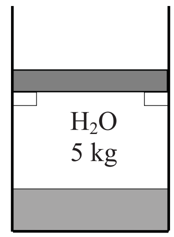
5-105 A cylinder equipped with a set of stops for the piston is initially filled with saturated liquid-vapor mixture of water a specified pressure. Heat is transferred to the water until the volume increases by 20%. The initial and final temperature, the mass of the liquid when the piston starts moving, and the work done during the process are to be determined, and the process is to be shown on a *P-v* diagram.

Assumptions The process is quasi-equilibrium.

Analysis (*a*) Initially the system is a saturated mixture at 125 kPa pressure, and thus the initial temperature is

$$T_1 = T_{\text{sat@125 kPa}} = \mathbf{106.0°C}$$

The total initial volume is



$$V_1 = m_f v_f + m_g v_g = 2\times 0.001048 + 3\times 1.3750 = 4.127\text{ m}^3$$

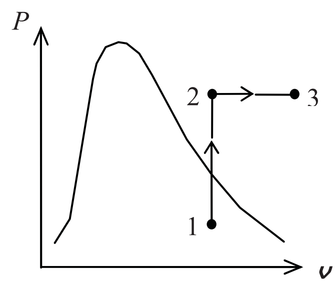
Then the total and specific volumes at the final state are

$$V_3 = 1.2V_1 = 1.2\times 4.127 = 4.953\text{ m}^3$$

$$v_3 = \frac{V_3}{m} = \frac{4.953\text{ m}^3}{5\text{ kg}} = 0.9905\text{ m}^3/\text{kg}$$

Thus,

$$\left.\begin{array}{l} P_3 = 300\text{ kPa} \\ v_3 = 0.9905\text{ m}^3/\text{kg} \end{array}\right\} T_3 = \mathbf{373.6°C}$$



(*b*) When the piston first starts moving, P_2 = 300 kPa and $V_2 = V_1$ = 4.127 m^3. The specific volume at this state is

$$v_2 = \frac{V_2}{m} = \frac{4.127\text{ m}^3}{5\text{ kg}} = 0.8254\text{ m}^3/\text{kg}$$

which is greater than v_g = 0.60582 m^3/kg at 300 kPa. Thus **no liquid** is left in the cylinder when the piston starts moving.

(*c*) No work is done during process 1-2 since $V_1 = V_2$. The pressure remains constant during process 2-3 and the work done during this process is

$$W_b = \int_2^3 P\,dV = P_2(V_3 - V_2) = (300\text{ kPa})(4.953 - 4.127)\text{m}^3\left(\frac{1\text{ kJ}}{1\text{ kPa}\cdot\text{m}^3}\right) = \mathbf{247.6\ kJ}$$