

Given:

A Carnot refrigeration cycle is executed in a closed system in the saturated liquid-vapor mixture region using 0.8 kg of R-134a as the working fluid. The maximum and minimum temperatures in the cycle are 20°C and -8°C, respectively. It is known that R-134a is a saturated liquid at the end of the heat rejection process, and the net work input to the cycle is 15 kJ.

Required:

Determine the mass that vaporizes during the heat addition process and the pressure at the end of the heat rejection process.

Solution:

The maximum and minimum temperatures in the cycle are defined as

$$T_H := 20 \text{ }^{\circ}\text{C} = 293.15 \text{ K} \quad T_L := (-8) \text{ }^{\circ}\text{C} = 265.15 \text{ K}$$

The net work input to the cycle is defined as

$$\dot{W}_{net,in} := 15 \text{ kJ}$$

The COP of the cycle is found by

$$COP_{R,rev} := \frac{1}{\frac{T_H}{T_L} - 1} = 9.470$$

The heat accepted by the cycle is found by

$$\dot{Q}_{L,rev} := COP_{R,rev} \cdot \dot{W}_{net,in} = 142.0 \text{ kJ}$$

Going to Table A-11 @ T°C-8 shows that the amount of energy to vaporize R-134a is

$$h_{fg} := 204.52 \frac{\text{kJ}}{\text{kg}}$$

Thus the mass that vaporizes in the cycle is given by

$$m_{vap} := \frac{\dot{Q}_{L,rev}}{h_{fg}} = 0.6945 \text{ kg}$$

The pressure at the end of the heat rejection process is then just the saturation pressure at the minimum temperature so going to Table A-11 @ $T_H = 20 \text{ }^{\circ}\text{C}$ shows

$$P_{sat} := 572.07 \text{ kPa} \quad \text{so} \quad P_4 := P_{sat} = 572.1 \text{ kPa}$$