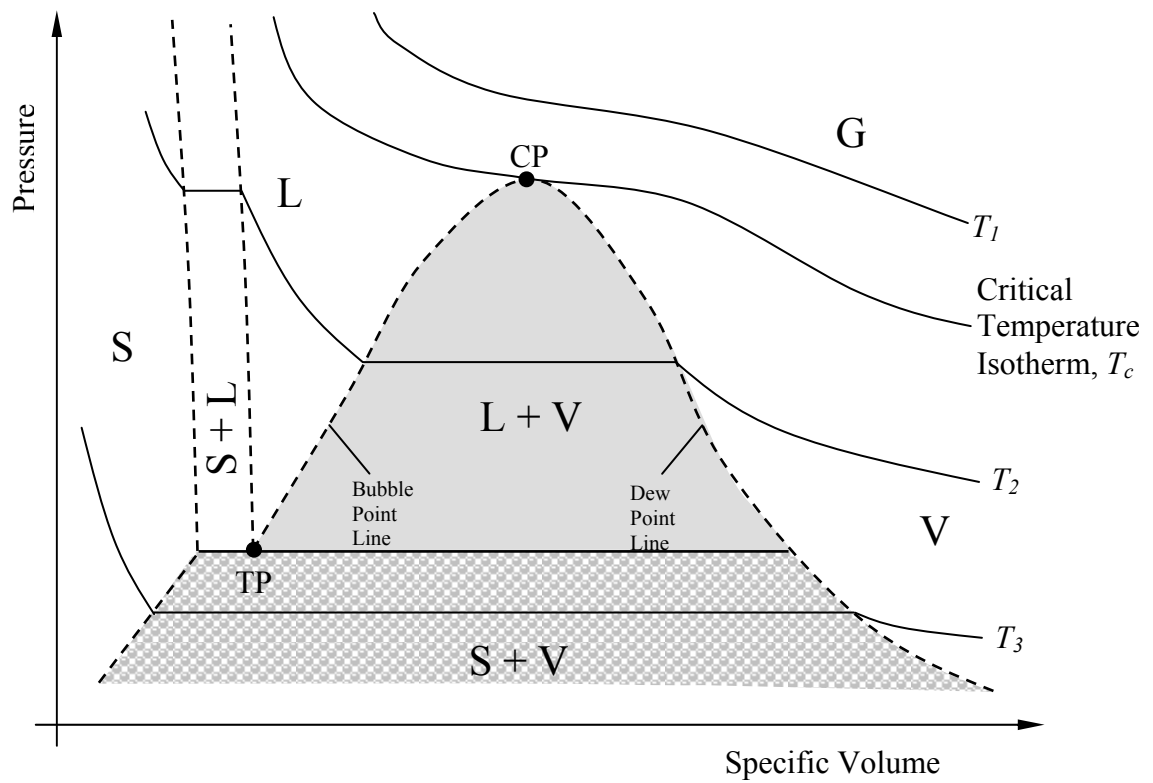
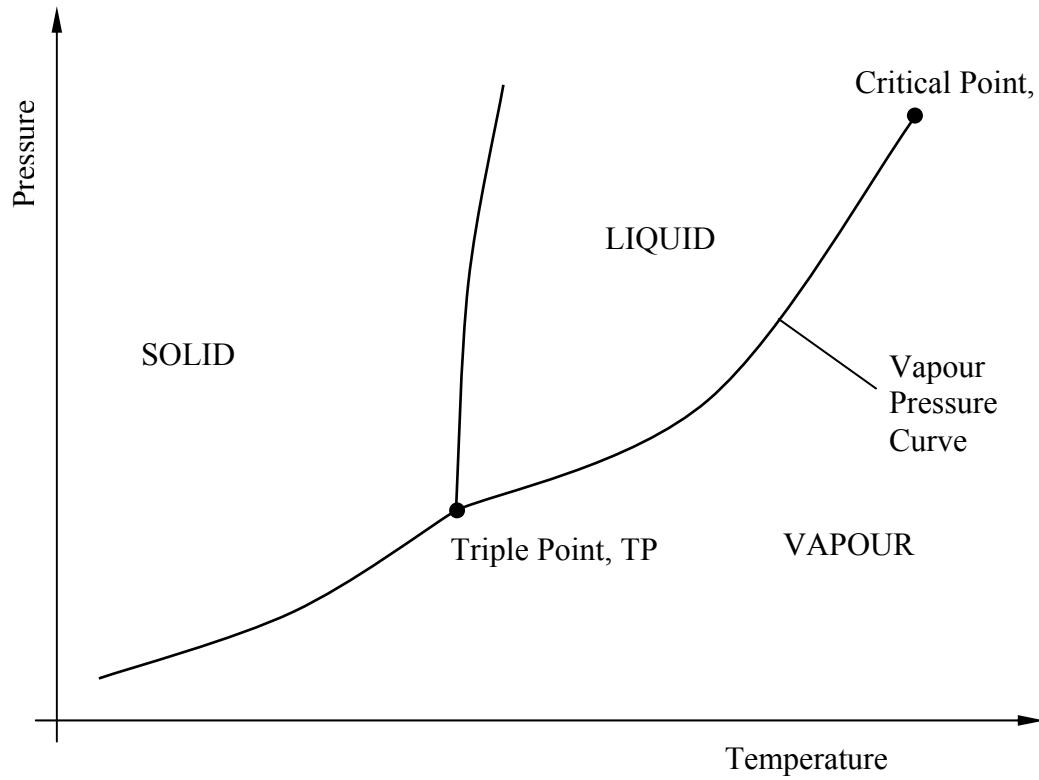
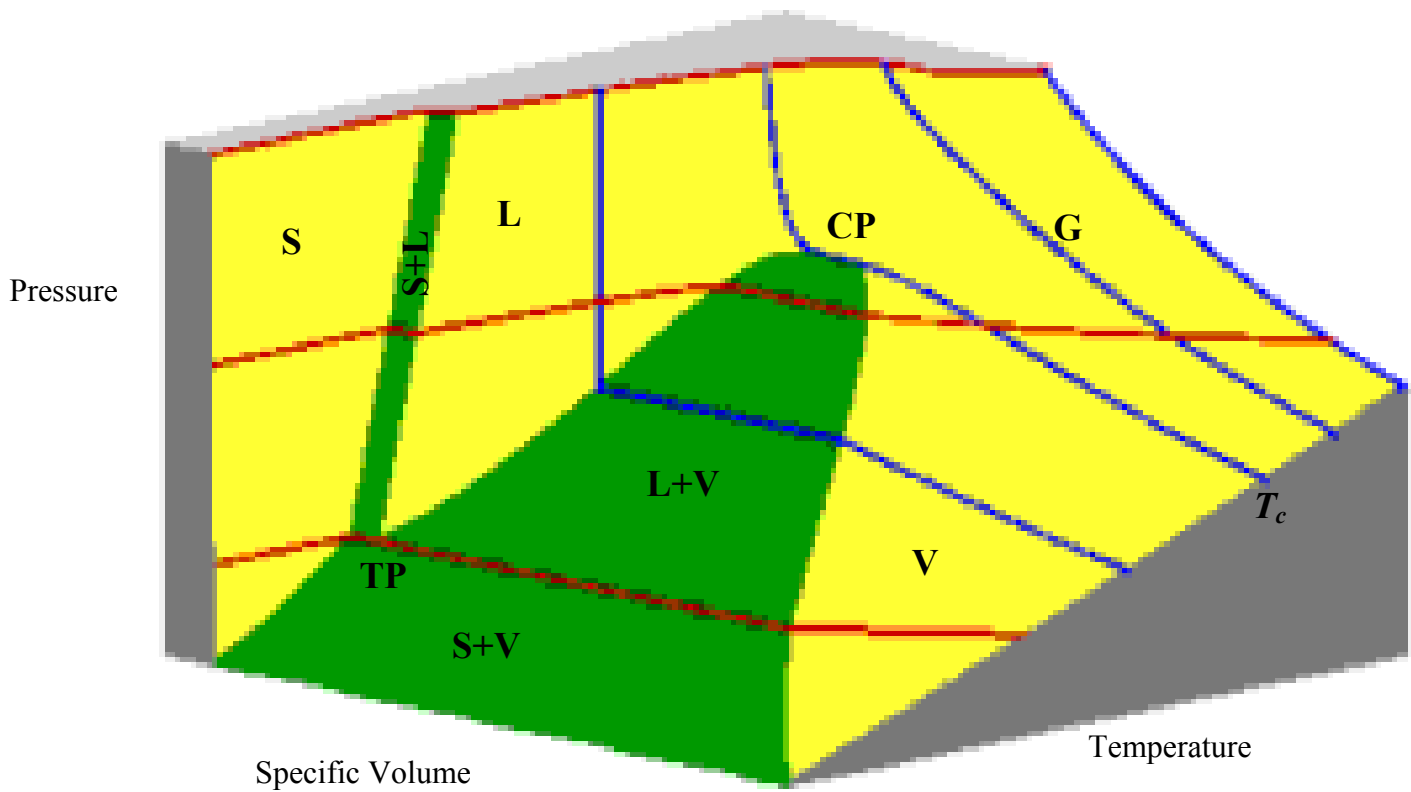


1. System at equilibrium means that there are no driving forces for thermal, mechanical, and diffusional changes.
2. Thermal equilibrium: achieved when system is at uniform temperature.
3. Mechanical equilibrium: achieved when system pressure is uniform.
4. Diffusional equilibrium: achieved when there are no net tendencies for substances to move between phases.
5. Phases: gas, liquid, solid (multiple), plasma.
6. Pure substances can exist in different phases.
7. Mixtures of substances can also exist in various phases.
8. Mixtures characterized by their compositions: mass or mole fraction.
9. If system contains n_c components, the $n_c - 1$ mass or mole fractions need to be specified.
10. The Phase Rule: **$F + P = C + 2$**
11. **F** is the number of degrees of freedom (intensive variables) in the system which can be changed independently while still having **P** phases.
12. System can contain multiple liquid phases.
13. System can contain multiple solid phases.
14. System can only have one gas phase.
15. If no chemical reactions, the number of independent components is the number of distinct chemical species in the system.
16. Intensive variables are those properties that are independent of the size of the phase (e.g. density). Extensive variables vary with the size of the phase (e.g. mass, volume).
17. Most important intensive variables are T° and P_r , density, mole (or mass) fractions of components of each phase.
18. Single component ($C=1$), single phase ($P=1$) system: $F = C+2-P = 2$. Two intensive variables can be specified and all other intensive properties are then fixed.
19. Single component ($C=1$), two phase ($P=2$) system: $F = C+2-P = 1$. Single intensive variable can be specified and all other intensive properties are then fixed.
20. Single component ($C=1$), three phase ($P=3$) system: $F = C+2-P = 0$. This means that no intensive variables can be varied without at least one of the phases disappearing. The T° and P_r where three phases exist is called the triple point.

1. The Pr. versus T° diagram.
2. The Pr.-versus Specific Volume (v) diagram.



1. The Pr.-versus Specific Volume (v) versus T° diagram.



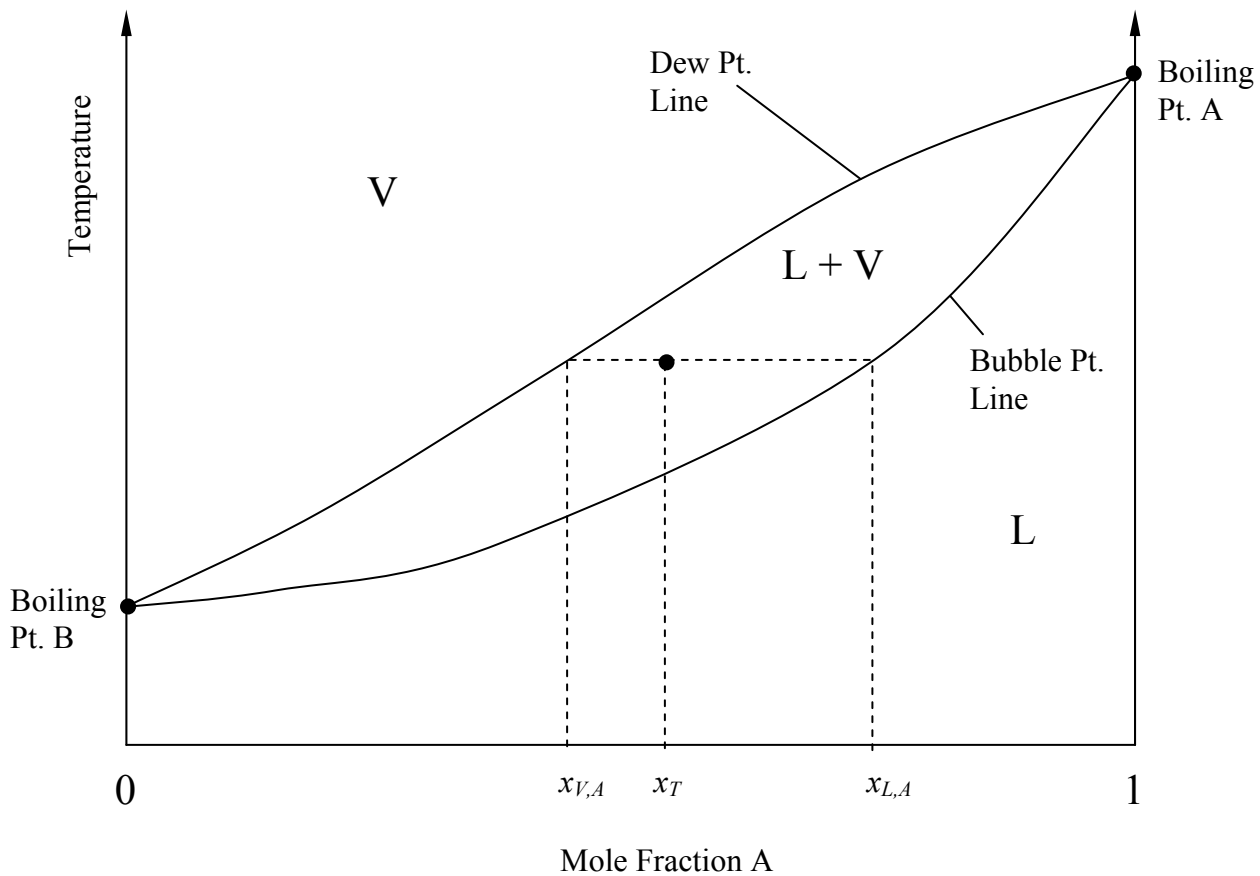
The diagram illustrates the phase behavior of a pure substance in the Pressure (P) vs. Specific Volume (v) plane. Key features include:

- Axes:** The vertical axis is Pressure (P) and the horizontal axis is Specific Volume (v).
- Phase Regions:** Solid regions are labeled S (Solid), L (Liquid), G (Gas), and V (Vapor). Two-phase regions are labeled S + L, L + V, and S + V.
- Key Points:** The Triple Point (TP) is at the intersection of the solid phase curves. The Critical Point (CP) is at the peak of the critical isotherm.
- Isotherms:** Solid curves represent isotherms T_1 and T_2 . A dashed curve represents the Critical Temperature Isotherm, T_c . A horizontal line at T_3 is shown below the critical temperature.
- Volume Markers:** Vertical dashed lines from the T_3 isotherm to the x-axis mark specific volumes v_w (at the start of the S+L region), v_T (at the CP), and v_v (at the end of the S+L region).
- Shading:** The L + V region is shaded with a light gray grid. The S + V region is shaded with a cross-hatch pattern.

$$\frac{m_v}{m_w} = \frac{v_T - v_w}{v_v - v_T}$$

Length of lines in
L-V region on P-v
diagram

1. Binary mixtures: $F=4-P$, $x_A + x_B = 1$, $w_A + w_B = 1$.
2. Miscible = capable of mixing in any ratio without separation into two phases
3. **Two completely miscible liquids.**

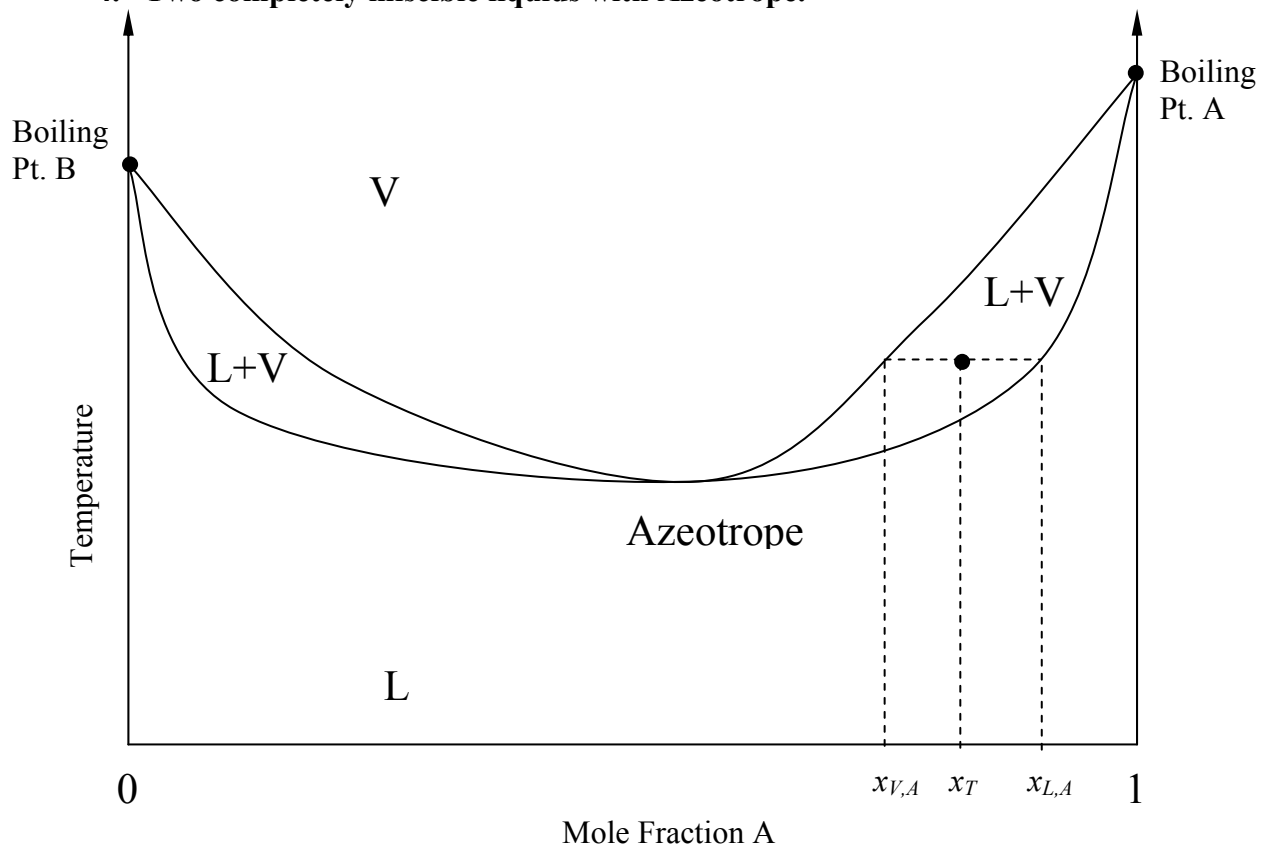


$$\frac{n_V}{n_T} = \frac{x_{L,A} - x_T}{x_{L,A} - x_{V,A}}$$

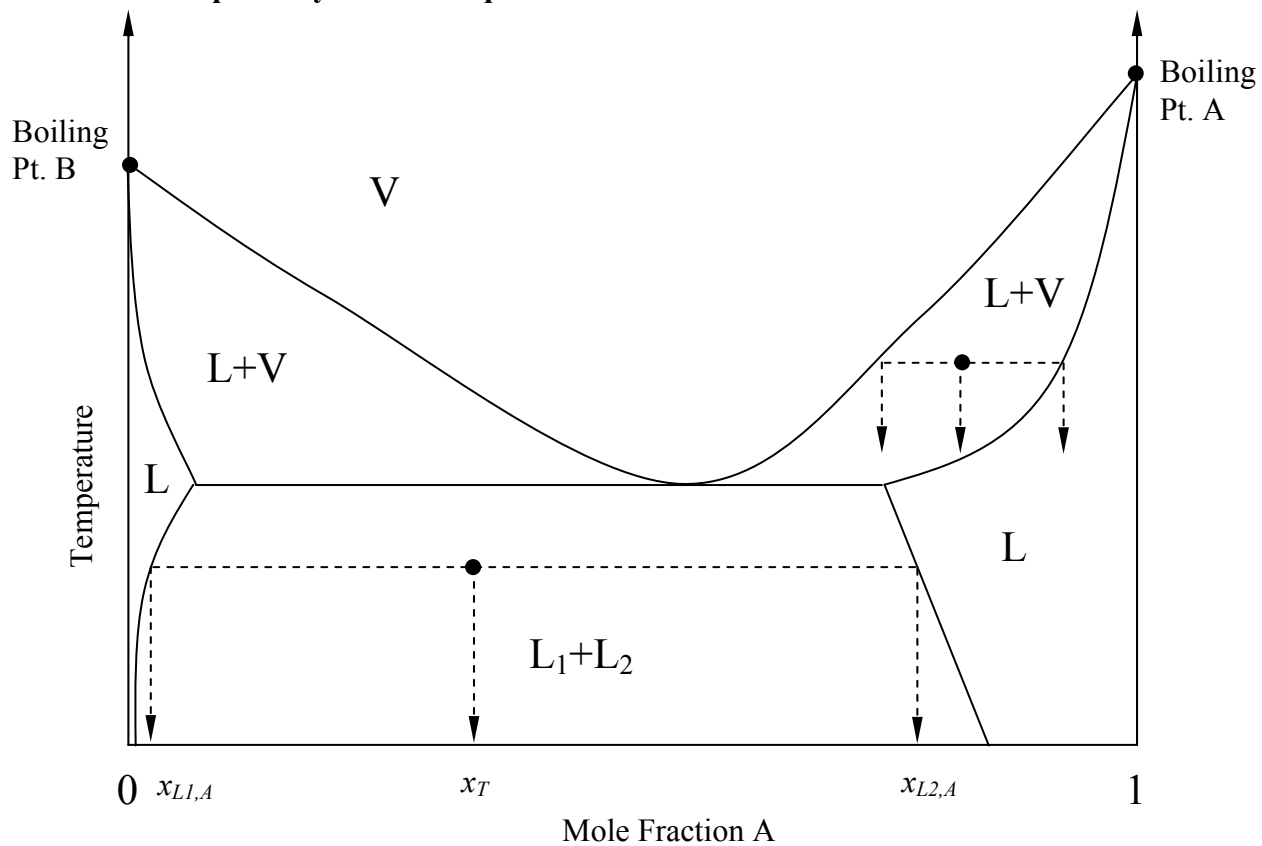
Length of lines in L-V region

$$\frac{n_L}{n_T} = \frac{x_T - x_{V,A}}{x_{L,A} - x_{V,A}}$$

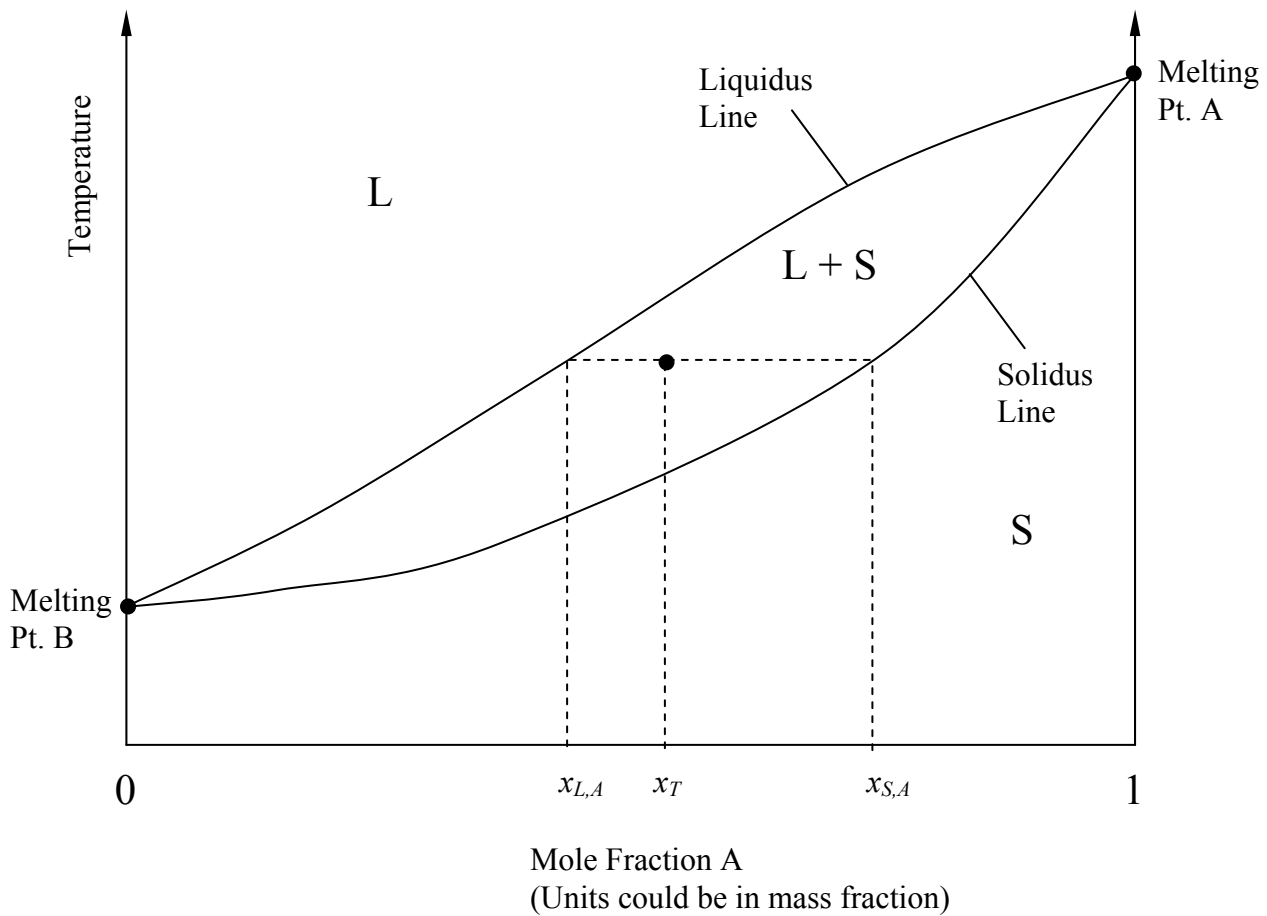
4. Two completely miscible liquids with Azeotrope.



5. Two partially miscible liquids.



1. Binary mixtures: $F=4-P$, $x_A + x_B = 1$, $w_A + w_B = 1$.
2. Miscible = capable of mixing in any ratio without separation into two phases
3. **Two completely miscible solids.**



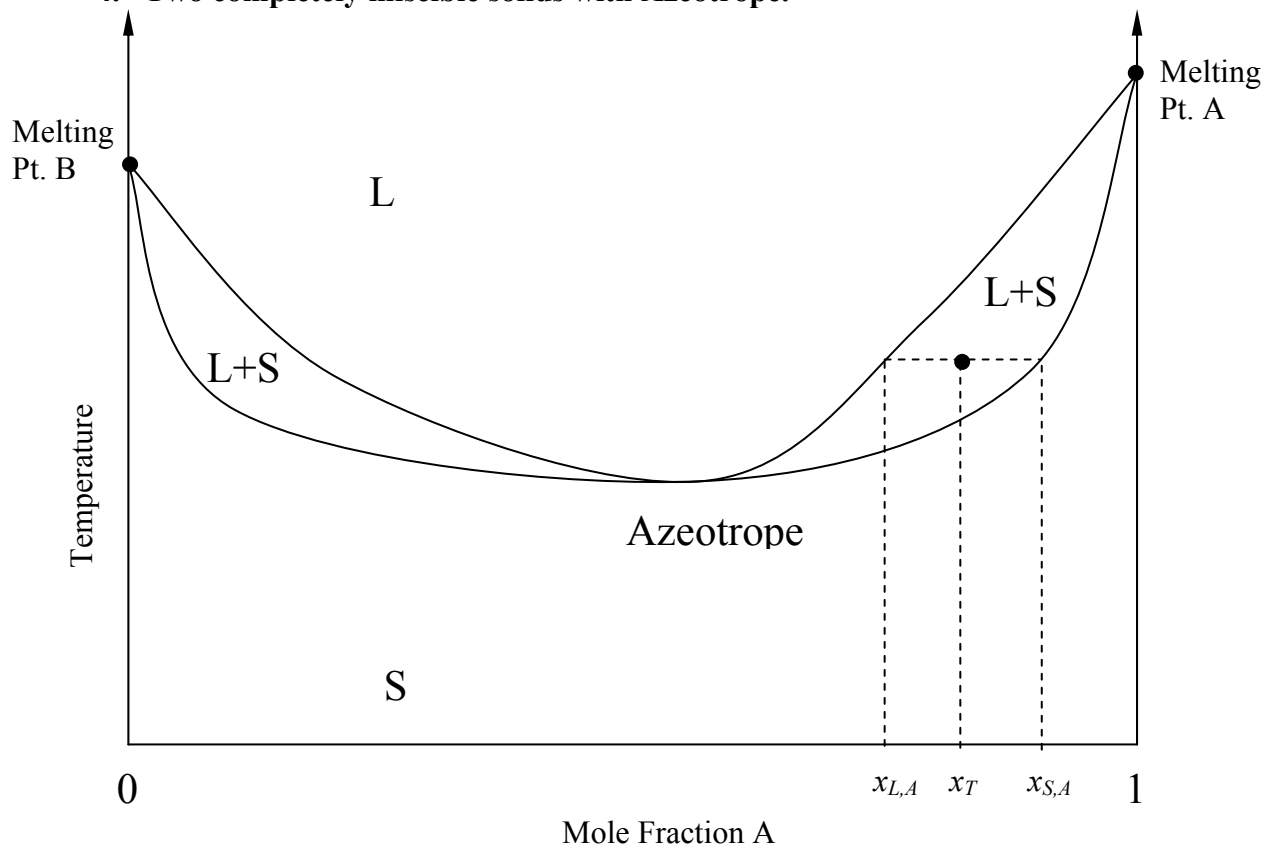
$$\frac{n_L}{n_T} = \frac{x_{S,A} - x_T}{x_{S,A} - x_{L,A}}$$

$$\frac{m_L}{m_T} = \frac{w_{S,A} - w_T}{w_{S,A} - w_{L,A}}$$

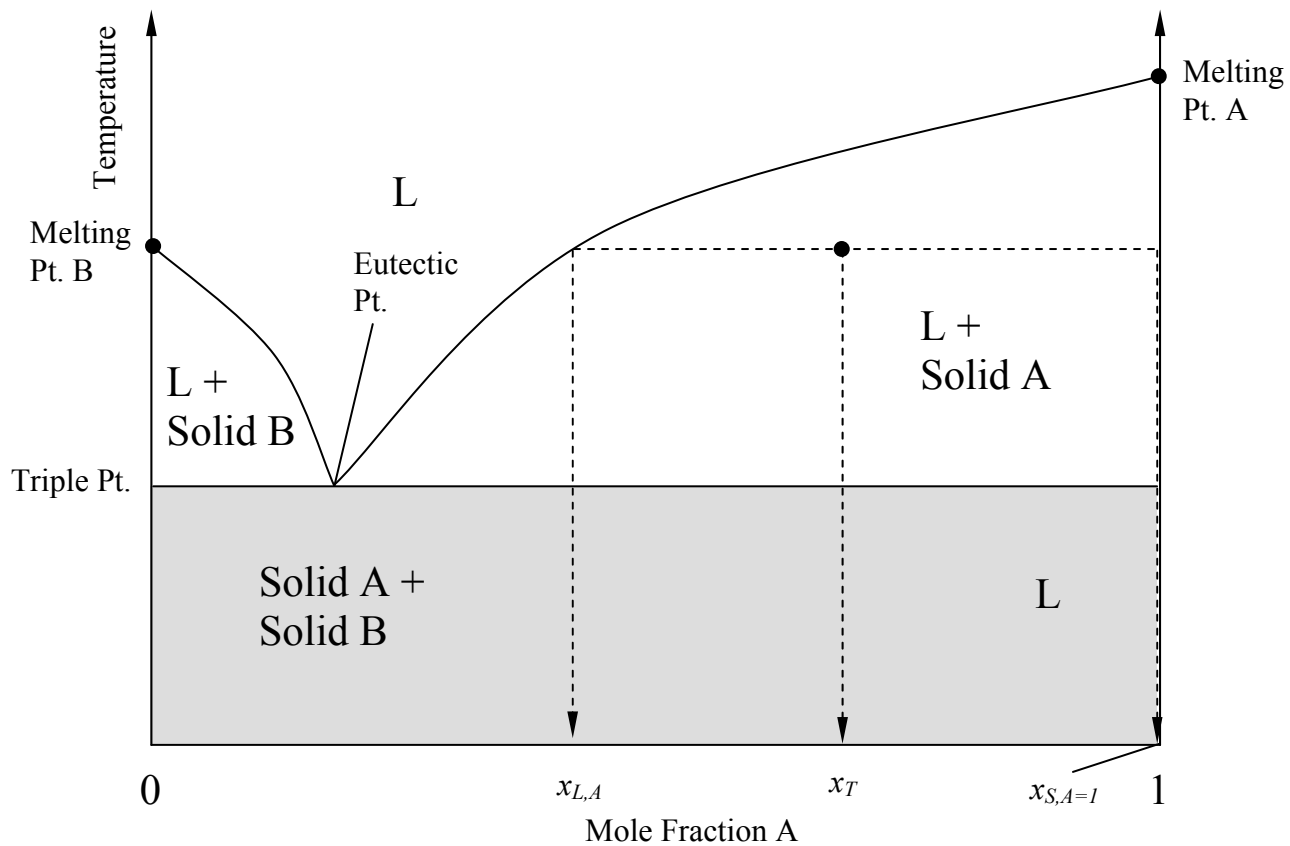
$$\frac{n_S}{n_T} = \frac{x_T - x_{L,A}}{x_{S,A} - x_{L,A}}$$

$$\frac{m_S}{m_T} = \frac{w_T - w_{L,A}}{w_{S,A} - w_{L,A}}$$

4. Two completely miscible solids with Azeotrope.



5. Immiscible solids.



6. Partially miscible solids.

