Thermodynamics I

# Lecture 13

# Property Tables (Ch-3)

**(Drawing Processes on Property Diagrams)**

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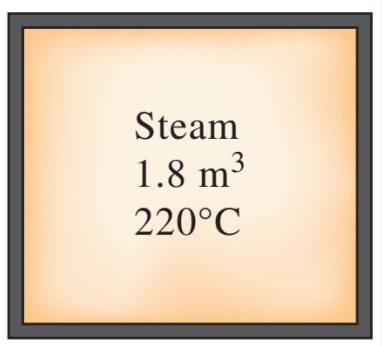
# Exercise:

A 1.8-m³ rigid tank contains steam at 220°C. One-third of the volume is in the liquid phase and the rest is in the vapor form. Determine (*a*) the pressure of the steam, (*b*) the quality of the saturated mixture, and (*c*) the density of the mixture.

**The pressure of the steam is the saturation pressure at the given temperature**




$$P = T_{\text{sat@220°C}} = \mathbf{2320\ kPa}$$

(*b*) The total mass and the quality are determined as

## Remember:

$$m_t = m_f + m_g$$

$$V = m\upsilon$$

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- $$V = m\upsilon$$

$$\boxed{m_f = \frac{V_f}{\upsilon_f}} \quad \boxed{= \frac{1/3 \times (1.8\ \text{m}^3)}{0.001190\ \text{m}^3/\text{kg}} = 504.2\ \text{kg}}$$

$$\boxed{m_g = \frac{V_g}{\upsilon_g}} \quad \boxed{= \frac{2/3 \times (1.8\ \text{m}^3)}{0.08609\ \text{m}^3/\text{kg}} = 13.94\ \text{kg}}$$

- $$\boxed{m_t = m_f + m_g = 504.2 + 13.94 = 518.1\ \text{kg}}$$

- $$\boxed{x = \frac{m_g}{m_t} = \frac{13.94}{518.1} = \mathbf{0.0269}}$$

(*c*) the density of the mixture.

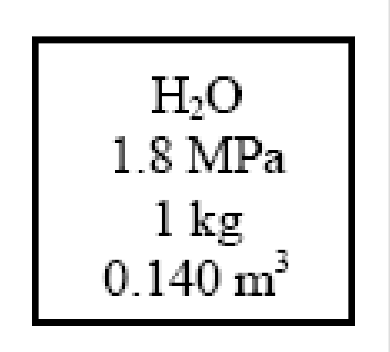
**Remember:** $v = v_f + x(v_g - v_f)$

$$= 0.001190 + (0.0269)(0.08609) = 0.003474 \text{ m}^3/\text{kg}$$

- $\rho = \frac{1}{v} = \frac{1}{0.003474} =$ **287.8 kg/m³**

# Exercise:

One kilogram of Water fills a 0.140 m³ rigid container at an initial pressure of 1.8 MPa. The container is then cooled to 40˚C. Determine the initial temperature and final pressure of the water.




*Analysis* The initial state is superheated vapor. The temperature is determined to be

$$\left.\begin{aligned} P_1 &= 1.8\ \text{MPa} \\ \upsilon_1 &= 0.140\ \text{m}^3/\text{kg} \end{aligned}\right\} T_1 = \mathbf{300°C} \quad \text{(Table A-6)}$$

$$\left.\begin{aligned} T_2 &= 40°\text{C} \\ \upsilon_2 &= \upsilon_1 = 0.140\ \text{m}^3/\text{kg} \end{aligned}\right\} P_2 = P_{\text{sat @ }40°\text{C}} = \mathbf{7.3851\ kPa} \ \text{(Table A-4)}$$

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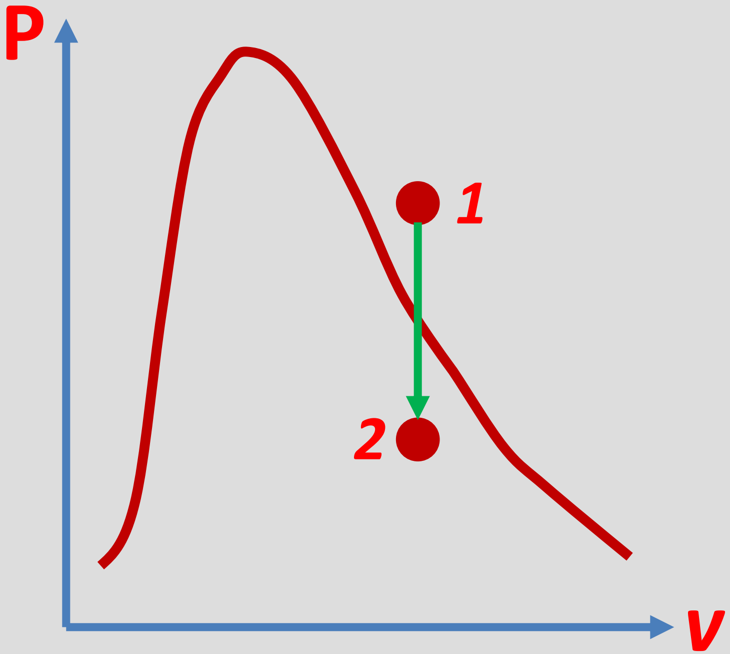
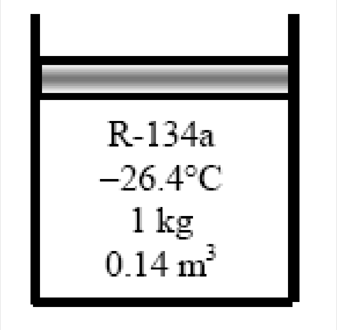


# Exercise:

One kilogram of R -134a fills a 0.14 $m^3$ weighted piston-cylinder device at a temperature of – 26.4 ˚C. The container is now heated until the temperature is 100 ˚C. Determine the final volume of the R-134a.




*Analysis* The initial specific volume is

$$v_1 = \frac{V_1}{m} = \frac{0.14\,\text{m}^3}{1\,\text{kg}} = 0.14\,\text{m}^3/\text{kg}$$

This is a constant-pressure process. The initial state is determined to be a mixture, and thus the pressure is the saturation pressure at the given temperature

$$P_1 = P_2 = P_{\text{sat @ -26.4°C}} = 100\,\text{kPa} \quad \text{(Table A-12)}$$

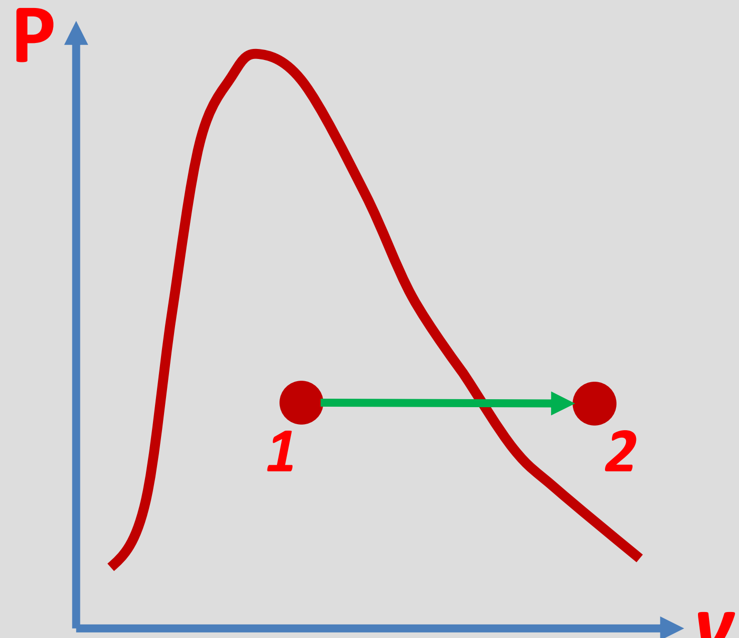
# Exercise

The final state is superheated vapor and the specific volume is

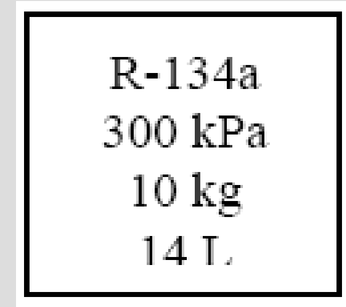
$$\left.\begin{array}{l} P_2 = 100\,\text{kPa} \\ T_2 = 100°\text{C} \end{array}\right\} v_2 = 0.30138\,\text{m}^3/\text{kg} \quad (\text{Table A-13})$$

The final volume is then

$$V_2 = m v_2 = (1\,\text{kg})(0.30138\,\text{m}^3/\text{kg}) = \mathbf{0.30138\,m^3}$$



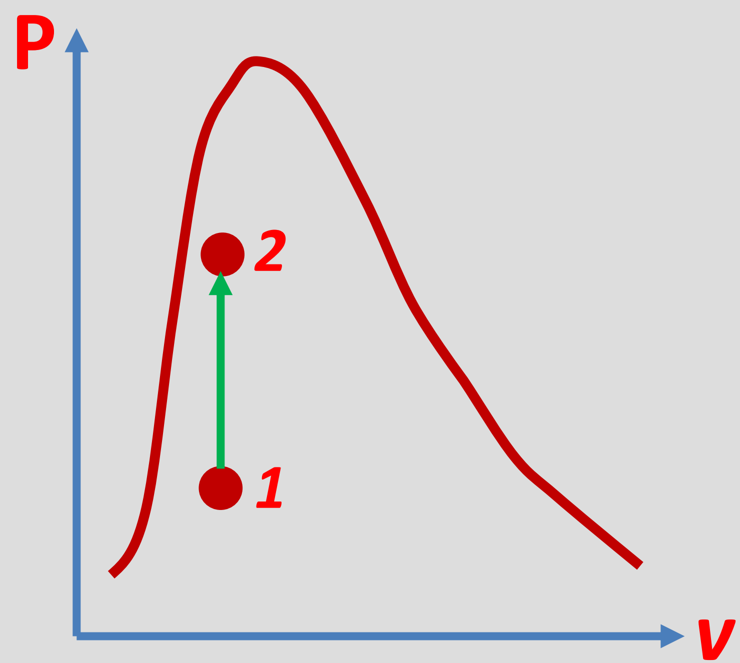
# Exercise 3-38




10 kg of R -134a at 300 kPa fills a rigid container whose volume is 14 L. Determine the temperature and total enthalpy in the container. The container is now heated until the pressure is 600 kPa. Determine the temperature and total enthalpy when the heating is completed.

*Analysis* This is a constant volume process. The specific volume is

$$v_1 = v_2 = \frac{V}{m} = \frac{0.014\,\mathrm{m}^3}{10\,\mathrm{kg}} = 0.0014\,\mathrm{m}^3/\mathrm{kg}$$



# Exercise 3-38

From Table A-12 by interpolation

$$T_1 = T_{\text{sat @ 300 kPa}} = \mathbf{0.61^\circ C}$$

$$x_1 = \frac{v_1 - v_f}{v_{fg}} = \frac{(0.0014 - 0.0007736)\ \text{m}^3/\text{kg}}{(0.067978 - 0.0007736)\ \text{m}^3/\text{kg}} = 0.009321$$

$$h_1 = h_f + x_1 h_{fg} = 52.67 + (0.009321)(198.13) = 54.52\ \text{kJ/kg}$$

The total enthalpy is then

$$H_1 = mh_1 = (10\ \text{kg})(54.52\ \text{kJ/kg}) = \mathbf{545.2\ kJ}$$

# Exercise 3-38

The final state is also saturated mixture. Repeating the calculations at this state,

$$T_2 = T_{\text{sat @ 600 kPa}} = \mathbf{21.55°C}$$

$$x_2 = \frac{v_2 - v_f}{v_{fg}} = \frac{(0.0014 - 0.0008199)\ \text{m}^3/\text{kg}}{(0.034295 - 0.0008199)\ \text{m}^3/\text{kg}} = 0.01733$$

$$h_2 = h_f + x_2 h_{fg} = 81.51 + (0.01733)(180.90) = 84.64\ \text{kJ/kg}$$

$$H_2 = mh_2 = (10\ \text{kg})(84.64\ \text{kJ/kg}) = \mathbf{846.4\ kJ}$$