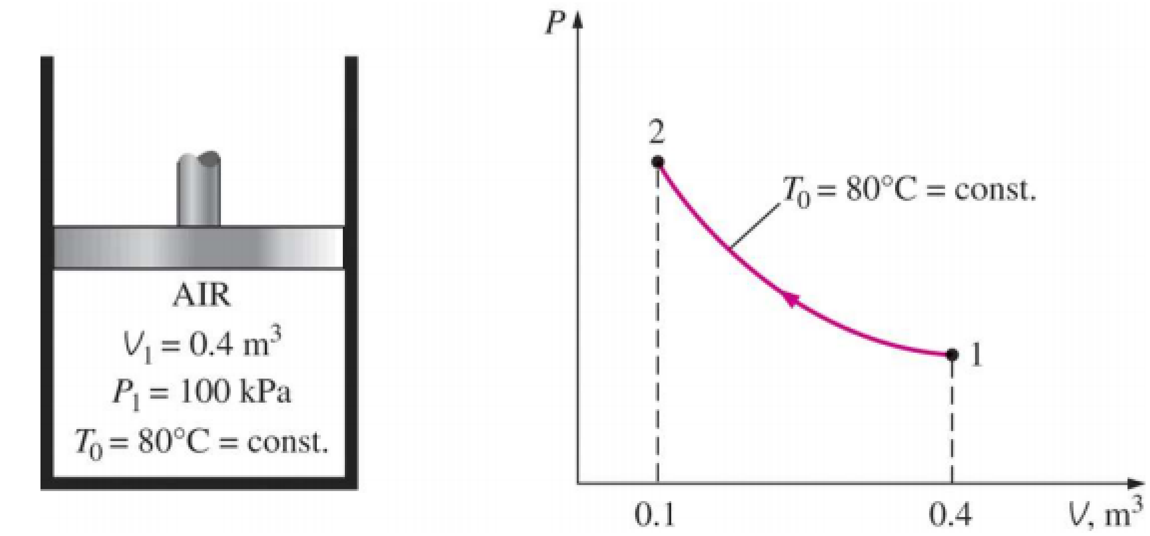
EX_4

EX 4.1

A piston-cylinder device initially contains $0.4\ m^3$ of air at $100\ kPa$ and at $80°C$. The air is now compressed to $0.1\ m^3$ in such a way that the temperature inside the cylinder remains constant.

Determine the work done during this process



since the process is a process where the temperature remains the constant

$$PV = nRT$$

$$nR = \frac{P_1 V_1}{T_0}$$

$$W = \int nRT_0 \frac{1}{V} \mathrm{d}V$$

$$= -P_1 V_1 \ln \frac{V_1}{V_2}$$

$$= -100\ kPa \times 0.4\ m^3 \times \ln 4$$

$$= -55.45\ kJ$$

EX 4.2

A rigid tank is divided into two equal parts by a partition. Initially, one side of the tank obtains $5\ kg$ of water at $200\ kPa$ and $25^\circ C$, and the other side is evacuated. The partition is then removed, and the water extends into the entire tank. The water returns to the initial value of $25^\circ C$

Determine (a) the volume of the tank, (b) the final pressure, and (c) the heat transfer for this process

(a)

Finding the data of the Table A-4 on p.904, we can get the water is in compressed situation, find $v_f = 0.001003m^3/kg$

$$V_1 = mv_f = 5 \times 0.001 = 0.005m^3$$

$$V_2 = 2V_1 = 0.01m^3$$

(b)

$$v_2 = \frac{0.01}{5} = 0.002\ m^3/kg$$

which is in the range of the v_f and v_g, which is the saturated water, therefore, the pressure is $P_{sat} = 3.1698kPa$

(c)

$$0.001003x + 43.340(5 - x) = 0.01$$

$$x = 4.999885\ kg$$

$$U_1 = m \cdot u_f = 5\ kg \times 104.83\ kJ/kg = 524.15\ kJ$$

$$U_2 = x \cdot 104.83 + (5 - x) \cdot 2409.1 = 524.41\ kJ$$

$$Q_{in} = U_2 - U_1 = 0.26\ kJ$$

EX 4.3

Air at $300\ K$ and $200\ kPa$ is heated at constant pressure to $600\ K$. Determine the change in internal energy of air per unit mass, using (a) data from the table (Table A-17), (b) the functional form of the specific heat (Table A-2c), and (c) the average specific heat value (Table A-2b)

(a)

$$\begin{aligned}\Delta u &= u_2 - u_1 \\ &= 434.78 - 214.07 \\ &= 220.71kJ\end{aligned}$$

(b)

$$\bar{c}_p = a + bT + cT^2 + dT^3$$

$$\Delta\bar{u} = \int_{T_1}^{T_2} (\bar{c}_p - R_u)\mathrm{d}T$$

$$= \left[(a - R_u)T + \frac{1}{2}bT^2 + \frac{1}{3}cT^3 + \frac{1}{4}dT^4\right]_{300}^{600}$$

$$= \left[19.80T + \frac{1}{2} \times 0.1967 \times 10^{-2}T^2 + \frac{1}{3} \times 0.4802 \times 10^{-5}T^3 - \frac{1}{4} \times 1.966 \times 10^{-9}T^4\right]_{300}^{600}$$

$$= 6447.01kJ/mol$$

$$\Delta u = \frac{\Delta\bar{u}}{M} = \frac{6447.01}{28.97} = 222.54kJ$$

(c)

$$\Delta u = c_{v,avg}\Delta T$$

$$= 0.733 \times 300$$

$$= 219.9kJ$$