CASE WESTERN RESERVE UNIVERSITY
Case School of Engineering

ENGR 225: Fall 2024

Homework #4: 2nd Law, heat pumps, refrigerators

Due: September 26

1. [Chapter 7] An automobile engine consumes fuel at a rate of 22 L/hr and delivers 50 kW of power to the wheels. If the fuel has a heating value of 44,000 kJ/kg and a density of 2 g/cm^3, determine the efficiency of this engine.

2. [Chapter 7] Determine the COP of a refrigerator that removes heat from the food compartment at a rate of 5100 kJ/hr for each kW of power it consumes. Also determine the rate of heat rejection to the outside air.

3. [Chapter 7] Determine the COP of a heat pump that supplies energy to a house at a rate of 6500 kJ/hr for each kW of electric power it draws. Also determine the rate of energy absorption from the outside air.

4. [Chapter 7] A Carnot heat engine receives 600 kJ of heat from a source of unknown temperature and rejects 175 kJ of it to a sink at 20°C. Determine (a) the temperature of the source and (b) the thermal efficiency of the heat engine.

5. [Chapter 7] A commercial refrigerator with R134a as the working fluid is used to keep the refrigerated space at -30°C by rejecting waste heat to cooling water that enters the condenser at 15°C at a rate of 0.25 kg/s and leaves at 28°C. The refrigerant enters the condenser at 1.2 MPa and 60°C and leaves at the same pressure as a saturated liquid. If the compressor consumes 3 kW of power, determine:

   (a) the mass flow rate of the refrigerant

   (b) the refrigeration load

   (c) the COP

   (d) the minimum power input to the compressor for the same refrigeration load.

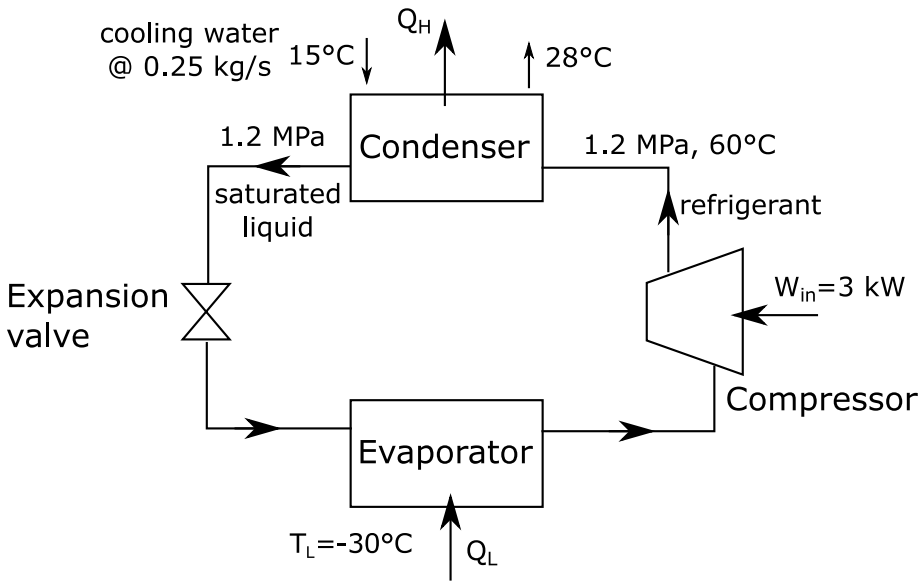

Figure 1: Schematic for Problem 5

Answers

1. 9.3%
2. 1.4167, 8700 kJ/hr
3. 1.8056, 2900 kJ/hr
4. (a) 1005 K, (b) 70.83%
5. (a) 0.079 kg/s, (b) 10.6 kW, (c) 3.53, (d) 1.96 kW