Given: $kJ := 1000J$

R-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.

Required:

If the compressor consumes 1.2 kW of power, determine the COP of the heat pump and the rate of heat absorption from the outside air.

Solution:

The inlet conditions, flow rate, and outlet conditions of the R-134a are defined as

$$P_1 := 800kPa \qquad T_1 := 35\,°C \qquad m' := 0.018\frac{kg}{s} \qquad P_2 := 800kPa \qquad x_2 := 0$$

The net work required of the compressor is defined as

$$W'_{net,in} := 1.2kW$$

<u>1st Law</u> for just the condensor (assuming steady state, rigid, and no ΔKE and ΔPE)

$$\frac{d}{dt}E_{sys} = E'_{in} - E'_{out}$$

$$0 = m' \cdot h_1 - m' \cdot h_2 - Q'_H$$

Solving for the heat rejected by the condensor yields

$$Q'_H = m' \cdot (h_1 - h_2)$$

Going to Table A-11 @ $T_1 = 35 \cdot °C$ & $P_1 = 800 \cdot kPa$ shows that the state is super heated.

Going to Table A-13 @ $T_1 = 35 \cdot °C$ & $P_1 = 800 \cdot kPa$ shows that interpolation is needed.

$$T_a := 31.31\,°C \qquad T_b := 40\,°C \qquad h_a := 267.29\frac{kJ}{kg} \qquad h_b := 276.45\frac{kJ}{kg}$$

$$h_1 := \frac{T_1 - T_a}{T_b - T_a} \cdot (h_b - h_a) + h_a = 271.18 \cdot \frac{kJ}{kg}$$

Going to Table A-12 @ $P_2 = 800 \cdot kPa$ & $x_2 = 0$ shows

$$h_2 := 95.47\frac{kJ}{kg}$$

The heat rejected by the condensor is then

$$Q'_H := m' \cdot (h_1 - h_2) = 3.163 \cdot kW$$

The COP of the heat pump is then given by

$$\boxed{COP_{HP} := \frac{Q'_H}{W'_{net,in}} = 2.636}$$

The heat rejected by the heat pump is then given by

$$\boxed{Q'_L := Q'_H - W'_{net,in} = 1.963 \cdot kW}$$