**Problem: 5-1**

**Given:** An ideal vapor refrigeration cycle uses Freon-12 as the working fluid. The condensing temperature is 35 $^\circ C$ and the evaporation temperature is -10 $^\circ C$.

**Find:** a) the coefficient of performance of the cycle
b) the power required to produce 1 ton of refrigeration
c) the circulation rate of fluid for each ton of refrigeration

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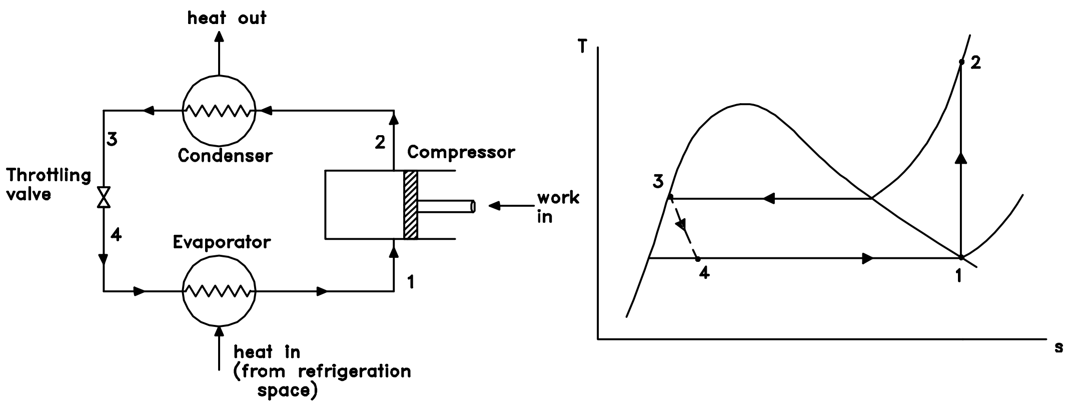


Part a) From the Freon-12 tables, we have

$$\begin{aligned}
h_1 &= h_g = 183.058\ kJ/kg \quad (at\ -10^\circ C) \\
s_1 &= s_g = 0.7014\ kJ/kg\cdot K \quad (at\ -10^\circ C) \\
h_3 &= h_f = 69.494\ kJ/kg \quad (at\ 35^\circ C) \\
P_3 &= P_2 = 0.8477\ MPa \quad \text{(saturation pressure at } 35^\circ C) \\
P_1 &= 0.2191\ MPa \quad \text{(saturation pressure at } -10^\circ C)
\end{aligned}$$

Since $s_2 = s_1$, state 2 is defined by $P_2 = 0.8477\ MPa$ and $s_2 = 0.7014\ kJ/kg\cdot K$. From the superheated tables of Freon-12, we have

$$h_2 = 205.632\ kJ/kg$$

For a throttling process, we have

$$h_3 = h_4 = 69.494\ kJ/kg$$

Thus the coefficient of performance is given by

$$
\begin{aligned}
COP_R &= \frac{h_1 - h_4}{h_2 - h_1} \\
&= \frac{183.058 - 69.494}{205.632 - 183.058} \\
&= 5.03
\end{aligned}
$$

Part b) The power required to produce 1 ton of refrigeration is related to the coefficient of performance according to the following expression

$$kW/ton = \frac{3.516}{COP_R}$$

Therefore

$$kW/ton = \frac{3.516}{5.03} = 0.699$$

Part c)

$$
\begin{aligned}
\dot{m} &= \frac{211\ kJ/min}{(h_1 - h_4)\ kJ/kg} \\
&= \frac{211}{183.058 - 69.494}\ kg/min \\
&= 1.858\ kg/min
\end{aligned}
$$

The operating temperature range in this example is typical of actual refrigeration systems designed for ordinary food-storage purposes. The power required to produce 1 ton of refrigeration for this type of plant is approximately 0.7 $kW$.