7-135 A Carnot refrigeration cycle is executed in a closed system with a fixed mass of R-134a. The net work input and the maximum and minimum temperatures are given. The mass fraction of the refrigerant that vaporizes during the heat addition process, and the pressure at the end of the heat rejection process are to be determined.

Properties The enthalpy of vaporization of R-134a at -8°C is h_{fg} = 204.52 kJ/kg (Table A-12).

Analysis The coefficient of performance of the cycle is

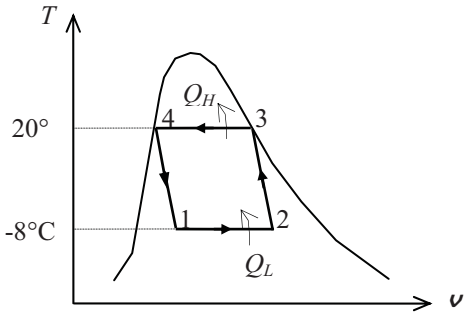
$$\text{COP}_\text{R} = \frac{1}{T_H / T_L - 1} = \frac{1}{293/265 - 1} = 9.464$$

and

$$Q_L = \text{COP}_\text{R} \times W_\text{in} = (9.464)(15\ \text{kJ}) = 142\ \text{kJ}$$

Then the amount of refrigerant that vaporizes during heat absorption is

$$Q_L = m h_{fg@T_L = -8^\circ\text{C}} \longrightarrow m = \frac{142\ \text{kJ}}{204.52\ \text{kJ/kg}} = 0.695\ \text{kg}$$



since the enthalpy of vaporization h_{fg} at a given T or P represents the amount of heat transfer per unit mass as a substance is converted from saturated liquid to saturated vapor at that T or P. Therefore, the fraction of mass that vaporized during heat addition process is

$$\frac{0.695\ \text{kg}}{0.8\ \text{kg}} = 0.868 \text{ or } \mathbf{86.8\%}$$

The pressure at the end of the heat rejection process is

$$P_4 = P_{\text{sat@20°C}} = \mathbf{572.1\ kPa}$$