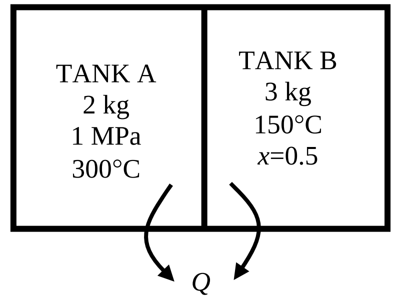
4-46 Two tanks initially separated by a partition contain steam at different states. Now the partition is removed and they are allowed to mix until equilibrium is established. The temperature and quality of the steam at the final state and the amount of heat lost from the tanks are to be determined.



Assumptions **1** The tank is stationary and thus the kinetic and potential energy changes are zero. **2** There are no work interactions.

Analysis (*a*) We take the contents of both tanks as the system. This is a closed system since no mass enters or leaves. Noting that the volume of the system is constant and thus there is no boundary work, the energy balance for this stationary closed system can be expressed as

$$\underbrace{E_{in} - E_{out}}_{\substack{\text{Net energy transfer}\\ \text{by heat, work, and mass}}} = \underbrace{\Delta E_{system}}_{\substack{\text{Change in internal, kinetic,}\\ \text{potential, etc. energies}}}$$

$$-Q_{out} = \Delta U_A + \Delta U_B = [m(u_2 - u_1)]_A + [m(u_2 - u_1)]_B \quad (\text{since } W = \text{KE} = \text{PE} = 0)$$

The properties of steam in both tanks at the initial state are (Tables A-4 through A-6)

$$\left.\begin{aligned} P_{1,A} &= 1000 \text{ kPa} \\ T_{1,A} &= 300°\text{C} \end{aligned}\right\} \begin{aligned} \boldsymbol{v}_{1,A} &= 0.25799 \text{ m}^3/\text{kg} \\ u_{1,A} &= 2793.7 \text{ kJ/kg} \end{aligned}$$

$$\left.\begin{aligned} T_{1,B} &= 150°\text{C} \\ x_1 &= 0.50 \end{aligned}\right\} \begin{aligned} \boldsymbol{v}_f &= 0.001091, \quad \boldsymbol{v}_g = 0.39248 \text{ m}^3/\text{kg} \\ u_f &= 631.66, \quad u_{fg} = 1927.4 \text{ kJ/kg} \end{aligned}$$

$$\boldsymbol{v}_{1,B} = \boldsymbol{v}_f + x_1 \boldsymbol{v}_{fg} = 0.001091 + [0.50 \times (0.39248 - 0.001091)] = 0.19679 \text{ m}^3/\text{kg}$$

$$u_{1,B} = u_f + x_1 u_{fg} = 631.66 + (0.50 \times 1927.4) = 1595.4 \text{ kJ/kg}$$

The total volume and total mass of the system are

$$\boldsymbol{V} = \boldsymbol{V}_A + \boldsymbol{V}_B = m_A \boldsymbol{v}_{1,A} + m_B \boldsymbol{v}_{1,B} = (2 \text{ kg})(0.25799 \text{ m}^3/\text{kg}) + (3 \text{ kg})(0.19679 \text{ m}^3/\text{kg}) = 1.106 \text{ m}^3$$

$$m = m_A + m_B = 3 + 2 = 5 \text{ kg}$$

Now, the specific volume at the final state may be determined

$$\boldsymbol{v}_2 = \frac{\boldsymbol{V}}{m} = \frac{1.106 \text{ m}^3}{5 \text{ kg}} = 0.22127 \text{ m}^3/\text{kg}$$

which fixes the final state and we can determine other properties

$$\left.\begin{aligned} P_2 &= 300 \text{ kPa} \\ \boldsymbol{v}_2 &= 0.22127 \text{ m}^3/\text{kg} \end{aligned}\right\} \begin{aligned} T_2 &= T_{sat\,@\,300\text{ kPa}} = \mathbf{133.5°C} \\ x_2 &= \frac{\boldsymbol{v}_2 - \boldsymbol{v}_f}{\boldsymbol{v}_g - \boldsymbol{v}_f} = \frac{0.22127 - 0.001073}{0.60582 - 0.001073} = \mathbf{0.3641} \\ u_2 &= u_f + x_2 u_{fg} = 561.11 + (0.3641 \times 1982.1) = 1282.8 \text{ kJ/kg} \end{aligned}$$

(*b*) Substituting,

$$\begin{aligned} -Q_{out} &= \Delta U_A + \Delta U_B = [m(u_2 - u_1)]_A + [m(u_2 - u_1)]_B \\ &= (2 \text{ kg})(1282.8 - 2793.7)\text{kJ/kg} + (3 \text{ kg})(1282.8 - 1595.4)\text{kJ/kg} = -3959 \text{ kJ} \end{aligned}$$

or

$$Q_{out} = \mathbf{3959\ kJ}$$