We know two intensive properties, pressure and specific volume; the state, therefore, is fully specified. We must locate a point in the steam tables with $P = 40$ bar, $V = 0.06\ \mathrm{m^3/kg}$. From the entries at 40 bar we obtain the following data:

$$T_1 = 300\ ^\circ\mathrm{C} \quad V_1 = 0.0589\ (\mathrm{m^3/kg})$$
$$T_2 = 350\ ^\circ\mathrm{C} \quad V_2 = 0.0665\ (\mathrm{m^3/kg}).$$

Interpolating for temperature at $V = 0.06\ \mathrm{m^3/kg}$ we have

$$T = \overset{300}{\cancel{0.0589}} + \frac{\overset{350 - 300}{\cancel{0.0665} - \cancel{0.0589}}}{\underset{0.0665 - 0.0589}{\cancel{350} - \cancel{300}}}(0.06 - 0.0589) = 307.2\ ^\circ\mathrm{C}.$$

Therefore, the temperature in the tank is 307.2 °C.

Example 2.6: Lever Rule

An additional 170 kg of steam is added to the tank of the previous example. If the final pressure is 50 bar, determine the temperature and phase of the contents of the tank.

Solution The new specific volume is

$$V = \frac{12\ \mathrm{m^3}}{(200 + 170)\ \mathrm{kg}} = 0.03243\ \mathrm{m^3/kg}.$$

This volume lies between the volume of the saturated liquid and saturated vapor at 50 bar:

$$P = 50\ \mathrm{bar} \quad T = 263.94\ ^\circ\mathrm{C}: \quad V_L = 0.0012864\ \mathrm{m^3/kg}, \quad V_V = 0.039446\ \mathrm{m^3/kg}.$$

The state, therefore, is wet steam at 50 bar, 263.94 °C. To determine the mass fractions of each phase we use the lever rule in eq. (2.10):

$$x_L = \frac{0.039446 - 0.03243}{0.039446 - 0.0012864} = 0.184 = 18.4\%,$$
$$x_V = 1 - x_L = 1 - 0.184 = 0.816 = 81.6\%.$$

Therefore, the quality of the steam in the tank is 81.6%.

2.3 Compressibility Factor and the *ZP* Graph

The compressibility factor, Z, is defined as the ratio

$$Z = \frac{PV}{RT}, \tag{2.16}$$

Second printing corrections for Matsoukas, Fundamentals of Chemical Engineering Thermodynamics (9780132693066).
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