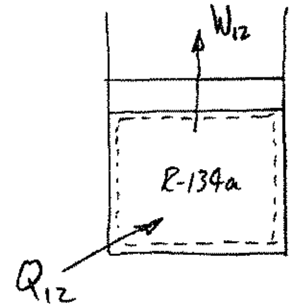
Given: R-134a in a piston-cylinder assembly



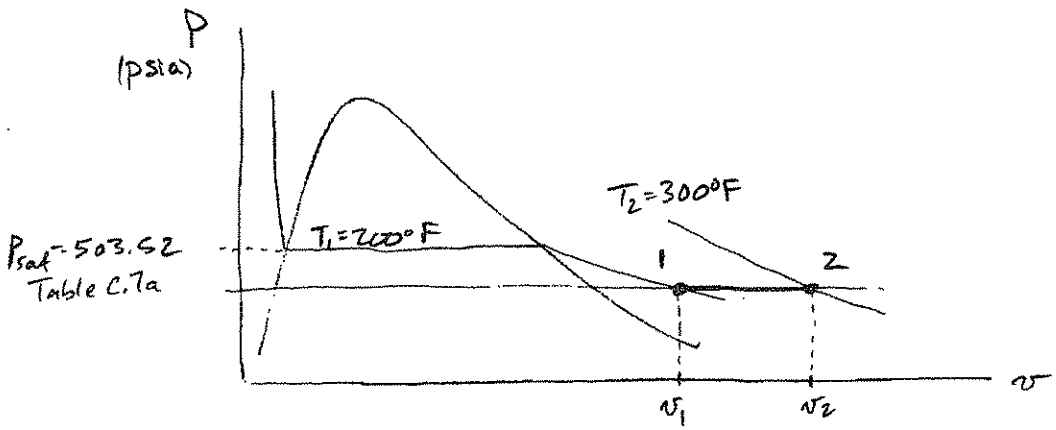
m = 1 lbm

P_1 = 200 psia
T_1 = 200°F
(P = const)

T_2 = 300°F

Find: W_{12} and Q_{12}

Solution: A P-v diagram of the process is helpful,



Properties (Table C.8a)

T_1 = 200°F
P_1 = 200 psia

v_1 = 0.2970 ft³/lbm
u_1 = 127.76 Btu/lbm
h_1 = 138.75 Btu/lbm
s_1 = 0.2494 Btu/lbm-R

T_2 = 300°F
P_2 = 200 psia

v_2 = 0.3671 ft³/lbm
u_2 = 152.10 Btu/lbm
h_2 = 165.69 Btu/lbm
s_2 = 0.2874 Btu/lbm-R

Applying the First Law to the system,

$$Q_{12} - W_{12} = m(u_2 - u_1) + \cancel{\Delta KE}^{\,0} + \cancel{\Delta PE}^{\,0}$$

From the P-v diagram (and in the problem statement), P = constant. Therefore,

$$W_{12} = \int_1^2 P\,d\forall = mP(v_2 - v_1)$$

$$W_{12} = (1\ \text{lbm})\left(200\ \frac{\text{lbf}}{\text{in}^2}\right)(0.3671 - 0.2970)\ \frac{\text{ft}^3}{\text{lbm}}\ \Bigg|\ \frac{144\ \text{in}^2}{\text{ft}^2}\ \Bigg|\ \frac{\text{Btu}}{778.16\ \text{ft-lbf}}$$

$$W_{12} = \underline{\underline{2.59\ \text{Btu}}} \longleftarrow$$ work done by the system

Then, from the First Law,

$$Q_{12} - W_{12} = m(u_2 - u_1)$$

$$Q_{12} = m(u_2 - u_1) + W_{12}$$

$$Q_{12} = (1\ \text{lbm})(152.10 - 127.76)\ \frac{\text{Btu}}{\text{lbm}} + 2.59\ \text{Btu}$$

$$Q_{12} = \underline{\underline{26.93\ \text{Btu}}} \longleftarrow$$

Reflection:

- The P-v diagram is helpful in identifying the phase of each state and in visualizing the work done.
- Both energy transfers are positive – Q is into the system and W is out of the system.