Given: $kJ := 1000J$

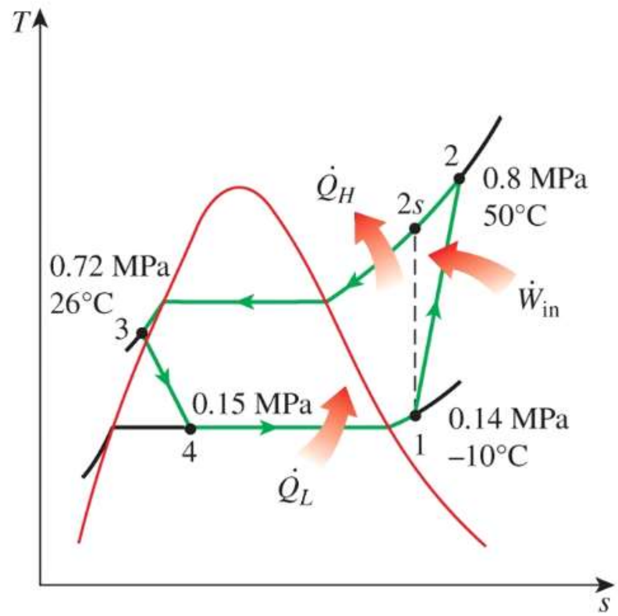
R-134a enters the compressor of a refrigerator as a superheated vapor at 0.14 MPa and -10°C at a rate of 0.05 kg/s and leaves at 0.8 MPa and 50°C. The refrigerant is cooled in the condenser to 26°C and 0.72 MPa and is throttled to 0.15 MPa.

$P_1 := 0.14MPa \qquad T_1 := (-10)\,°C$

$P_2 := 0.8MPa \qquad T_2 := 50\,°C$

$P_3 := 0.72MPa \qquad T_3 := 26\,°C$

$P_4 := 0.15MPa \qquad m' := 0.05\,\frac{kg}{s}$



Required:

Disregarding any heat transfer and pressure drops in the connecting lines between components, determine the rate of heat removal from the refrigerated space and the power input to the compressor, the isentropic efficiency of the compressor, and the COP of the refrigerator.

Solution:

Going to Table A-12 @ $P_1 = 140 \cdot kPa$ & $T_1 = -10 \cdot °C$ shows that the state is superheated.

Going to Table A-13 @ $P_1 = 0.14 \cdot MPa$ & $T_1 = -10 \cdot °C$ shows

$h_1 := 246.36\,\frac{kJ}{kg} \qquad s_1 := 0.9724\,\frac{kJ}{kg \cdot K}$

Going to Table A-12 @ $P_2 = 800 \cdot kPa$ & $T_2 = 50 \cdot °C$ shows that the state is superheated.

Going to Table A-13 @ $P_2 = 0.8 \cdot MPa$ & $T_2 = 50 \cdot °C$ shows

$h_2 := 286.69\,\frac{kJ}{kg}$

Going to Table A-11 @ $T_3 = 26 \cdot °C$ & $P_3 = 720 \cdot kPa$ shows the state is compressed liquid. However, it will be approximated as a saturated liquid.

$h_3 := 87.83\,\frac{kJ}{kg}$

Since the process from state 3 to state 4 is throttling value, the enthalpies are the same.

$h_4 := h_3 = 87.83 \cdot \frac{kJ}{kg}$

The rate of heat removal is found by

$\boxed{Q'_L := m' \cdot (h_1 - h_4) = 7.926 \cdot kW}$

Solution (contd.):

The power input to the compressor is found by

$$\boxed{W'_{in} := m' \cdot (h_2 - h_1) = 2.017 \cdot kW}$$

Going to Table A-13 @ $P_2 = 0.8 \cdot MPa$ & $s_{2s} := s_1 = 0.9724 \cdot \frac{kJ}{kg \cdot K}$ shows that interpolation is needed.

$$s_a := 0.9480 \frac{kJ}{kg \cdot K} \qquad s_b := 0.9802 \frac{kJ}{kg \cdot K}$$

$$h_a := 276.45 \frac{kJ}{kg} \qquad h_b := 286.69 \frac{kJ}{kg}$$

$$h_{2s} := \frac{s_{2s} - s_a}{s_b - s_a} \cdot (h_b - h_a) + h_a = 284.21 \cdot \frac{kJ}{kg}$$

The isentropic efficiency of the compressor is then found by

$$\boxed{\eta_c := \frac{h_{2s} - h_1}{h_2 - h_1} = 93.8 \cdot \%}$$

The COP of the refrigerator is then found by

$$\boxed{COP_R := \frac{Q'_L}{W'_{in}} = 3.931}$$