5.51 Let's start with van der Waals equation in the form of equation 5.49

\[
\left( P + \frac{aN^2}{V^2} \right) (V - Nb) = NkT
\]

Using our definition of the reduced variables,

\[
T = \frac{t^*}{T_c} = \left( \frac{8a}{27bK} \right) t^*
\]

\[
P = \frac{p}{P_c} = \left( \frac{1}{27b^*} \right) p
\]

\[
V = \frac{v}{V_c} = 3Nb^* v
\]

Plug these into the van der Waals equation

\[
\left( \frac{\frac{1}{27b^*} p + \frac{aN^2}{9Nb^*V^2}}{9N^2b^*V^2} \right) \left( 3Nb^*v - Nb^* \right) = Nk \left( \frac{\frac{8a}{27bK}}{27bK} \right) t^*
\]

\[
\left( \frac{p}{27} + \frac{1}{9v^2} \right) (3v - 1) = \frac{8t^*}{27}
\]

\[
\left( \frac{p + \frac{3}{V^2}}{V^2} \right) (3v - 1) = 8t^*
\]