Observations

In the three diagrams above (PV, PH, and PU), the horizontal part of the 0°C isotherm describes the liquid-vapor equilibrium for carbon dioxide. Any point on this horizontal represents where two phases—saturated liquid and saturated vapor—coexist in equilibrium.

**Point L** is the saturated liquid phase, where its specific volume is \( \hat{V}_{\text{SL}} \), its specific enthalpy is \( \hat{H}_{\text{SL}} \), and its specific internal energy is \( \hat{U}_{\text{SL}} \).

**Point V** is the saturated vapor, where its specific volume is \( \hat{V}_{\text{SV}} \), its specific enthalpy is \( \hat{H}_{\text{SV}} \), and its specific internal energy \( \hat{U}_{\text{SV}} \).

**Point T** is a representative example of the vapor-liquid equilibrium, where its specific volume is \( \hat{V}_{\text{T}} \), its specific enthalpy is \( \hat{H}_{\text{T}} \), and its specific internal energy \( \hat{U}_{\text{T}} \).

The specific properties at Points L, T, and V are related through the reverse lever rule using the vapor fraction (\( V_f \)) and liquid fraction (\( L_f \)). See the equilibrium relationships on the next page for any pure-compound system, like pure carbon dioxide.

If you compare the PH diagram above with the PU diagram above, you’ll note that the isotherms in the PH diagram curve back at high pressures. Remember that by definition
\[
\hat{H} = \hat{U} + P \hat{V}.
\]

The Chemicalogic™ Corporation provides software for the carbon dioxide system. [Click here](#) to see their phase diagram, and [click here](#) to see their PH diagram for carbon dioxide. Note the reference state for the Chemicalogic PH diagram is not the same as that for the NIST PH diagram above.
If you substitute $L_i = 1 - V_i$ into this equation and algebraically solve for $V_i$, then you will have derived an equation for the reverse lever rule.

**Diagram**

- Isothermal vapor
  - $T_v = T_b$
  - $p_v = p^*$
  - $n_v = n_i$ (pure component)
  - $Y_{PC} = 1.0$

- Isothermal liquid
  - $T_L = T_b$
  - $p_L = p^*$
  - $n_L = n_i$
  - $X_{PC} = 1.0$

- Thermal equlibrium: $T_v = T_L = T_b$ (boiling temperature)

**PT Diagram**

- Solid
- Liquid
- Supercritical fluid

**PVT Diagram**

- Solid
- Liquid
- Gas

For $p^* = 1$ atm, $T_b = T_{bwp}$ found in Table B.1, F+R, 3rd Ed.

For vapor and liquid coexisting at same time, line in PT diagram between triple point and critical point is modeled by the Antoine Equation: $\log_{10} p^* = A - \frac{B}{T + c}$ as given in Table B.4, F+R, 3rd Ed.