56. Two 1100-kg cars are traveling 95 km/h in opposite directions when they collide and are brought to rest. Estimate the change in entropy of the universe as a result of this collision. Assume $T = 20°\text{C}$.

57. A 120-g insulated aluminum cup at 15°C is filled with 140 g of water at 50°C. After a few minutes, equilibrium is reached. (*a*) Determine the final temperature, and (*b*) estimate the total change in entropy.

* 58. (*a*) What is the coefficient of performance of an ideal heat pump that extracts heat from 6°C air outside and deposits heat inside your house at 24°C? (*b*) If this heat pump operates on 1200 W of electrical power, what is the maximum heat it can deliver into your house each hour?

59. The burning of gasoline in a car releases about 3.0×10^4 kcal/gal. If a car averages 41 km/gal when driving 90 km/h, which requires 25 hp, what is the efficiency of the engine under those conditions?

60. A Carnot engine has a lower operating temperature $T_L = 20°\text{C}$ and an efficiency of 30%. By how many kelvins should the high operating temperature T_H be increased to achieve an efficiency of 40%?

61. Calculate the work done by an ideal gas in going from state A to state C in Fig. 15–28 for each of the following processes: (*a*) ADC, (*b*) ABC, and (*c*) AC directly.

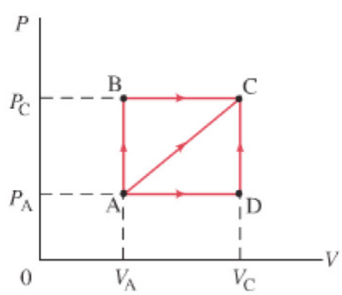

FIGURE 15–28 Problem 61.

62. A 33% efficient power plant puts out 850 MW of electrical power. Cooling towers are used to take away the exhaust heat. (*a*) If the air temperature is allowed to rise 7.0 C°, estimate what volume of air (km^3) is heated per day. Will the local climate be heated significantly? (*b*) If the heated air were to form a layer 200 m thick, estimate how large an area it would cover for 24 h of operation. Assume the air has density $1.2\ \text{kg/m}^3$ and that its specific heat is about $1.0\ \text{kJ/kg}\cdot\text{C}°$ at constant pressure.

63. Suppose a power plant delivers energy at 980 MW using steam turbines. The steam goes into the turbines superheated at 625 K and deposits its unused heat in river water at 285 K. Assume that the turbine operates as an ideal Carnot engine. (*a*) If the river flow rate is $37\ \text{m}^3/\text{s}$, estimate the average temperature increase of the river water immediately downstream from the power plant. (*b*) What is the entropy increase per kilogram of the downstream river water in $\text{J/kg}\cdot\text{K}$?

64. A 100-hp car engine operates at about 15% efficiency. Assume the engine's water temperature of 85°C is its cold-temperature (exhaust) reservoir and 495°C is its thermal "intake" temperature (the temperature of the exploding gas–air mixture). (*a*) What is the ratio of its efficiency relative to its maximum possible (Carnot) efficiency? (*b*) Estimate how much power (in watts) goes into moving the car, and how much heat, in joules and in kcal, is exhausted to the air in 1.0 h.

65. An ideal gas is placed in a tall cylindrical jar of cross-sectional area $0.080\ \text{m}^2$. A frictionless 0.10-kg movable piston is placed vertically into the jar such that the piston's weight is supported by the gas pressure in the jar. When the gas is heated (at constant pressure) from 25°C to 55°C, the piston rises 1.0 cm. How much heat was required for this process? Assume atmospheric pressure outside.

66. Metabolizing 1.0 kg of fat results in about 3.7×10^7 J of internal energy in the body. (*a*) In one day, how much fat does the body burn to maintain the body temperature of a person staying in bed and metabolizing at an average rate of 95 W? (*b*) How long would it take to burn 1.0-kg of fat this way assuming there is no food intake?

67. An ideal air conditioner keeps the temperature inside a room at 21°C when the outside temperature is 32°C. If 5.3 kW of power enters a room through the windows in the form of direct radiation from the Sun, how much electrical power would be saved if the windows were shaded so that the amount of radiation were reduced to 500 W?

68. A dehumidifier is essentially a "refrigerator with an open door." The humid air is pulled in by a fan and guided to a cold coil, where the temperature is less than the dew point, and some of the air's water condenses. After this water is extracted, the air is warmed back to its original temperature and sent into the room. In a well-designed dehumidifier, the heat is exchanged between the incoming and outgoing air. This way the heat that is removed by the refrigerator coil mostly comes from the condensation of water vapor to liquid. Estimate how much water is removed in 1.0 h by an ideal dehumidifier, if the temperature of the room is 25°C, the water condenses at 8°C, and the dehumidifier does work at the rate of 600 W of electrical power.

Answers to Exercises

A: 700 J.
B: Less.
C: -6.8×10^3 J.
D: Equation 14–1 applies only to an ideal monatomic gas, not to liquid water.