11-58 + 2 stage R-134a

Pressure limits 1.4 mPa and 160 kPa

$P_3 = 1.4$ mPa

GIVEN: $P_4 = 0.5$ mPa

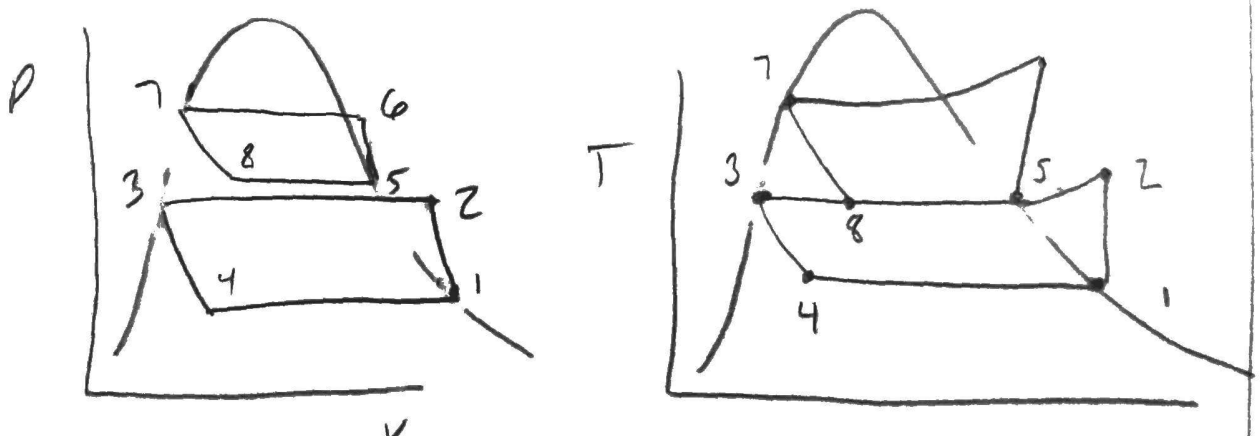
Saturated liquid @ condensor exit

Saturated vapor @ compressor inlet

$\dot{m}_{r,lower} = .11$ kg/s

$\eta_C = .8$

FIND: a) $\dot{m}_{r,upper}$; b) $\dot{Q}_L$; c) COP



1 $P_1 = 160$ kPa $x_1 = 1$ $h_1 = 241.14$ kJ/kg $s_1 = 0.94202$ kJ/kg-K

2 $P_2 = 0.4$ mPa $h_{2s} = 255.88$ kJ/kg ; $h_2 = 264.57$ kJ/kg

3 $P_3 = 6.4$ mPa $x_3 = 0$ $h_3 = h_3 = 63.92$ kJ/kg

4 $P_4 = 160$ kPa $h_4 = 63.92$ kJ/kg

5 $P_5 = 0.5$ mPa $x_5 = 1$ $h_5 = 259.36$ kJ/kg $s_5 = .92420$ kJ/kg-K

6 $P_6 = 1.4$ mPa $h_{6s} = 280.62$ kJ/kg $h_6 = 285.94$ kJ/kg

7 $P_7 = 1.4$ mPa $x_7 = 0$ $h_7 = 127.25$ kJ/kg

8 $P_5 = 0.5$ mPa $h_8 = 127.25$ kJ/kg

$$\eta_c = \frac{w_{in,\,isentropic}}{w_{in,\,actual}} = \frac{h_{2s} - h_1}{h_2 - h_1}$$

$$\eta_c (h_2 - h_1) = h_{2s} - h_1$$

$$\eta_c h_2 - \eta_c h_1 = h_{2s} - h_1 + \eta_c h_1$$

$$h_2 - h_1 = \frac{h_{2s} - h_1}{\eta_c} + h_1 = \frac{259.88 - 241.14}{.8} + 241.14$$

$$h_2 = 264.57 \text{ kJ/kg}$$

$$h_6 = \frac{h_{6s} - h_5}{\eta_c} + h_5 = \frac{280.62 - 259.36}{.8} + 259.36$$

$$h_6 = 285.94 \text{ kJ/kg}$$

$$\dot{m}_u (h_5 - h_8) = \dot{m}_L (h_2 - h_3)$$

$$\dot{m}_u = .11 \frac{(264.57 - 63.92)}{259.36 - 127.25} = .11 \frac{(200.77}{132.11}$$

$$\boxed{\dot{m}_u = .17 \text{ kg/s}}$$

$$\dot{Q}_L = \dot{m}_L (h_1 - h_4) = .11 (241.14 - 63.92)$$

$$\boxed{\dot{Q}_L = 19.49 \text{ kW}}$$

$$COP_R = \frac{Q_L}{\dot{W}_{in,\,net}} = \frac{Q_L}{\dot{m}_u (h_6 - h_5) + \dot{m}_L (h_2 - h_1)}$$

$$COP_R = \frac{19.49}{4.519 + 257} = \frac{19.49}{.17 (285.94 - 259.36) + .11 (264.57 - 241.14)}$$

$$COP_R = 7.5$$

11-60 2 Evap, R-134a

$T_{EV1} = 0°C$

$T_{EV2} = -26.4°C$

$P_{cond} = 800$ kPa

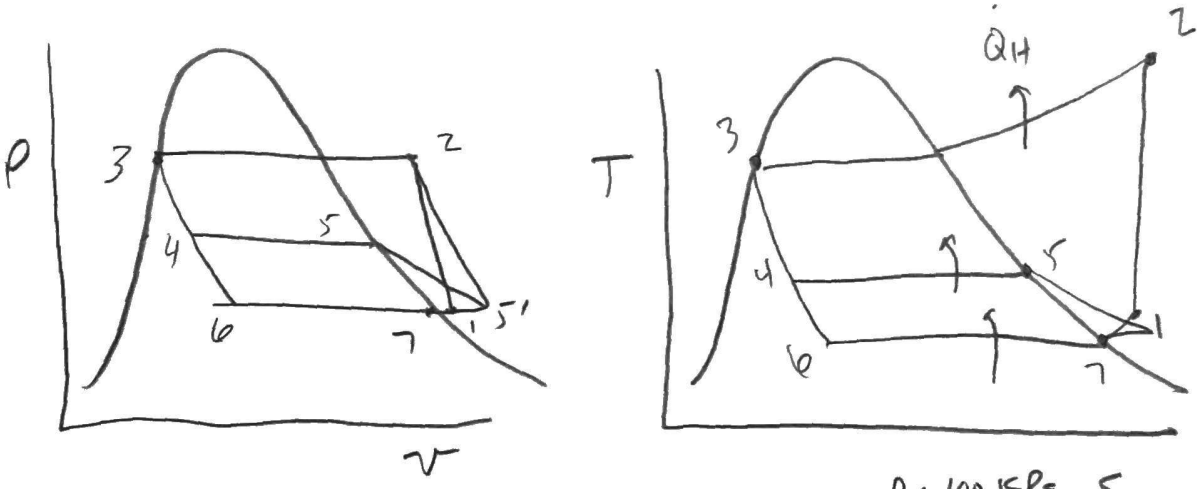
$\dot{Q}_{L,2} = 8$ kW

$\dot{m}_R = 0.1$ kg/s

Saturated liquid @ cond ex.t

Saturated vapor @ ex.t of evaps

Compressor is isentropic



1 $s_1 = s_2$ $h_1 = 241.25$ kJ/kg $T_1 = -26.4$ $P \approx 100$ kPa $s_1 = 0.97881$ kJ/kg K

2 $P_2 = 800$ kPa; $s_2 = s_1$, $s_2 = 0.97881$ kJ/kg-K $\Rightarrow h_2 = 286.23$ kJ/kg

3 $P_3 = 800$ kPa $x_3 = 0$; $h_3 = 95.48$ kJ/kg $s_3 = .35408$ kJ/kg-K

4 $T_4 = 0°C$ $h_4 = 95.48$ kJ/kg

5 $T_5 = 0°C$ $x_5 = 1$ $h_5 = 250.50$ kJ/kg $s_5 = .93158$ kJ/kg-K

6 $T_6 = -26.4°C$ $h_6 = 95.48$ kJ/kg

7 $T_7 = -26.4°C$ $x_7 = 1$; $h_7 = 234.44$ kJ/kg $s_7 = .95152$ kJ/kg-K

$$Q_{L,2} = \dot{m}_2 (h_7 - h_6)$$

$$\dot{m}_2 = \frac{Q_L}{h_7 - h_6} = \frac{8\ KW}{234.44 - 95.48} = 0.057\ kg/s$$

$$\dot{m}_{net} = \dot{m}_1 + \dot{m}_2$$

$$\dot{m}_1 = \dot{m}_{net} - \dot{m}_2 = .1 - .057 = 0.043\ kg/s$$

$$\dot{Q}_{L,1} = \dot{m}_1 (h_5 - h_4)$$

$$Q_{L,1} = 0.043 (250.5 - 95.48) = \boxed{6.67\ KW}$$

$$h_1 = \frac{\dot{m}_1 h_5 + \dot{m}_2 h_7}{\dot{m}} = \frac{(.0429)(250.5) + (.0575)(234.44)}{0.1\ kg/s}$$

$$h_1 = 241.25\ KJ/kg$$

$$W_{in} = \dot{m} (h_2 - h_1) = .1 (286.23 - 241.25)$$

$$\boxed{\dot{W}_{in} = 4.498\ KW}$$

$$COP_R = \frac{\dot{Q}_L}{\dot{W}_{in}} = \frac{8\ KW + 6.67\ KW}{4.498\ KW} = \boxed{3.24}$$