Example van der Waals Equation of State (CO_2)

$T_c := 304.2K$ $\quad R := 8.314 \frac{J}{mol \cdot K}$ $\quad P := 50atm$

$P_c := 72.9atm$ $\quad T := 400K$

Define Interaction Parameters

$$a := \frac{27 \cdot R^2 \cdot T_c^{\,2}}{64 \cdot P_c} \qquad a = 0.365 \frac{m^5 \cdot kg}{mol^2 \cdot s^2}$$

$$b := \frac{R \cdot T_c}{8 \cdot P_c} \qquad b = 4.28 \times 10^{-5} \frac{m^3}{mol}$$

Define Function- equation to solve for volume

$$f(V) := P - \frac{R \cdot T}{V - b} + \frac{a}{V^2} \qquad f\left(2 \frac{L}{mol}\right) = 3.458 \times 10^6 Pa$$

Define initial guess using ideal gas law. Use Root Function to Solve

$$V := \frac{R \cdot T}{P} \qquad V = 0.656 \cdot \frac{L}{mol}$$

$$V_{vdw} := root(f(V), V) \qquad V_{vdw} = 0.585 \cdot \frac{L}{mol} \qquad ratio := \frac{V_{vdw}}{V}$$

Compare to Corresponding States From Table 5.4-2 $ratio = 0.891$

$$T_r := \frac{T}{T_c} \qquad T_r = 1.315 \qquad z := 0.91$$

$$P_r := \frac{P}{P_c} \qquad P_r = 0.686 \qquad V_{cs} := \frac{z \cdot R \cdot T}{P} \qquad V_{cs} = 0.597 \cdot \frac{L}{mol}$$

Redefine function with P as a variable to facilitate range calculations

$$f(V,P) := P - \frac{R \cdot T}{V - b} + \frac{a}{V^2} \qquad P := 0atm, .01atm .. 10atm$$

$$V_{vdw}(P) := root(f(V,P),V) \qquad V_{ideal}(P) := \frac{R \cdot T}{P}$$