Given:

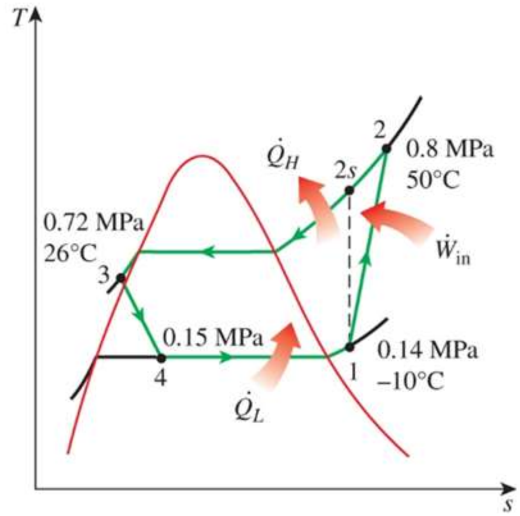
R-134a enters the compressor of a refrigerator as a superheated vapor at 0.14 MPa and -10°C at a rate of 0.05 kg/s and leaves at 0.8 MPa and 50°C. The refrigerant is cooled in the condenser to 26°C and 0.72 MPa and is throttled to 0.15 MPa.

$P_1 := 0.14\ \text{MPa}$ $\quad T_1 := (-10)\ °\text{C}$

$P_2 := 0.8\ \text{MPa}$ $\quad T_2 := 50\ °\text{C}$

$P_3 := 0.72\ \text{MPa}$ $\quad T_3 := 26\ °\text{C}$

$P_4 := 0.15\ \text{MPa}$ $\quad m' := 0.05\ \frac{\text{kg}}{\text{s}}$



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 @ $P_1 = 140.0\ \text{kPa}$ and $T_1 = -10.00\ °\text{C}$ shows that the state is superheated.

Going to Table A-13 @ $P_1 = 0.1400\ \text{MPa}$ and $T_1 = -10.00\ °\text{C}$ shows

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

Going to Table A-12 @ $P_2 = 800.0\ \text{kPa}$ and $T_2 = 50.00\ °\text{C}$ shows that the state is superheated.

Going to Table A-13 @ $P_2 = 0.8000\ \text{MPa}$ and $T_2 = 50.00\ °\text{C}$ shows

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

Going to Table A-11 @ $T_3 = 26.00\ °\text{C}$ and $P_3 = 720.0\ \text{kPa}$ shows the state is compressed liquid. However, it will be approximated as a saturated liquid.

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

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

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

The rate of heat removal is found by

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

The power input to the compressor is found by

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

Solution (contd.):
Going to Table A-13 @ $P_2 = 0.8000\ \mathrm{MPa}$ and $s_{2s} := s_1 = 0.9724\ \frac{\mathrm{kJ}}{\mathrm{kg\ K}}$ shows that interpolation is needed.

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

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

$$h_{2s} := \frac{s_{2s} - s_a}{s_b - s_a} \cdot \left(h_b - h_a\right) + h_a = 284.2\ \frac{\mathrm{kJ}}{\mathrm{kg}}$$

The isentropic efficiency of the compressor is then found by

$$\boxed{\eta_c := \frac{h_{2s} - h_1}{h_2 - h_1} = 93.85\ \%}$$

The COP of the refrigerator is then found by

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