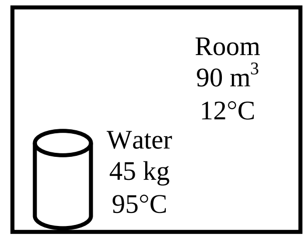
7-101 A container filled with liquid water is placed in a room and heat transfer takes place between the container and the air in the room until the thermal equilibrium is established. The final temperature, the amount of heat transfer between the water and the air, and the entropy generation are to be determined.

Assumptions **1** Kinetic and potential energy changes are negligible. **2** Air is an ideal gas with constant specific heats. **3** The room is well-sealed and there is no heat transfer from the room to the surroundings. **4** Sea level atmospheric pressure is assumed. P = 101.3 kPa.

Properties The properties of air at room temperature are R = 0.287 kPa.m^3/kg.K, c_p = 1.005 kJ/kg.K, c_v = 0.718 kJ/kg.K. The specific heat of water at room temperature is c_w = 4.18 kJ/kg.K (Tables A-2, A-3).

Analysis (a) The mass of the air in the room is



$$m_a = \frac{P\mathbf{V}}{RT_{a1}} = \frac{(101.3\,\text{kPa})(90\,\text{m}^3)}{(0.287\,\text{kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(12+273\,\text{K})} = 111.5\text{ kg}$$

An energy balance on the system that consists of the water in the container and the air in the room gives the final equilibrium temperature

$$0 = m_w c_w (T_2 - T_{w1}) + m_a c_v (T_2 - T_{a1})$$

$$0 = (45\,\text{kg})(4.18\,\text{kJ/kg.K})(T_2 - 95) + (111.5\,\text{kg})(0.718\,\text{kJ/kg.K})(T_2 - 12) \longrightarrow T_2 = \mathbf{70.2°C}$$

(b) The heat transfer to the air is

$$Q = m_a c_v (T_2 - T_{a1}) = (111.5\,\text{kg})(0.718\,\text{kJ/kg.K})(70.2 - 12) = \mathbf{4660\ kJ}$$

(c) The entropy generation associated with this heat transfer process may be obtained by calculating total entropy change, which is the sum of the entropy changes of water and the air.

$$\Delta S_w = m_w c_w \ln\frac{T_2}{T_{w1}} = (45\,\text{kg})(4.18\,\text{kJ/kg.K})\ln\frac{(70.2+273)\,\text{K}}{(95+273)\,\text{K}} = -13.11\,\text{kJ/K}$$

$$P_2 = \frac{m_a R T_2}{\mathbf{V}} = \frac{(111.5\,\text{kg})(0.287\,\text{kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(70.2+273\,\text{K})}{(90\,\text{m}^3)} = 122\text{ kPa}$$

$$\Delta S_a = m_a\left(c_p \ln\frac{T_2}{T_{a1}} - R\ln\frac{P_2}{P_1}\right)$$

$$= (111.5\,\text{kg})\left[(1.005\,\text{kJ/kg.K})\ln\frac{(70.2+273)\,\text{K}}{(12+273)\,\text{K}} - (0.287\,\text{kJ/kg.K})\ln\frac{122\,\text{kPa}}{101.3\,\text{kPa}}\right] = 14.88\,\text{kJ/K}$$

$$S_{\text{gen}} = \Delta S_{\text{total}} = \Delta S_w + \Delta S_a = -13.11 + 14.88 = \mathbf{1.77\ kJ/K}$$