Indian Institute of Technology Kanpur

Thermodynamics (ESO201A)
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Tutorial 5

6–43C What is a thermal energy reservoir? Give some examples.

6–44 A household refrigerator that has a power input of 450 W and a COP of 1.5 is to cool 5 large watermelons, 10 kg each, to 8°C. If the watermelons are initially at 28°C, determine how long it will take for the refrigerator to cool them. The watermelons can be treated as water whose specific heat is 4.2 kJ/kg·°C. Is your answer realistic or optimistic? Explain. *Answer:* 104 min

6–53 Refrigerant-134a enters the condenser of a residential heat pump at 800 kPa and 35°C at a rate of 0.018 kg/s and leaves at 800 kPa as a saturated liquid. If the compressor consumes 1.2 kW of power, determine (*a*) the COP of the heat pump and (*b*) the rate of heat absorption from the outside air.

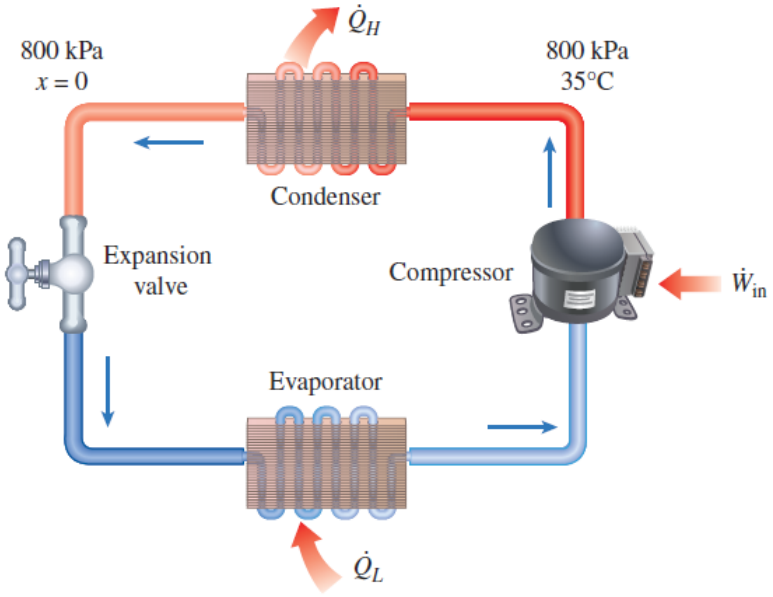

FIGURE P6–55

6–64C How do you distinguish between internal and external irreversibilities?

6–81 A heat engine receives heat from a heat source at 1200°C and has a thermal efficiency of 40 percent. The heat engine does maximum work equal to 500 kJ. Determine the heat supplied to the heat engine by the heat source, the heat rejected to the heat sink, and the temperature of the heat sink.

6–101 A commercial refrigerator with refrigerant-134a as the working fluid is used to keep the refrigerated space at −35°C by rejecting waste heat to cooling water that enters the condenser at 18°C at a rate of 0.25 kg/s and leaves at 26°C. The refrigerant enters the condenser at 1.2 MPa and 50°C and leaves at the same pressure subcooled by 5°C. If the compressor consumes 3.3 kW of power, determine (*a*) the mass flow rate of the refrigerant, (*b*) the refrigeration load, (*c*) the COP, and (*d*) the minimum power input to the compressor for the same refrigeration load.

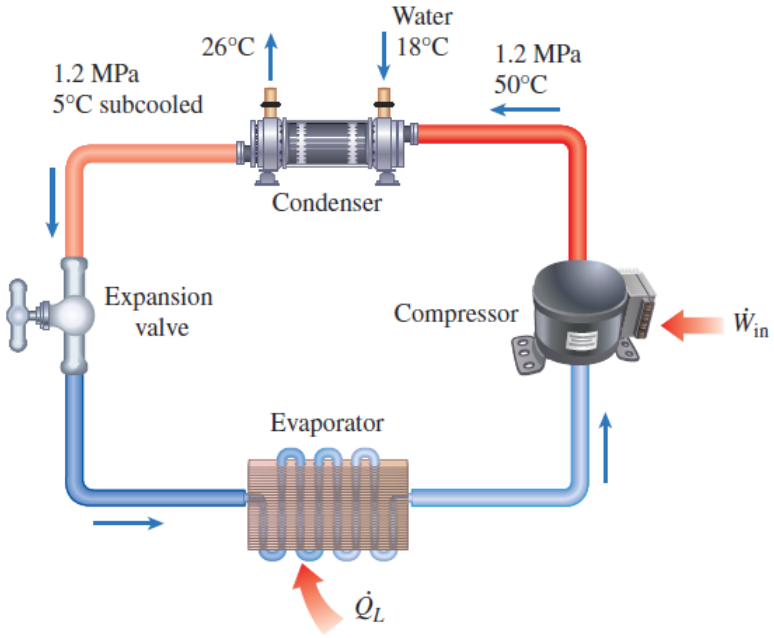

FIGURE P6–101

Additional Homework Problems

6–9C Is it possible for a heat engine to operate without rejecting any waste heat to a low-temperature reservoir? Explain. violates Kelvin Planck statement

6–13C Are the efficiencies of all the work-producing devices, including the hydroelectric power plants, limited by the Kelvin–Planck statement of the second law? Explain. no only to heat engines

6–26 A coal-burning steam power plant produces a net power of 300 MW with an overall thermal efficiency of 32 percent. The actual gravimetric air–fuel ratio in the furnace is calculated to be 12 kg air/kg fuel. The heating value of the coal is 28,000 kJ/kg. Determine (*a*) the amount of coal consumed during a 24-hour period and (*b*) the rate of air flowing through the furnace. *Answers:* (*a*) 2.89×10^6 kg, (*b*) 402 kg/s

6–28C What is the difference between a refrigerator and a heat pump?

6–45 When a man returns to his well-sealed house on a summer day, he finds that the house is at 35°C. He turns on the air conditioner, which cools the entire house to 20°C in 30 min. If the COP of the air-conditioning system is 2.8, determine the power drawn by the air conditioner. Assume the entire mass within the house is equivalent to 800 kg of air for which $c_v = 0.72$ kJ/kg·°C and $c_p = 1.0$ kJ/kg·°C.

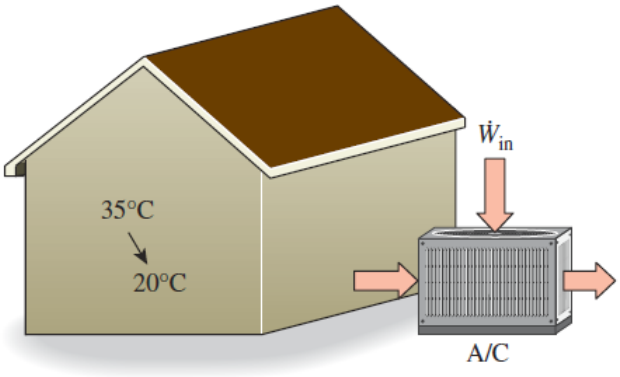

FIGURE P6–45

6–97 A heat pump is used to maintain a house at 25°C by extracting heat from the outside air on a day when the outside air temperature is 4°C. The house is estimated to lose heat at a rate of 110,000 kJ/h, and the heat pump consumes 4.75 kW of electric power when running. Is this heat pump powerful enough to do the job?

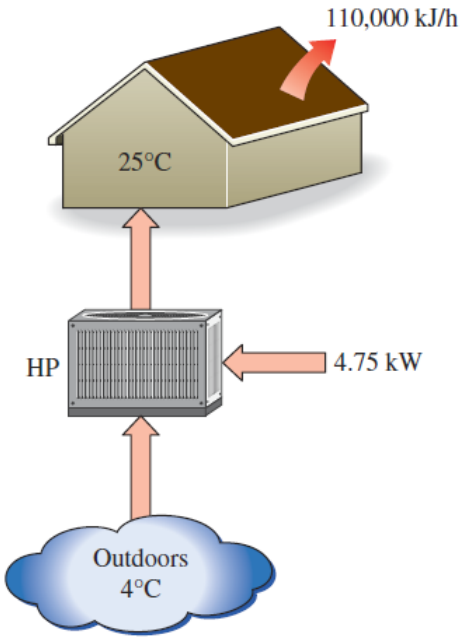

FIGURE P6–97

6–108 An air-conditioner with refrigerant-134a as the working fluid is used to keep a room at 23°C by rejecting the waste heat to the outdoor air at 34°C. The room gains heat through the walls and the windows at a rate of 250 kJ/min while the heat generated by the computer, TV, and lights amounts to 900 W. The refrigerant enters the compressor at 400 kPa as a saturated vapor at a rate of 80 L/min and leaves at 1200 kPa and 70°C. Determine (*a*) the actual COP, (*b*) the maximum COP, and (*c*) the minimum volume flow rate of the refrigerant at the compressor inlet for the same compressor inlet and exit conditions. *Answers:* (*a*) 4.33, (*b*) 26.9, (*c*) 12.9 L/min

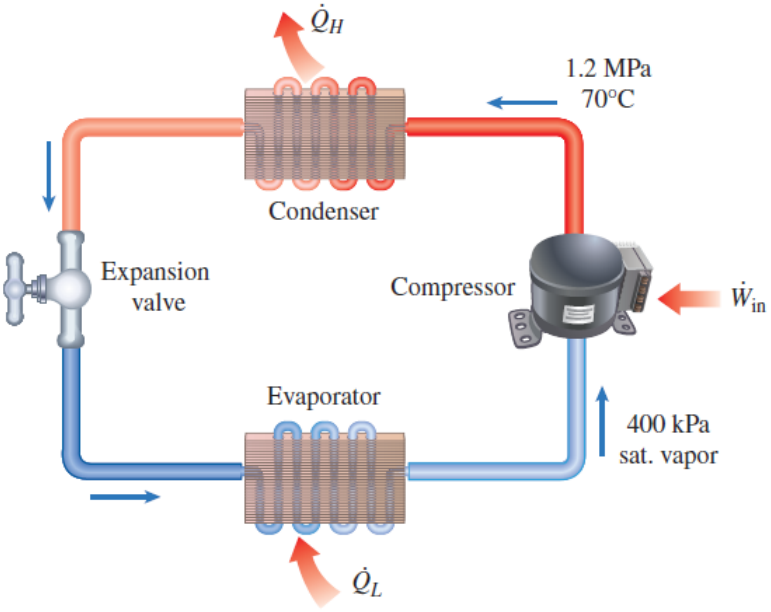

FIGURE P6–108