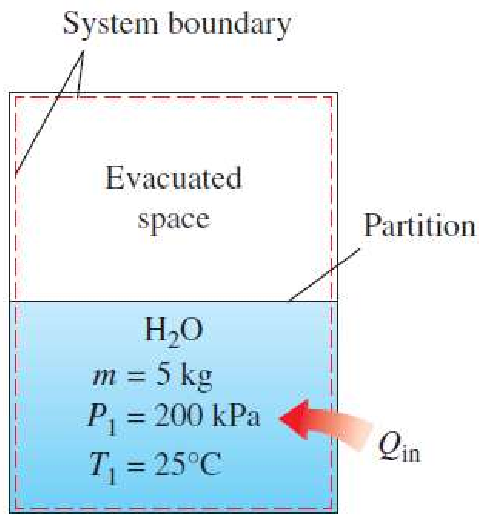
Given:

A rigid tank is divided into two equal parts by a partition. Initially, one side contains 5 kg of water at 200 kPa and 25 °C and the other side is evacuated (i.e., is a vacuum). Once the partition is removed, water expands into the evacuated space. During the expansion, the system is allowed to exchange heat with its surroundings to maintain its initial temperature of 25 °C.

$m := 5\ \text{kg}$ $\quad P_1 := 200\ \text{kPa}$ $\quad T_1 := 25\ °\text{C} = 298.15\ \text{K}$ $\quad T_2 := T_1 = 298.2\ \text{K}$

Required:



Determine the final pressure and the heat transfer for this process.

Solution:

Going to Table A-4 @ $T := T_1 = 25\ °\text{C}$ shows

$P_{sat} := 3.1698\ \text{kPa}$ $\quad \nu_f := 0.001003\ \frac{\text{m}^3}{\text{kg}}$ $\quad u_f := 104.83\ \frac{\text{kJ}}{\text{kg}}$

Since $P_1 > P_{sat}$, state 1 is a compressed liquid. However, the compressed liquid tables are inadequate for the given pressure and temperature. The saturated liquid value at T_1 will be used to approximate the specific volume and specific internal energy at state 1. This is shown below.

$\nu_1 := \nu_f = 0.001003\ \frac{\text{m}^3}{\text{kg}}$ $\quad u_1 := u_f = 104.8\ \frac{\text{kJ}}{\text{kg}}$

The volume occupied by the water is then

$$V_1 := m \cdot \nu_1 = 0.005015\ \text{m}^3$$

The volume occupied by the water after the partition is removed is

$$V_2 := 2 \cdot V_1 = 0.01003\ \text{m}^3$$

The specific volume then at state 2 is

$$\nu_2 := \frac{V_2}{m} = 0.002\ \frac{\text{m}^3}{\text{kg}}$$

Going to Table A-4 @ $T := T_2 = 25\ °\text{C}$ shows

$\nu_f := 0.001003\ \frac{\text{m}^3}{\text{kg}}$ $\quad \nu_g := 43.340\ \frac{\text{m}^3}{\text{kg}}$ $\quad P_{sat} := 3.1698\ \text{kPa}$

$u_f := 104.83\ \frac{\text{kJ}}{\text{kg}}$ $\quad u_g := 2409.1\ \frac{\text{kJ}}{\text{kg}}$

Since $\nu_2 > \nu_f$ and $\nu < \nu_g$, state 2 is in the two phase region. Thus,

$$P_2 := P_{sat} = 3.17\ \text{kPa}$$

The quality at state 2 is then

$$x_2 := \frac{\nu_2 - \nu_f}{\nu_g - \nu_f} = 2.3143 \cdot 10^{-5}$$

The specific internal energy at state 2 is then

$$u_2 := x_2 \cdot \left(u_g - u_f\right) + u_f = 104.9\ \frac{\text{kJ}}{\text{kg}}$$

Solution (cont.):
1st Law for closed system with no KE and PE

$$\Delta E_{sys} = \Sigma E_{in} - \Sigma E_{out}$$

$$\Delta U + \Delta KE + \Delta PE = \Delta U = \Sigma E_{in} - \Sigma E_{out}$$

$$\Delta U = Q_{in}$$

$$m \cdot \Delta u = Q_{in}$$

Solving for the heat transfer term yields

$$\boxed{Q_{in} := m \cdot \left(u_2 - u_1\right) = 266.6\ J}$$

Since Q_{in} is positive, the heat is being absorbed by the system or the heat is being added to the system.