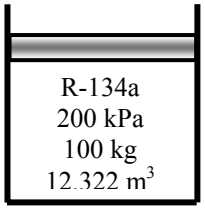
4-42 A piston-cylinder device that is filled with R-134a is cooled at constant pressure. The final temperature and the change of total internal energy are to be determined.

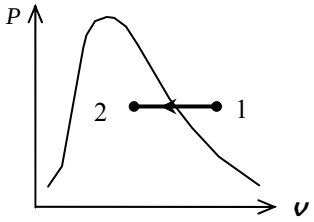


Analysis The initial specific volume is

$$v_1 = \frac{V}{m} = \frac{12.322\ \text{m}^3}{100\ \text{kg}} = 0.12322\ \text{m}^3/\text{kg}$$

The initial state is superheated and the internal energy at this state is

$$\left.\begin{array}{l} P_1 = 200\ \text{kPa} \\ v_1 = 0.12322\ \text{m}^3/\text{kg} \end{array}\right\} u_1 = 263.08\ \text{kJ/kg} \quad \text{(Table A-13)}$$



The final specific volume is

$$v_2 = \frac{v_1}{2} = \frac{0.12322\ \text{m}^3\ /\ kg}{2} = 0.06161\ \text{m}^3/\text{kg}$$

This is a constant pressure process. The final state is determined to be saturated mixture whose temperature is

$$T_2 = T_{\text{sat @ 200 kPa}} = \mathbf{-10.09^\circ C} \quad \text{(Table A-12)}$$

The internal energy at the final state is (Table A-12)

$$x_2 = \frac{v_2 - v_f}{v_{fg}} = \frac{(0.06161 - 0.0007533)\ \text{m}^3/\text{kg}}{(0.099867 - 0.0007533)\ \text{m}^3/\text{kg}} = 0.6140$$

$$u_2 = u_f + x_2 u_{fg} = 38.28 + (0.6140)(186.21) = 152.61\ \text{kJ/kg}$$

Hence, the change in the internal energy is

$$\Delta u = u_2 - u_1 = 152.61 - 263.08 = \mathbf{-110.47\ kJ/kg}$$

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