We have a few loose ends:
For the van der Walls EOS in dimensionless form:
\[
\begin{align*}
    P^* &= \frac{Pb^2}{a} \\
    V^* &= \frac{V}{b} \\
    T^* &= \frac{RTb}{a}
\end{align*}
\]
We get:
\[
P^* = \frac{T^*}{(V^*-1)} - \frac{1}{V^*^2}
\]
We noticed that a point of inflection developed at the critical point.
What does this mean in terms of \(\frac{\partial V_c^*}{\partial P_c^*}\)_{Tc^*} ; \(\frac{\partial^2 V_c^*/\partial P_c^*}{\partial P_c^*}Tc^*\)?
We get \(Vc^* = 3\) \(\rightarrow Vc = 3b\)
\(Pc^* = 1/27 \rightarrow Pc = a/27b^2\)
\(Tc^* = 8/27 \rightarrow Tc = 8a/27Rb\)
\[
Zc = \frac{Pc*Vc*/Tc*}{Tc*} = \frac{PcVc}{RTc} = 3/8
\]
This suggests another form of dimensionless representation, reduced variables:
\[
\begin{align*}
    Pr &= P/Pc ; Tr = T/Tc ; Vr = V/Vc \\
    P^* &= \frac{Pr}{27} ; V^* = 3Vr ; T^* = 8 Tr/27
\end{align*}
\]
The van der Walls equation becomes:
\[ Pr = \frac{8Tr}{(3Vr-1)} - \frac{3}{Vr^2} \]

Or

\[ \frac{Z}{Zc} = \frac{PrVr}{Tr} = \frac{8Vr}{(3Vr-1)} - \frac{3}{TrVr} \]

\[ Z = \frac{3Vr}{(3Vr-1)} - \frac{9}{8TrVr} \]

We have remarked that these dimensionless forms are applicable for all materials which obey the van der Waals EOS. The van der Waals EOS is not a very accurate representation. But this approach suggests the following:

*All fluids have approximately the same compressibility factor when at the same reduced pressures and temperatures. Further, they reflect a similar deviation from ideal gas behavior.*

**Principal of Corresponding States**

We employ this concept for the generalized correlations as well as in many (most) equations of state: van der Waals, Peng Robinson, Redlich-Kwong etc.
Total or Partial

\[ T_{in} \quad aA + bB \quad T_{out} \]

\[ cC + dD \]

\[ Q(\Delta H) \]

\[ aA + bB \rightarrow cC + dD \]

Information available at stp, 298.15K, 1 bar

\[ \Delta H_f^0 \text{ in table E-6} \]

Elements

\[(C, O_2, H_2, Cl_2, N_2, S...etc.)\]

\[ \Delta H_f^0(CO) \]

\[ \Delta H_f^0(H_2O) \]

\[ \Delta H_f^0(CO_2) \]

\[ \Delta H_f^0(H_2) = 0 \]

\[ CO + H_2O \rightarrow CO_2 + H_2 \]

\[ \Delta H_{react}^0 @ stp \]

\[ c, d = 1 \text{ and } a, b = -1 \text{ call them } v_i \]

\[ \Delta H_{react}^0 = \sum v_i \Delta H_{fi} \]
What do we do about the heat involved in reacting systems?

First we need to understand the reaction, balance the equation first:

\[ aA + bB \rightarrow cC + dD \]

\( a, b, c, d \) are the stoichiometric coefficients, e.g.:

- \( O_2 + C_2H_4 \rightarrow C_2H_4O \) ethylene epoxidation
- \( O_2 + C_2H_4 \rightarrow CO_2 + H_2O \) combustion
- \( HCl + O_2 \rightarrow H_2O + Cl_2 \) Deacon
- \( H_2S + SO_2 \rightarrow H_2O + S \) Claus
- \( H_2S + O_2 \rightarrow H_2O + SO_2 \)

**What to do next** - Look up \( \Delta H_f^0 \) for each of the Reactants and Products (Table E-6, note at 298K).

\[ \Delta H^{0\text{react}}(298K) = \sum v_i \Delta H_f^{0i} \]

What happens when we multiply all stoichiometric coefficients by a constant?
We now know the $\Delta H$ of reaction at 298 but need the $\Delta H$ at another temperature(s)!
$\text{CH}_4 + \frac{3}{2}\text{O}_2 \rightarrow \text{CO} + 2\text{H}_2\text{O}$

$\Delta H^0_{\text{react}} (298K)$

$\text{Temp.}$

$\text{Tin}$

$\text{Tout}$

$\text{CO} + 2\text{H}_2\text{O}$
Questions Remain: If only partial reaction?
If reaction reaches equilibrium?
If a diluent is present (e.g., N₂ in air)?
If multiple reactions?

Compress

Q

Exchange

Turbine

Substitute for "Claude"

Throttle "Linde"

liquid out