Homework 6 Solutions.

3-27 *Complete the following table for H_2O*:

T, °C	P, kPa	*h*, kJ / kg	*x*	Phase description
120.21	200	***2045.8***	0.7	***Saturated mixture***
140	***361.53***	1800	***0.565***	***Saturated mixture***
177.66	950	***752.74***	0.0	***Saturated liquid***
80	500	***335.37***	**- - -**	***Compressed liquid***
350.0	800	3162.2	**- - -**	***Superheated vapor***

3-28 *Complete the following table for Refrigerant-134a*:

T, °C	P, kPa	*v*, m^3 / kg	Phase description
-8	320	***0.0007569***	***Compressed liquid***
30	***770.64***	0.015	***Saturated mixture***
-12.73	180	***0.11041***	Saturated vapor
80	600	***0.044710***	***Superheated vapor***

3-88 The specific volume of steam is to be determined using the ideal gas relation, the compressibility chart, and the steam tables. The errors involved in the first two approaches are also to be determined.

Properties The gas constant, the critical pressure, and the critical temperature of water are, from Table A-1,

$$R = 0.4615 \text{ kPa·m}^3\text{/kg·K}, \qquad T_{cr} = 647.1 \text{ K}, \qquad P_{cr} = 22.06 \text{ MPa}$$

Analysis (*a*) From the ideal gas equation of state,

$$v = \frac{RT}{P} = \frac{(0.4615 \text{ kPa}\cdot\text{m}^3\text{/kg}\cdot\text{K})(673 \text{ K})}{(10{,}000 \text{ kPa})} = \mathbf{0.03106 \ m^3/kg \ \ (17.6\% \ error)}$$

(*b*) From the compressibility chart (Fig. A-15),

$$\left.\begin{aligned} P_R &= \frac{P}{P_{cr}} = \frac{10 \text{ MPa}}{22.06 \text{ MPa}} = 0.453 \\ T_R &= \frac{T}{T_{cr}} = \frac{673 \text{ K}}{647.1 \text{ K}} = 1.04 \end{aligned}\right\} Z = 0.84$$

Thus,

$$v = Zv_{\text{ideal}} = (0.84)(0.03106 \text{ m}^3/\text{kg}) = \mathbf{0.02609 \ m^3/kg} \quad \textbf{(1.2\% error)}$$

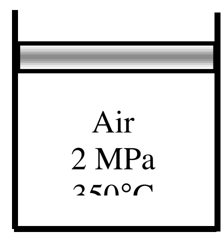
(c) From the superheated steam table (Table A-6),

$$\left.\begin{aligned} P &= 10 \text{ MPa} \\ T &= 400°\text{C} \end{aligned}\right\} v = \mathbf{0.02644 \ m^3/kg}$$

4-25 A piston-cylinder device contains air gas at a specified state. The air undergoes a cycle with three processes. The boundary work for each process and the net work of the cycle are to be determined.

Properties The properties of air are $R = 0.287$ kJ/kg.K , $k = 1.4$ (Table A-2a).

Analysis For the isothermal expansion process:



$$V_1 = \frac{mRT}{P_1} = \frac{(0.15 \text{ kg})(0.287 \text{ kJ/kg.K})(350 + 273 \text{ K})}{(2000 \text{ kPa})} = 0.01341 \text{ m}^3$$

$$V_2 = \frac{mRT}{P_2} = \frac{(0.15 \text{ kg})(0.287 \text{ kJ/kg.K})(350 + 273 \text{ K})}{(500 \text{ kPa})} = 0.05364 \text{ m}^3$$

$$W_{b,1-2} = P_1V_1 \ln\left(\frac{V_2}{V_1}\right) = (2000 \text{ kPa})(0.01341 \text{ m}^3)\ln\left(\frac{0.05364 \text{ m}^3}{0.01341 \text{ m}^3}\right) = \mathbf{37.18 \ kJ}$$

For the polytropic compression process:

$$P_2V_2^n = P_3V_3^n \longrightarrow (500 \text{ kPa})(0.05364 \text{ m}^3)^{1.2} = (2000 \text{ kPa})V_3^{1.2} \longrightarrow V_3 = 0.01690 \text{ m}^3$$

$$W_{b,2-3} = \frac{P_3V_3 - P_2V_2}{1-n} = \frac{(2000 \text{ kPa})(0.01690 \text{ m}^3) - (500 \text{ kPa})(0.05364 \text{ m}^3)}{1-1.2} = \mathbf{-34.86 \ kJ}$$

For the constant pressure compression process:

$$W_{b,3-1} = P_3(V_1 - V_3) = (2000 \text{ kPa})(0.01341 - 0.01690)\text{m}^3 = \mathbf{-6.97 \ kJ}$$

The net work for the cycle is the sum of the works for each process

$$W_{\text{net}} = W_{b,1-2} + W_{b,2-3} + W_{b,3-1} = 37.18 + (-34.86) + (-6.97) = \mathbf{-4.65 \ kJ}$$