\text{C}$.
- a. 40.6 $^\circ\text{C}$
 - b. 34.7 $^\circ\text{C}$
 - c. 31.0 $^\circ\text{C}$
 - d. 27.3 $^\circ\text{C}$
43. In cloud formation, water vapor turns into water droplets which get bigger and bigger until it rains. This will cause the temperature of the air in the clouds to:
- a. get warmer.
 - b. get cooler.
 - c. will not affect the temperature of the air in the clouds.
 - d. There is no air in clouds.
44. I take 1.0 kg of ice and dump it into 1.0 kg of water and, when equilibrium is reached, I have 2.0 kg of ice at 0°C . The water was originally at 0°C . The specific heat of water = 1.00 kcal/kg $\cdot^\circ\text{C}$, the specific heat of ice = 0.50 kcal/kg $\cdot^\circ\text{C}$, and the latent heat of fusion of water is 80 kcal/kg. The original temperature of the ice was:
- a. one or two degrees below 0°C .
 - b. -80°C .
 - c. -160°C .
 - d. The whole experiment is impossible.
45. Consider two different rods. The greatest thermal conductivity will be in the rod with:
- a. electrons that are freer to move from atom to atom.
 - b. the greater specific heat.
 - c. the greater cross-sectional area.
 - d. the greater length.
46. Which type of heating causes sunburn?
- a. conduction
 - b. convection
 - c. radiation
 - d. all of the above
47. Carbon dioxide and water molecules in the atmosphere will absorb:
- a. infrared light.
 - b. visible light.
 - c. ultraviolet light.
 - d. radio waves.

48. How many calories are equal to one BTU? (One calorie = 4.186 J, one BTU = 1 054 J.)
- a. 0.252
 - b. 3.97
 - c. 252
 - d. 397
49. In winter, light-colored clothes will keep you warmer than dark-colored clothes if:
- a. you are warmer than your surroundings.
 - b. you are at the same temperature as your surroundings.
 - c. you are cooler than your surroundings.
 - d. you are standing in sunlight.
50. Find the final equilibrium temperature when 10.0 g of milk at 10.0°C is added to 160 g of coffee at 90.0°C. (Assume the specific heats of coffee and milk are the same as water and neglect the heat capacity of the container.) $c_{\text{water}} = 1.00 \text{ cal/g}\cdot^\circ\text{C} = 4186 \text{ J/kg}\cdot^\circ\text{C}$
- a. 85.3°C
 - b. 77.7°C
 - c. 71.4°C
 - d. 66.7°C
51. How much heat energy is required to vaporize a 1.0-g ice cube at 0°C? The heat of fusion of ice is 80 cal/g. The heat of vaporization of water is 540 cal/g, and $c_{\text{water}} = 1.00 \text{ cal/g}\cdot^\circ\text{C}$.
- a. 620 cal
 - b. 720 cal
 - c. 820 cal
 - d. 1 kcal
52. How much heat energy must be removed from 100 g of oxygen at 22°C to liquefy it at -183°C? (The specific heat of oxygen gas is 0.218 cal/g·°C and its heat of vaporization is 50.9 cal/g.)
- a. 13 700 cal
 - b. 9 560 cal
 - c. 4 320 cal
 - d. 2 160 cal
53. 100 g of liquid nitrogen at its boiling point of 77 K is stirred into a beaker containing 500 g of 15°C water. If the nitrogen leaves the solution as soon as it turns to gas, how much water freezes? The heat of vaporization of nitrogen is 48 cal/g and that of water is 80 cal/g.
- a. none
 - b. 29 g
 - c. 68 g
 - d. 109 g

54. A silver bar of length 30 cm and cross-sectional area 1.0 cm^2 is used to transfer heat from a 100°C reservoir to a 0°C block of ice. How much ice is melted per second? (For silver, $k = 427 \text{ J/s}\cdot\text{m}\cdot^\circ\text{C}$. For ice, $L_f = 334\,000 \text{ J/kg}$.)
- a. 4.2 g/s
 - b. 2.1 g/s
 - c. 0.80 g/s
 - d. 0.043 g/s
55. A slice of bread contains about 100 kcal. If specific heat of a person were 1.00 kcal/kg , by how many $^\circ\text{C}$ would the temperature of a 70.0-kg person increase if all the energy in the bread were converted to heat?
- a. 2.25°C
 - b. 1.86°C
 - c. 1.43°C
 - d. 1.00°C
56. At high noon, the sun delivers $1\,000 \text{ W}$ to each square meter of a blacktop road. What is the equilibrium temperature of the hot asphalt, assuming its emissivity $e = 1$? ($\sigma = 5.67 \times 10^{-8} \text{ W/m}^2\cdot\text{K}^4$).
- a. 75°C
 - b. 84°C
 - c. 91°C
 - d. 99°C
57. A 5-g lead bullet traveling in 20°C air at 300 m/s strikes a flat steel plate and stops. What is the final temperature of the lead bullet? (Assume the bullet retains all heat.) The melting point of lead is 327°C . The specific heat of lead is $0.128 \text{ J/g}\cdot^\circ\text{C}$. The heat of fusion of lead is 24.5 J/g .
- a. 227°C
 - b. 260°C
 - c. 293°C
 - d. 327°C
58. The surface of the Sun has a temperature of about $5\,800 \text{ K}$. If the radius of the Sun is $7 \times 10^8 \text{ m}$, determine the power output of the sun. (Take $e = 1$, and $\sigma = 5.67 \times 10^{-8} \text{ W/m}^2\cdot\text{K}^4$).
- a. $3.95 \times 10^{26} \text{ W}$
 - b. $5.17 \times 10^{27} \text{ W}$
 - c. $9.62 \times 10^{28} \text{ W}$
 - d. $6.96 \times 10^{30} \text{ W}$

59. The tungsten filament of a light bulb has an operating temperature of about 2 100 K. If the emitting area of the filament is 1.0 cm^2 , and its emissivity is 0.68, what is the power output of the light bulb? ($\sigma = 5.67 \times 10^{-8} \text{ W/m}^2 \cdot \text{K}^4$)
- a. 100 W
 - b. 75 W
 - c. 60 W
 - d. 40 W
60. Which of the following statements is true?
- a. A hot object contains a lot of heat.
 - b. A cold object contains only a little heat.
 - c. Objects do not contain heat.
 - d. Statements a and b are true.
61. An object at 27°C has its temperature increased to 37°C . The power then radiated by this object increases by how many percent?
- a. 3.3
 - b. 14
 - c. 37
 - d. 253
62. What temperature increase is necessary to increase the power radiated from an object by a factor of 8?
- a. 8 K
 - b. 2 K
 - c. 100%
 - d. about 68%
63. A metal bar is used to conduct heat. When the temperature at one end is 100°C and at the other is 20°C , heat is transferred at a rate of 16 J/s. If the temperature of the hotter end is reduced to 80°C , what will be the rate of heat transfer?
- a. 4 J/s
 - b. 8 J/s
 - c. 9 J/s
 - d. 12 J/s

64. A metal bar is used to conduct heat. When the temperature at one end is 100°C and at the other is 20°C , heat is transferred at a rate of 16 J/s . The bar is then stretched uniformly to twice its original length. If again it has ends at 100°C and 20°C , at what rate will heat be transferred between its ends?
- a. 4 J/s
 - b. 8 J/s
 - c. 16 J/s
 - d. 32 J/s
65. Which of the following involves the greatest heat transfer?
- a. One gram of steam at 100°C changing to water at 100°C .
 - b. One gram of ice at 0°C changing to water at 0°C ,
 - c. One gram of water cooling from 100°C to 0°C .
 - d. One gram of ice heating from -100°C to 0°C .
66. Twenty grams of a solid at 70°C is placed in 100 grams of a fluid at 20°C . Thermal equilibrium is reached at 30°C . The specific heat of the solid
- a. is equal to that of the fluid.
 - b. is less than that of the fluid.
 - c. is more than that of the fluid.
 - d. cannot be compared to that of a material in a different phase.

CHAPTER 11 - ANSWERS

#	Ans	Difficulty	#	Ans	Difficulty
1.	A	1	34.	B	3
2.	B	1	35.	B	2
3.	D	1	36.	D	3
4.	A	1	37.	B	3
5.	C	1	38.	B	2
6.	B	1	39.	C	1
7.	B	1	40.	D	2
8.	A	1	41.	D	2
9.	D	3	42.	C	1
10.	D	1	43.	A	1
11.	A	1	44.	C	2
12.	A	1	45.	A	1
13.	C	2	46.	C	1
14.	B	1	47.	A	1
15.	C	1	48.	C	2
16.	A	2	49.	A	2
17.	B	1	50.	A	2
18.	C	2	51.	B	2
19.	A	2	52.	B	2
20.	C	2	53.	A	2
21.	A	2	54.	D	3
22.	D	2	55.	C	2
23.	B	2	56.	C	2
24.	B	2	57.	D	3
25.	D	2	58.	A	2
26.	B	2	59.	B	2
27.	C	3	60.	C	2
28.	B	3	61.	B	2
29.	C	2	62.	D	2
30.	C	2	63.	D	2
31.	B	2	64.	A	3
32.	C	2	65.	A	2
33.	C	2	66.	C	2