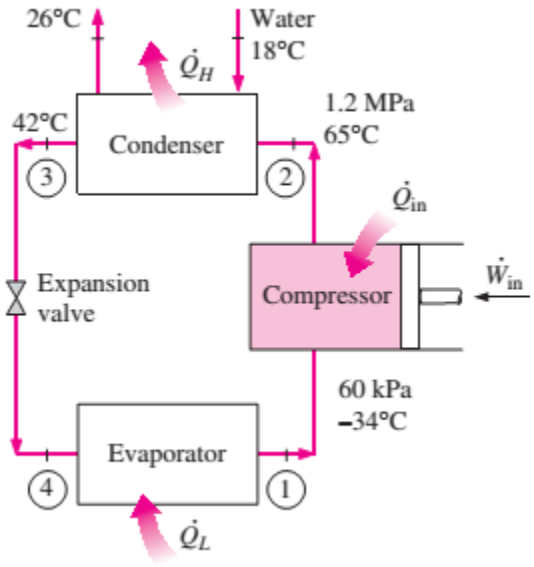
1. A commercial refrigerator with refrigerant-134a as the working fluid is used to keep the refrigerated space at 30°C by rejecting its waste heat to cooling water that enters the condenser at 18°C at a rate of 0.25 kg/s and leaves at 26°C. The refrigerant enters the condenser at 1.2 MPa and 65°C and leaves at 42°C. The inlet state of the compressor is 60 kPa and 34°C and the compressor is estimated to gain a net heat of 450 W from the surroundings.



Determine
   a. the quality of the refrigerant at the evaporator inlet,
   b. the refrigeration load,
   c. the COP of the refrigerator, and
   d. the theoretical maximum refrigeration load for the same power input to the compressor.

2. A refrigerator uses refrigerant-134a as the working fluid and operates on an ideal vapor-compression refrigeration cycle between 0.12 and 0.7 MPa. The mass flow rate of the refrigerant is 0.05 kg/s. Determine
   a. the rate of heat removal from the refrigerated space and the power input to the compressor,
   b. the rate of heat rejection to the environment, and
   c. the coefficient of performance.

   Answers: (a) 7.41 kW, 1.83 kW, (b) 9.23 kW, (c) 4.06

3. Refrigerant-134a enters the compressor of a refrigerator as superheated vapor at 0.14 MPa and 10°C at a rate of 0.12 kg/s, and it leaves at 0.7 MPa and 50°C. The refrigerant is cooled in the condenser to 24°C and 0.65 MPa, and it is throttled to 0.15 MPa. Determine
   a. the rate of heat removal from the refrigerated space and the power input to the compressor,
   b. the isentropic efficiency of the compressor, and
   c. the COP of the refrigerator

   Answers: (a) 19.4 kW, 5.06 kW, (b) 82.5 percent, (c) 3.83

4. A refrigerator uses refrigerant-134a as the working fluid and operates on the ideal vapor-compression refrigeration cycle. The refrigerant enters the evaporator at 120 kPa with a quality of 30 percent and leaves the compressor at 60°C. If the compressor consumes 450 W of power, determine
   a. the mass flow rate of the refrigerant,
   b. the condenser pressure, and
   c. the COP of the refrigerator.

   Answers: (a) 0.00727 kg/s, (b) 672 kPa, (c) 2.43

5. Consider a two-stage cascade refrigeration system operating between the pressure limits of 1.2 MPa and 200 kPa with refrigerant-134a as the working fluid. Heat rejection from the lower cycle to the upper cycle takes place in an adiabatic counterflow heat exchanger where the pressure in the upper and lower cycles are 0.4 and 0.5 MPa, respectively. In both cycles, the refrigerant is a saturated liquid at the condenser exit and a saturated vapor at the compressor inlet, and the isentropic efficiency of the compressor is 80 percent. If the mass flow rate of the refrigerant through the lower cycle is 0.15 kg/s, determine
   (a) the mass flow rate of the refrigerant through the upper cycle,
   (b) the rate of heat removal from the refrigerated space, and
   (c) the COP of this refrigerator.

   Answers: (a) 0.212 kg/s, (b) 25.7 kW, (c) 2.68

6. A heat pump that operates on the ideal vapor compression cycle with refrigerant-134a is used to heat a house and maintain it at 75°F by using underground water at 50°F as the heat source. The house is losing heat at a rate of 60,000 Btu/h. The evaporator and condenser pressures are 50 and 120 psia, respectively. Determine the power input to the heat pump and the electric power saved by using a heat pump instead of a resistance heater.

   Answers: 2.46 hp, 21.1 hp

7. A heat pump using refrigerant-134a heats a house by using underground water at 8°C as the heat source. The house is losing heat at a rate of 60,000 kJ/h. The refrigerant enters the compressor at 280 kPa and 0°C, and it leaves at 1 MPa and 60°C. The refrigerant exits the condenser at 30°C. Determine
   a. the power input to the heat pump,
   b. the rate of heat absorption from the water, and
   c. the increase in electric power input if an electric resistance heater is used instead of a heat pump.

   Answers: (a) 3.55 kW, (b) 13.12 kW, (c) 13.12 kW