

Dec. 6 2002: Lecture 30:

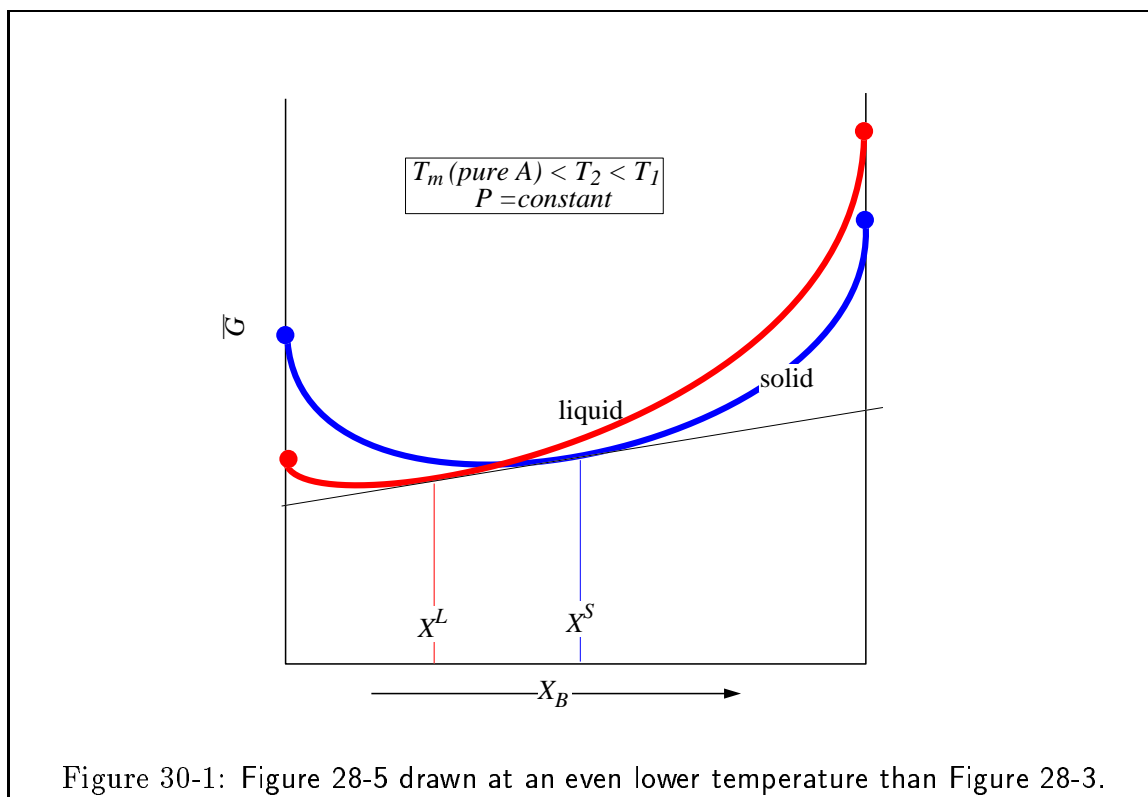
Phase Diagrams

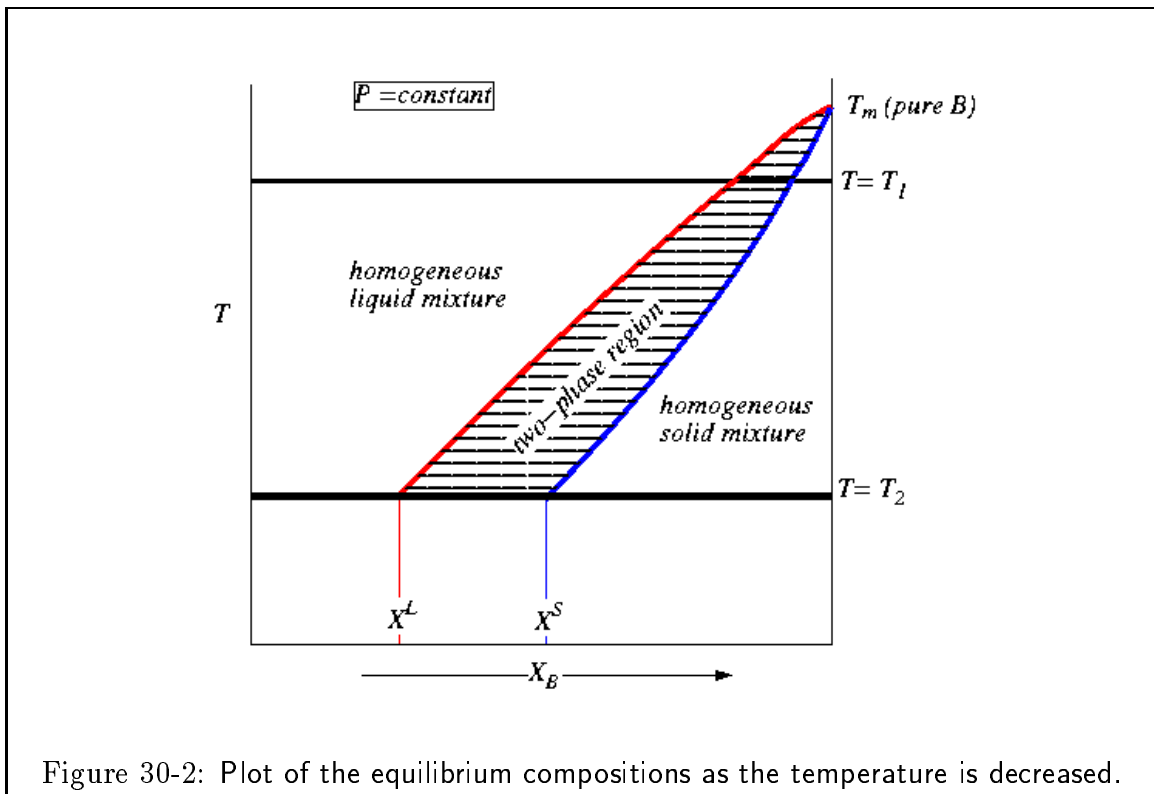
Last Time

Common Tangent Construction

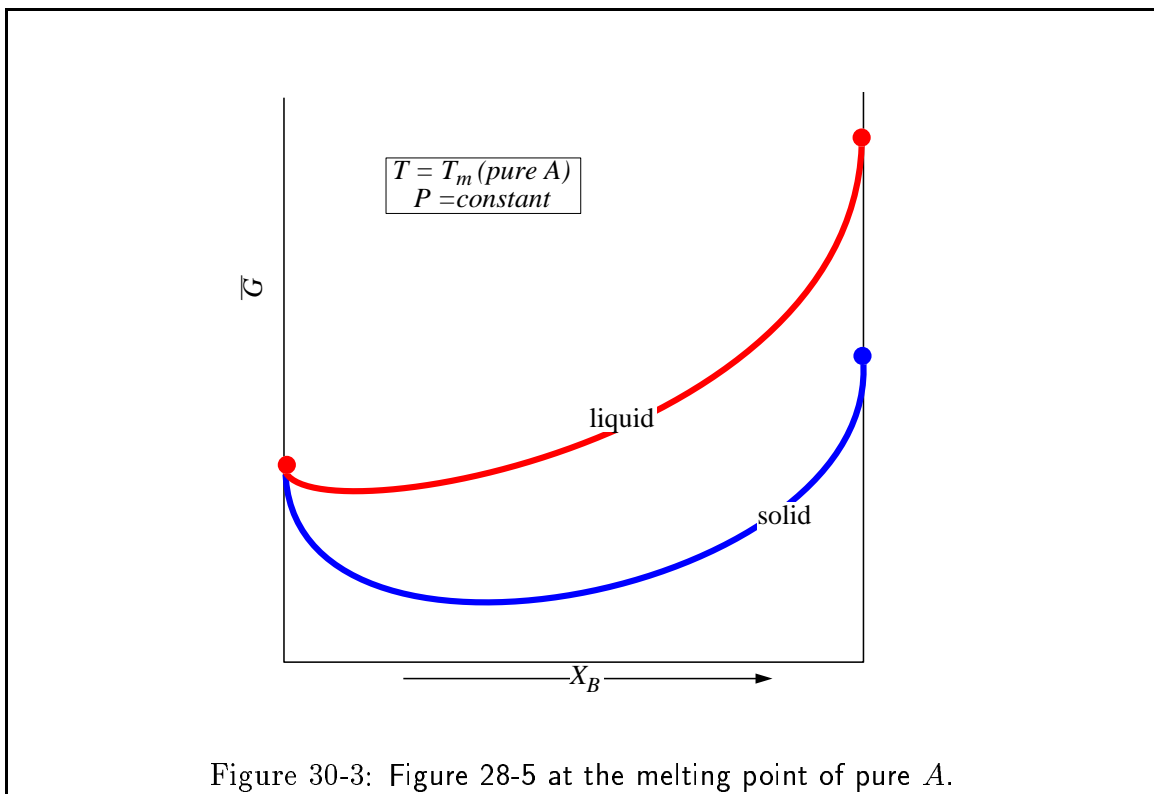
Construction of Phase Diagrams from Gibbs Free Energy Curves

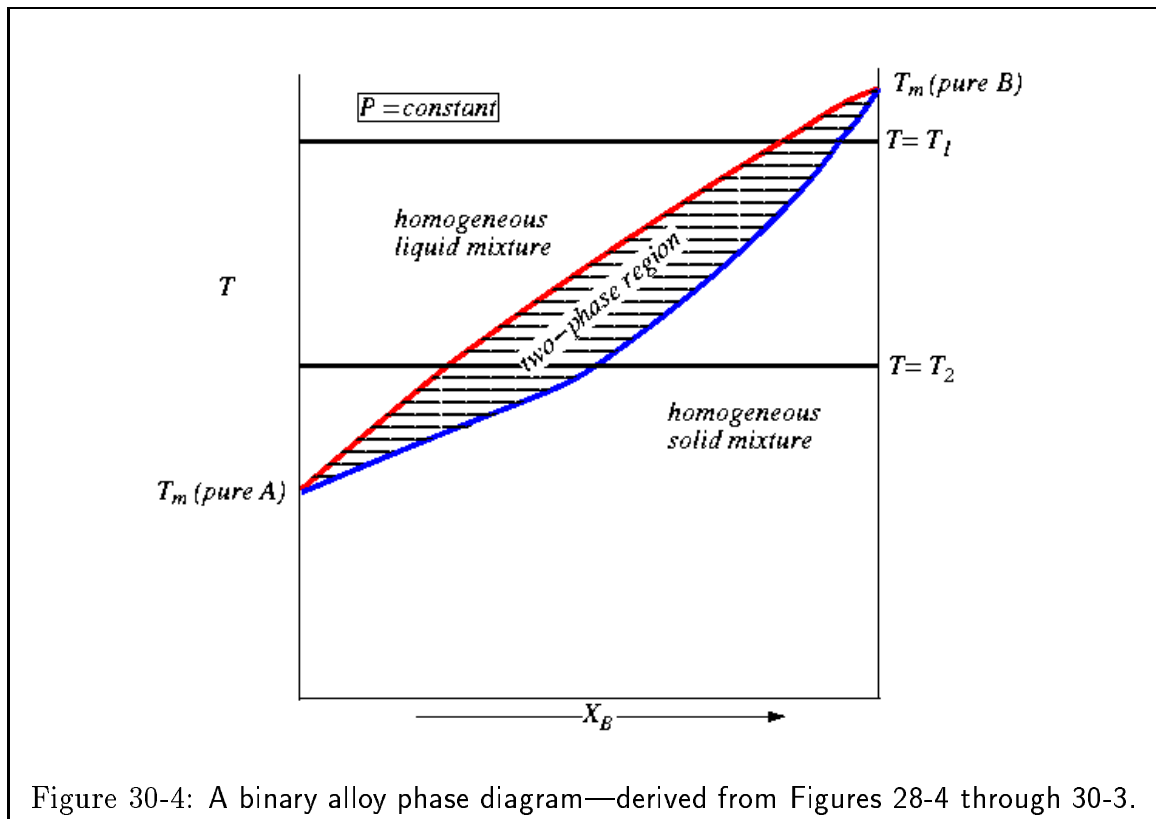
If the temperature in Figure 28-5 is decreased a little further:





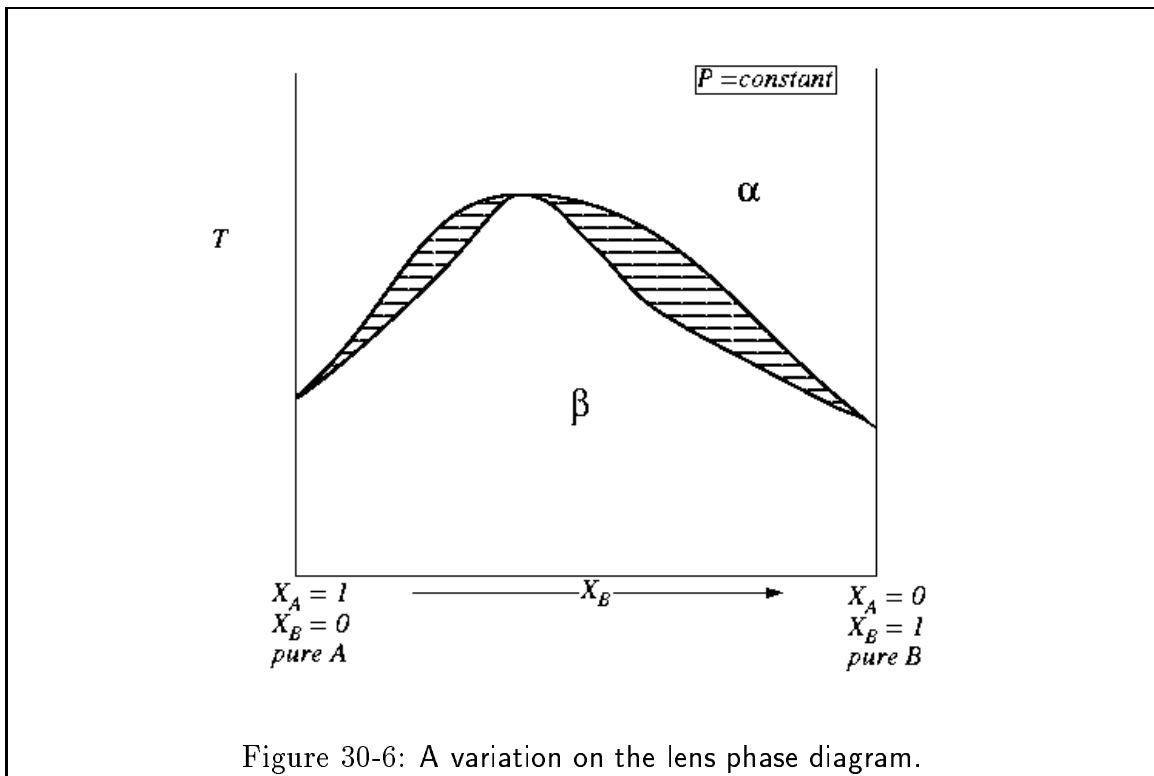
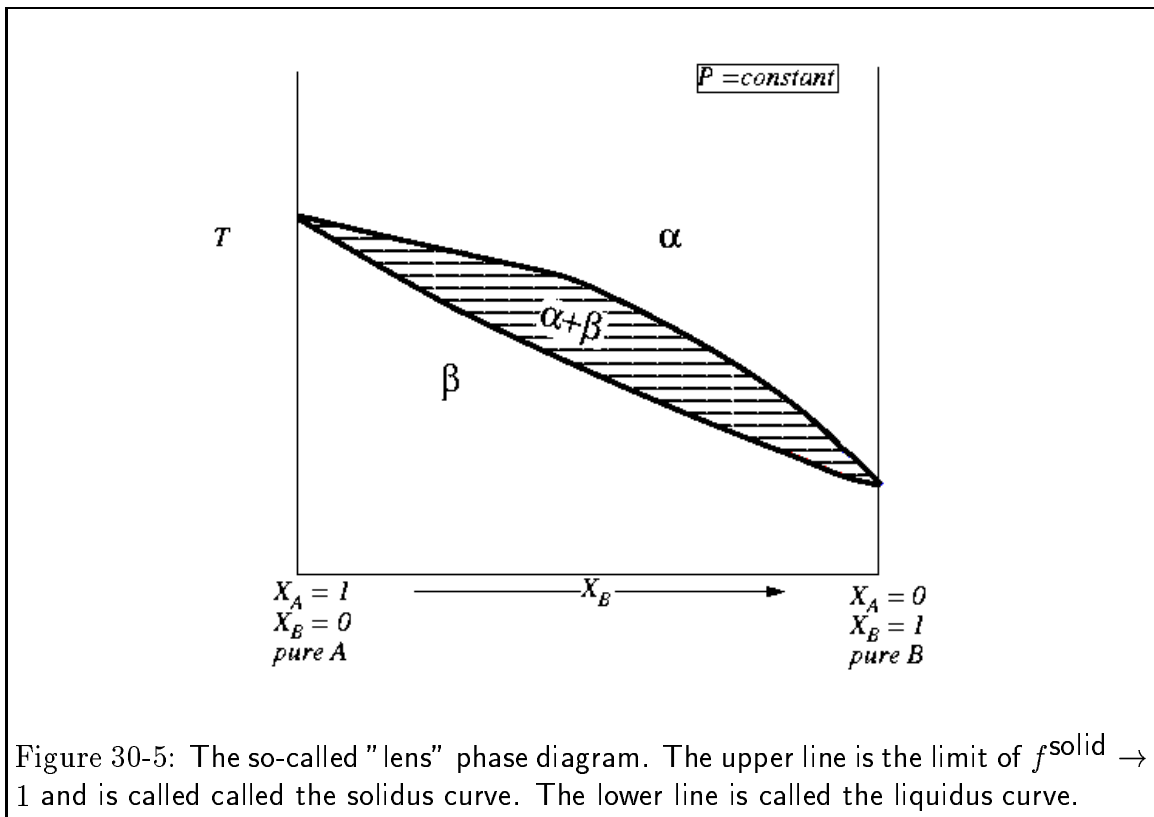
Lowering it to the melting point of pure A





A Menagerie of Binary Phase Diagrams

The phase diagram in Figure 30-4 is the simplest possible two-component phase diagram at constant pressure.



Consider how the Gibbs phase rule relates to the above phase diagrams.

The Gibbs phase rule is: $D = C + 2 - f$

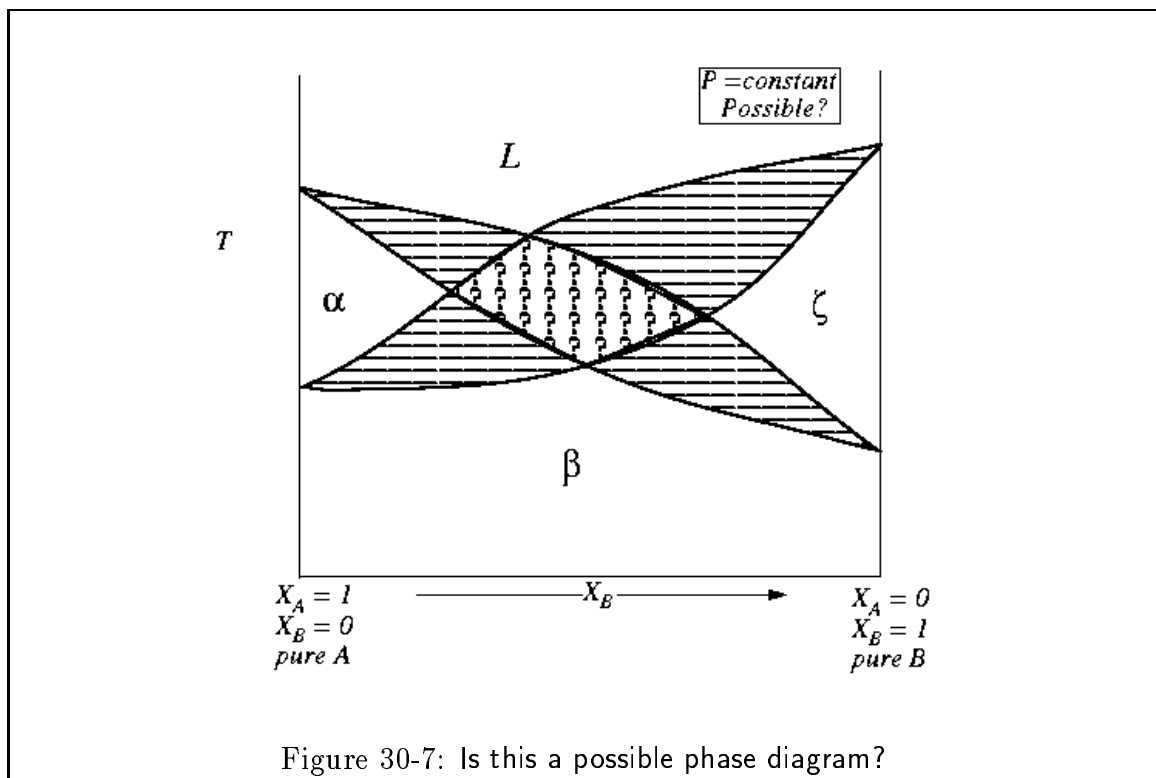
However, P is constant so we lose one degree of freedom: $D = C + 1 - f$

In the two phase region— $D = 2 + 1 - 2 = 1$ —so there is one degree of freedom.

Question: What is the degree of freedom? What does it mean?

- If temperature is changed at fixed $\langle X_o \rangle$, then the change in volume fraction of phases is determined. In other words there is a relation between dT and df^{solid} .
- If $\langle X_o \rangle$ is changed with fixed phase fractions then ΔT is determined by the change.

Consider another two-component phase diagram and see if it violates the Gibbs phase rule.



Consider the three-phase region: $D = C + 1 - f = 0$

Because there are no degrees of freedom, the three-phase region must shrink to a point in a two component system. This places restrictions on the topology of binary phase diagrams.

The diagrams below illustrate how such an invariant point (i.e., three phase equilibria in a two component system) arises:

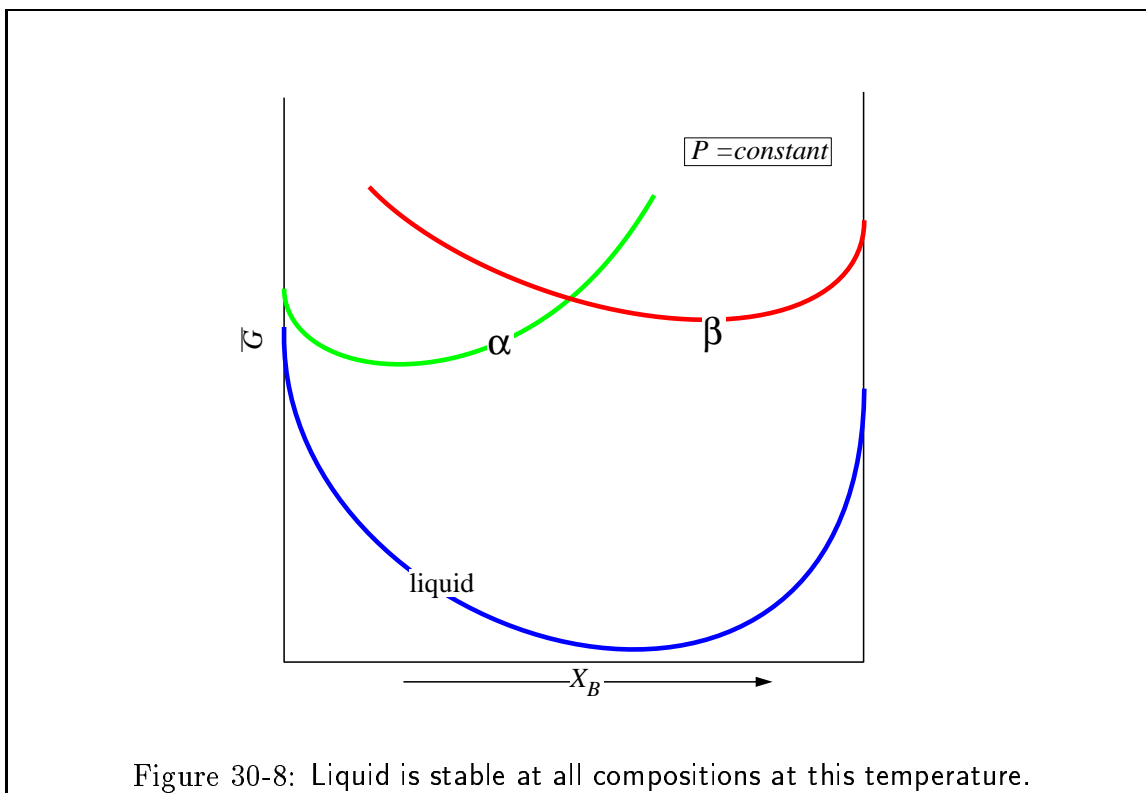


Figure 30-8: Liquid is stable at all compositions at this temperature.

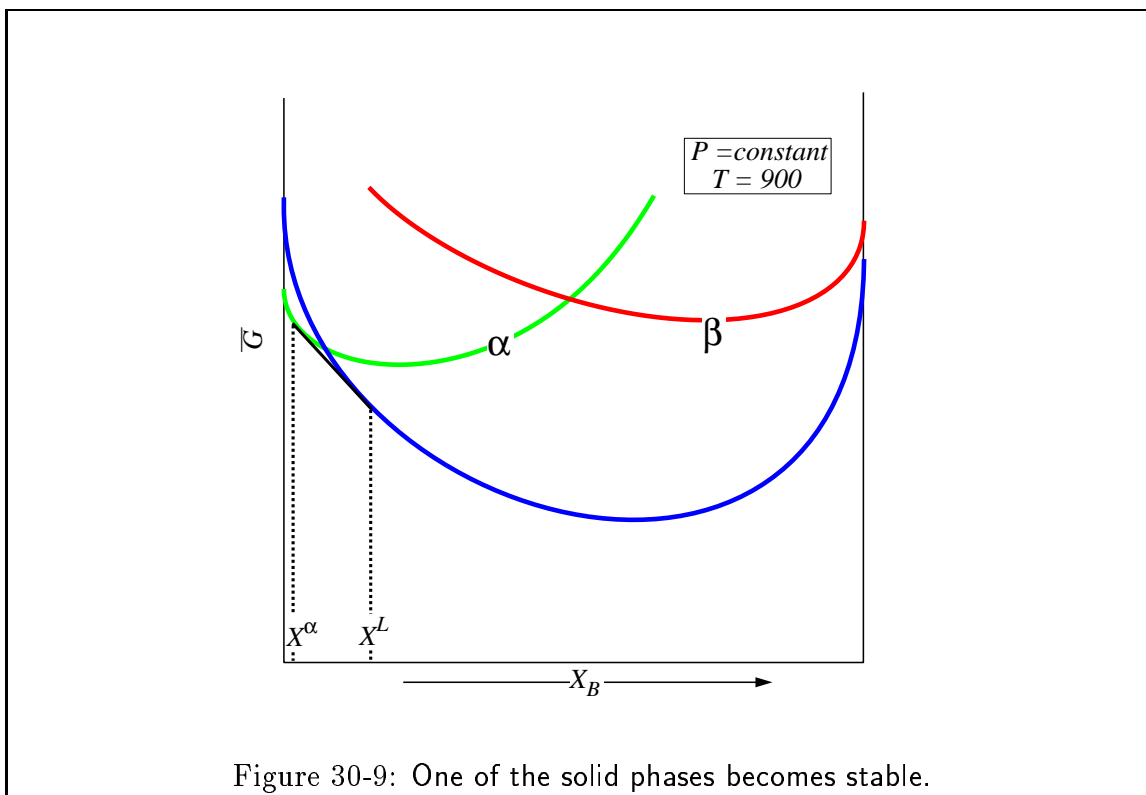
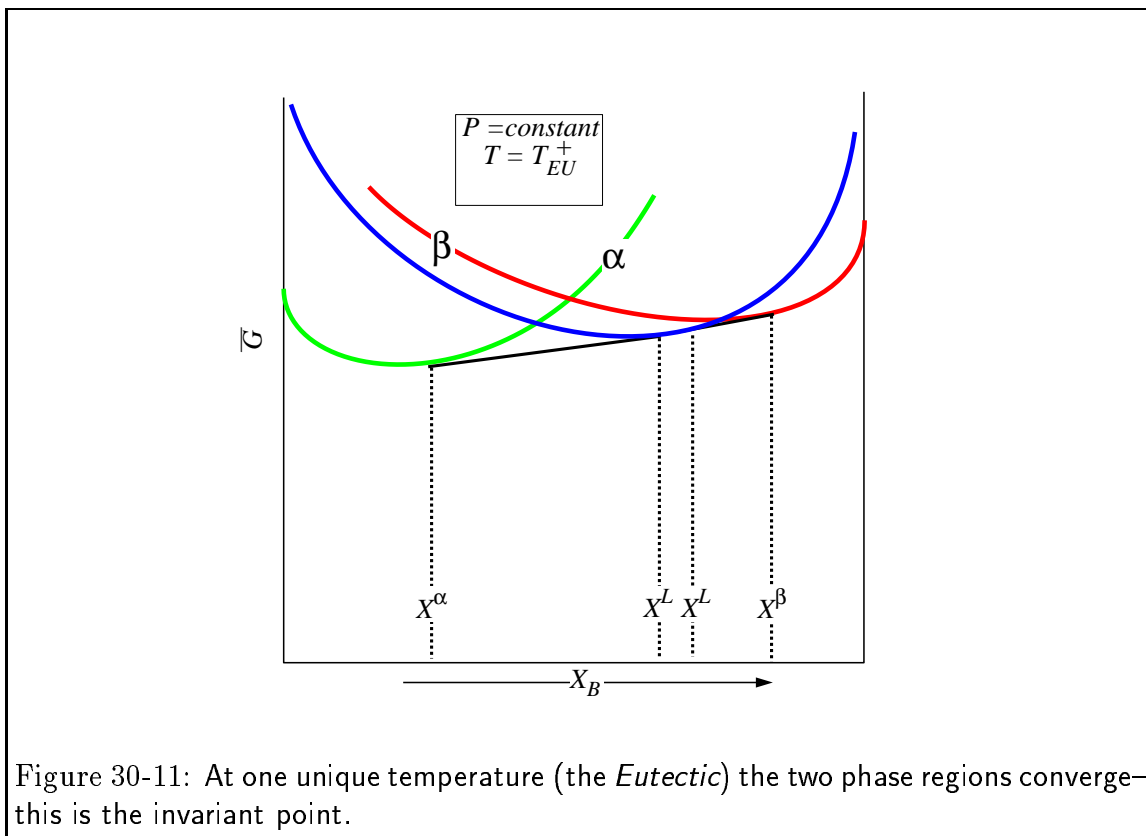
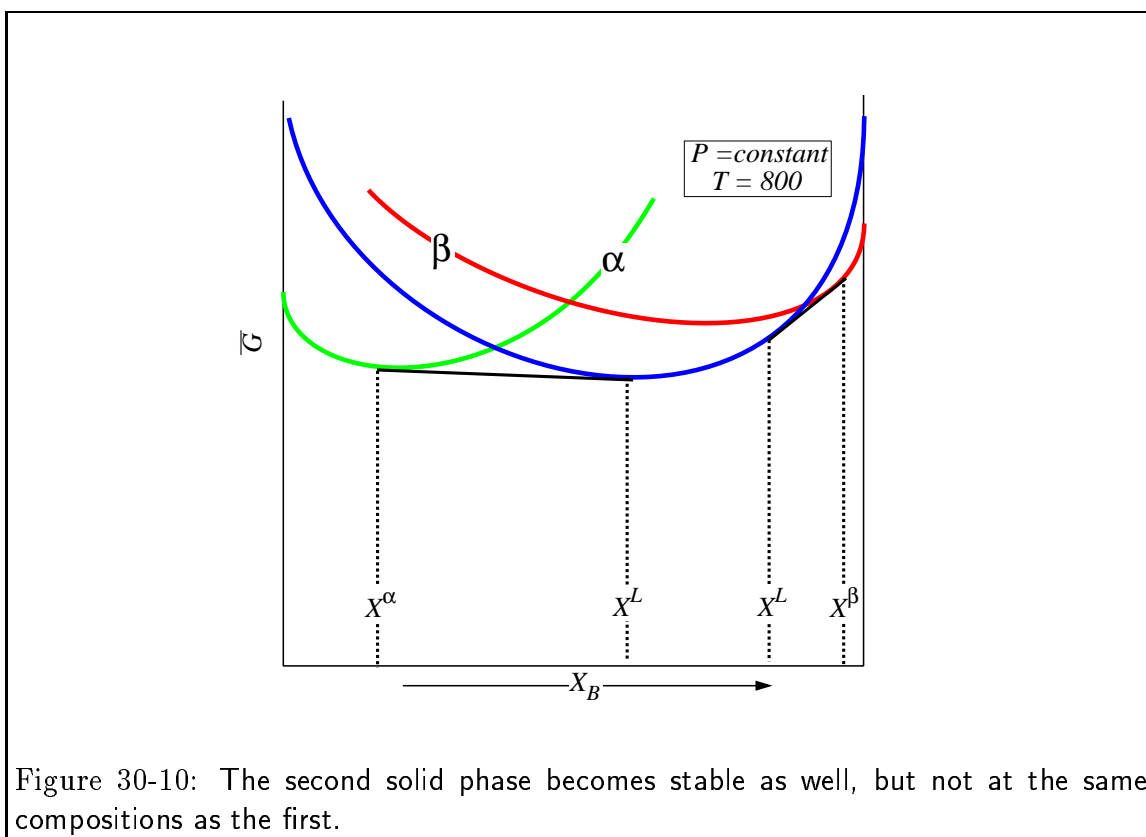
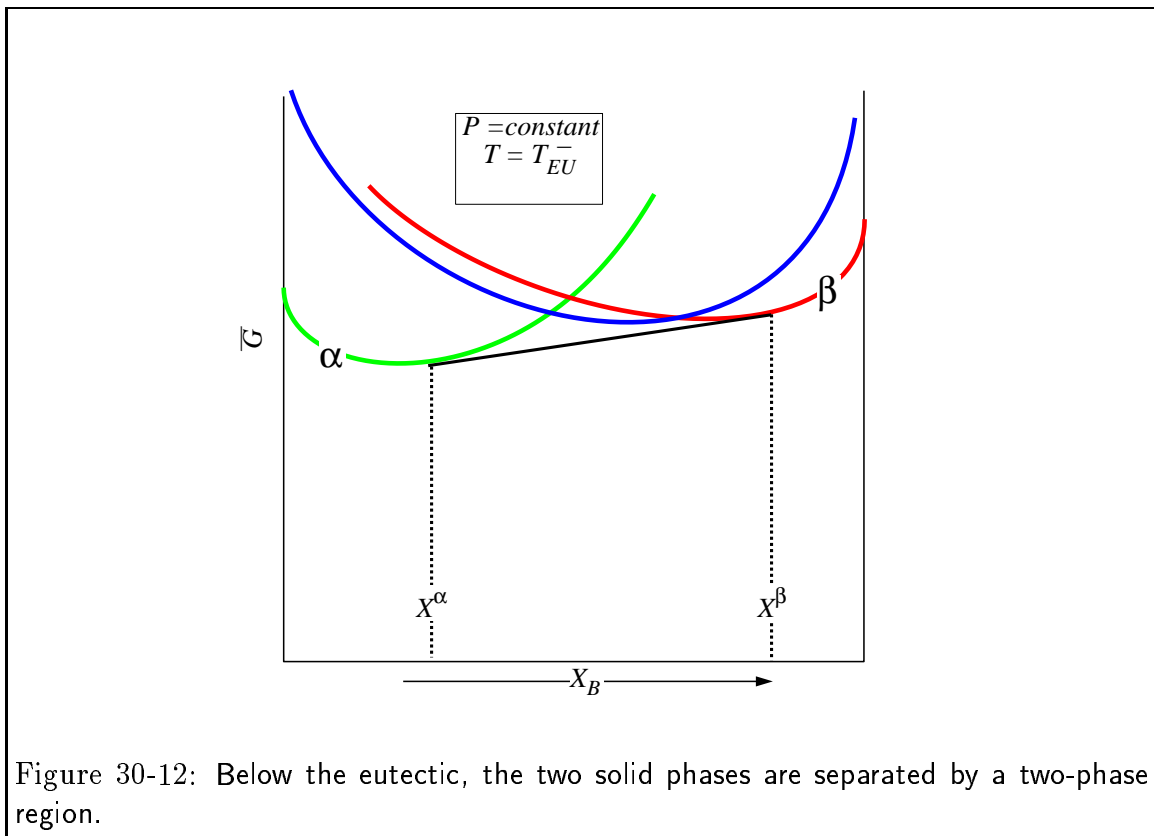
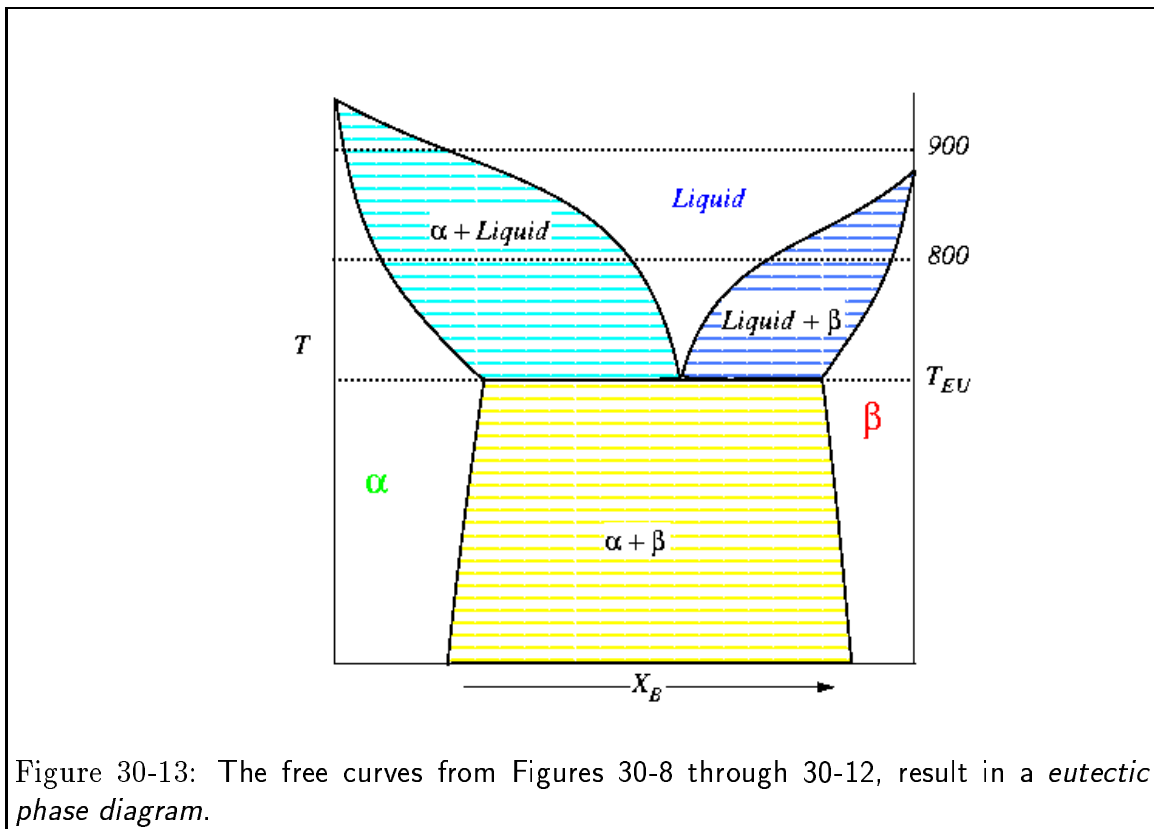


Figure 30-9: One of the solid phases becomes stable.





This yields the following phase diagram



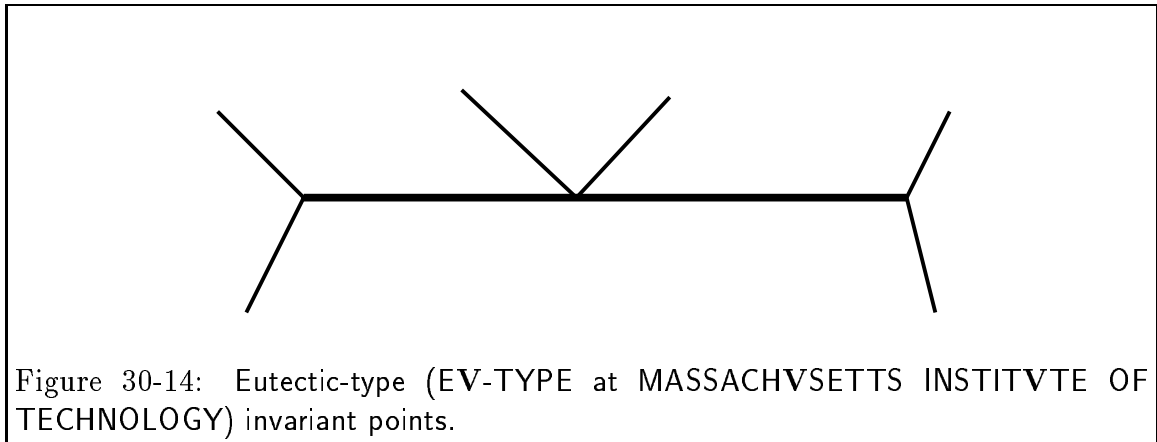
Classifying the Invariant Points: Drawing Phase Diagrams

There are two fundamental ways that invariant points can arise:²⁹

1. When *two* two-phase regions join at a temperature and become *one* two-phase region:

Eutectic $(\alpha + \text{liquid}) + (\text{liquid} + \beta) \rightleftharpoons (\alpha + \beta)$

Eutectoid $(\alpha + \gamma) + (\gamma + \beta) \rightleftharpoons (\alpha + \beta)$

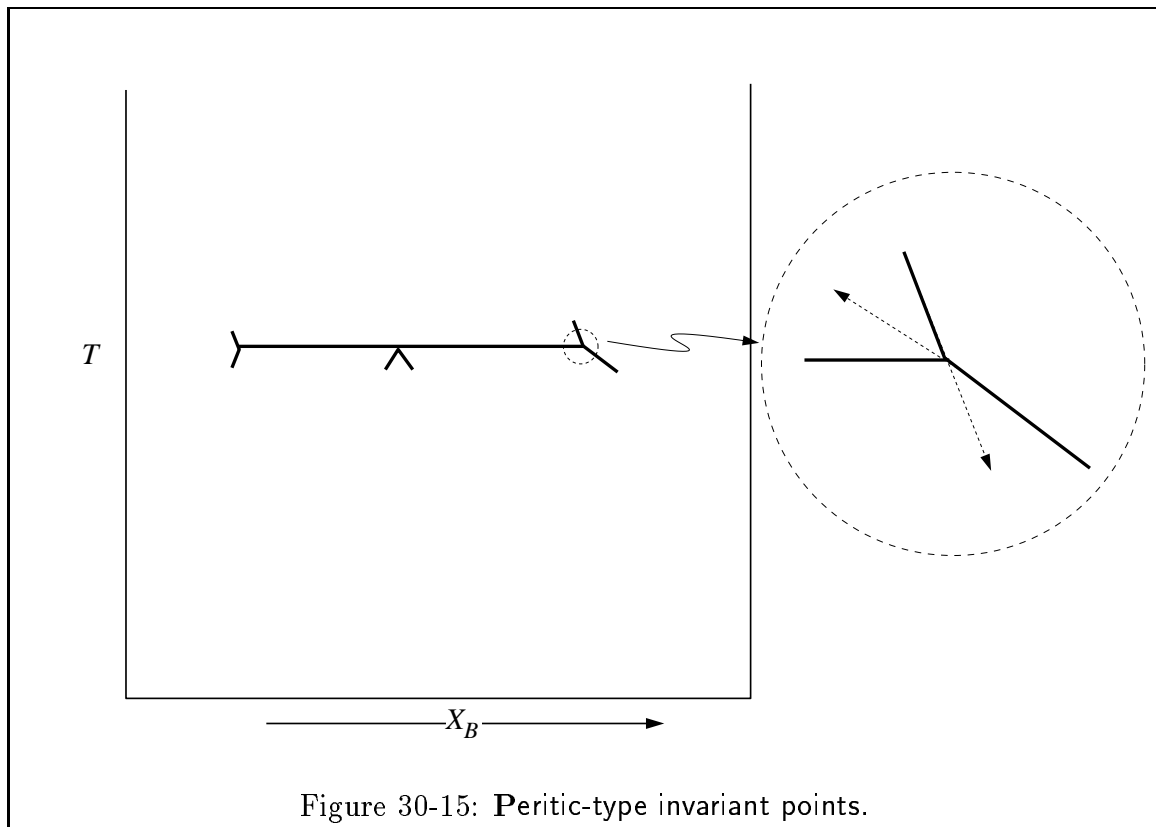


2. When *one* two-phase region splits into *two* two-phase regions:

Peritectic $(\alpha + \text{liquid}) \rightleftharpoons (\text{liquid} + \beta) + (\alpha + \beta)$

Peritectoid $(\alpha + \gamma) \rightleftharpoons (\gamma + \beta) + (\alpha + \beta)$

²⁹There is a third type of invariant point that we will learn about later.



The invariant points determine the topology of the phase diagram:

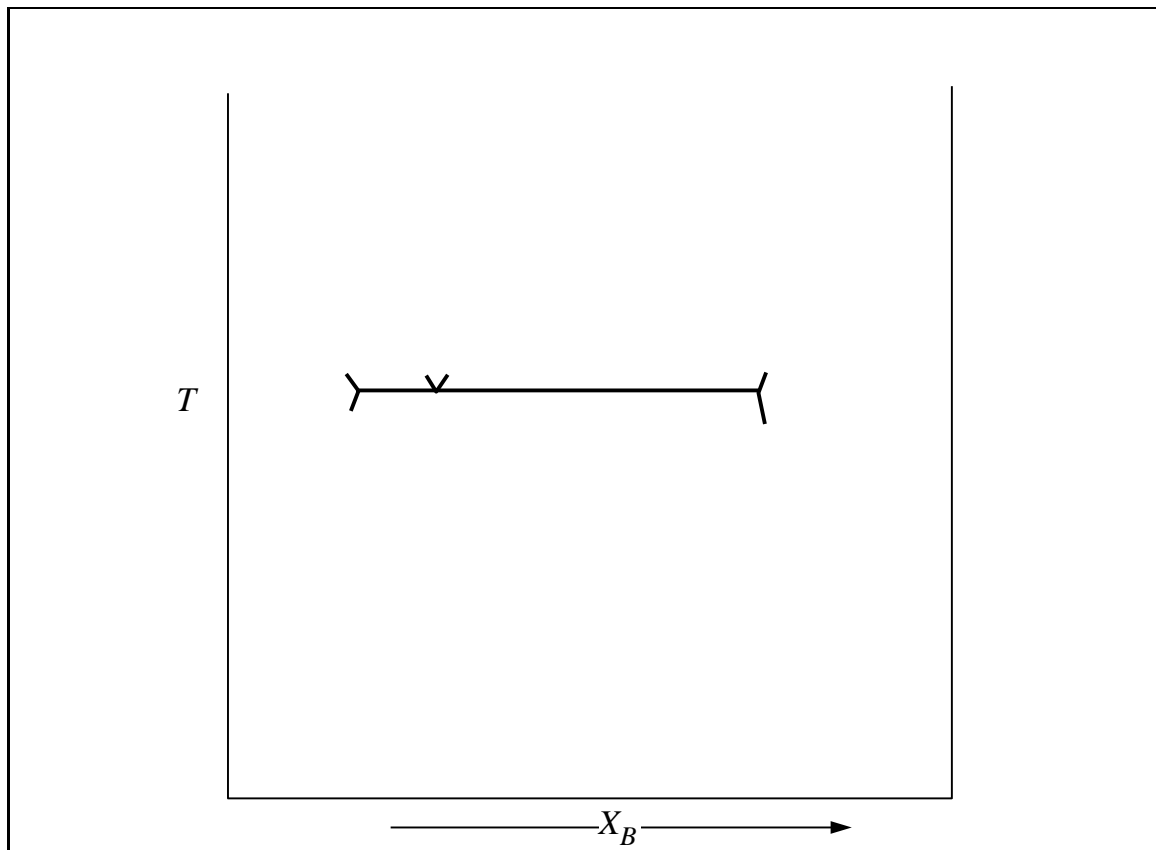
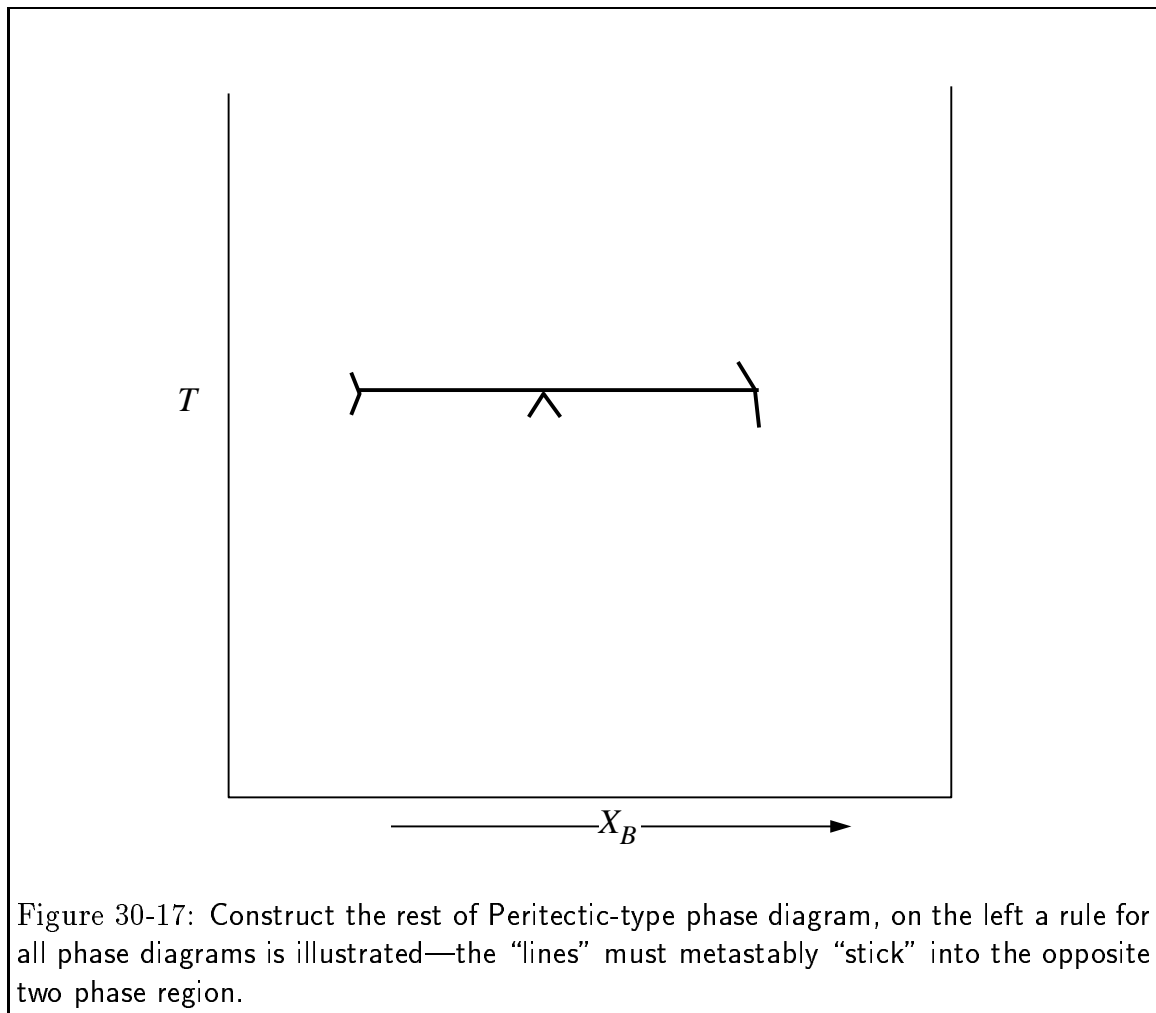
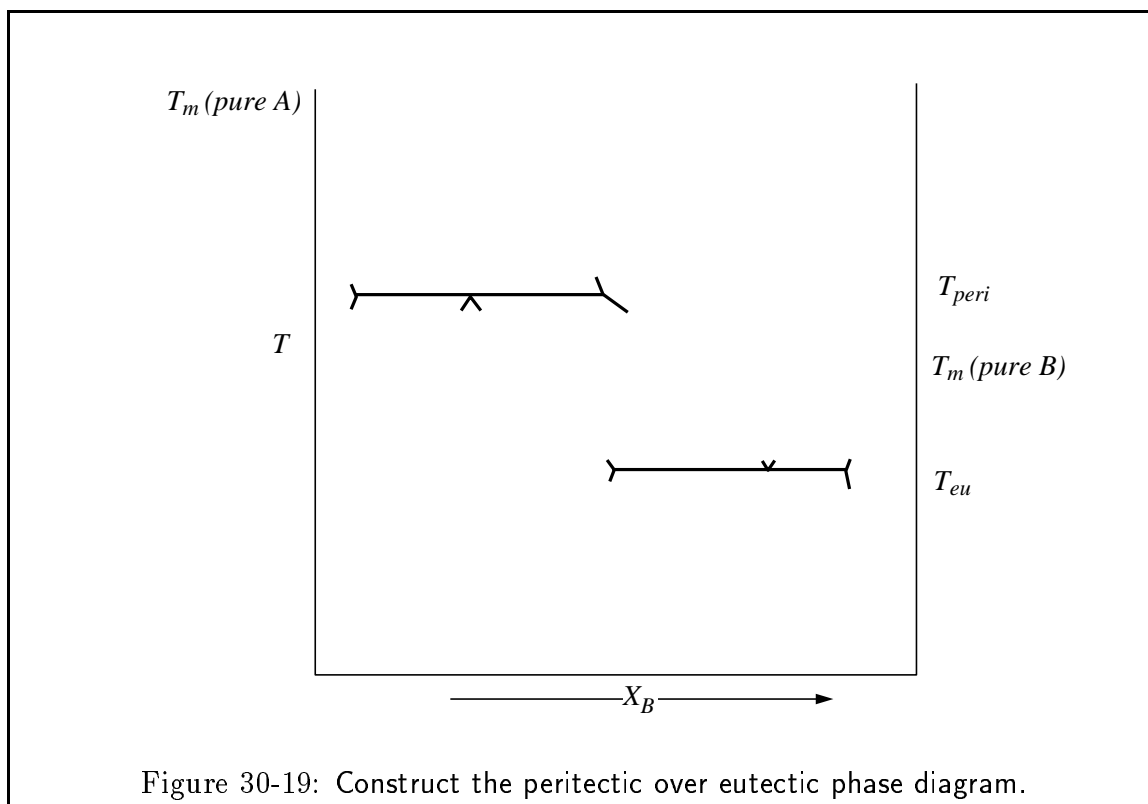
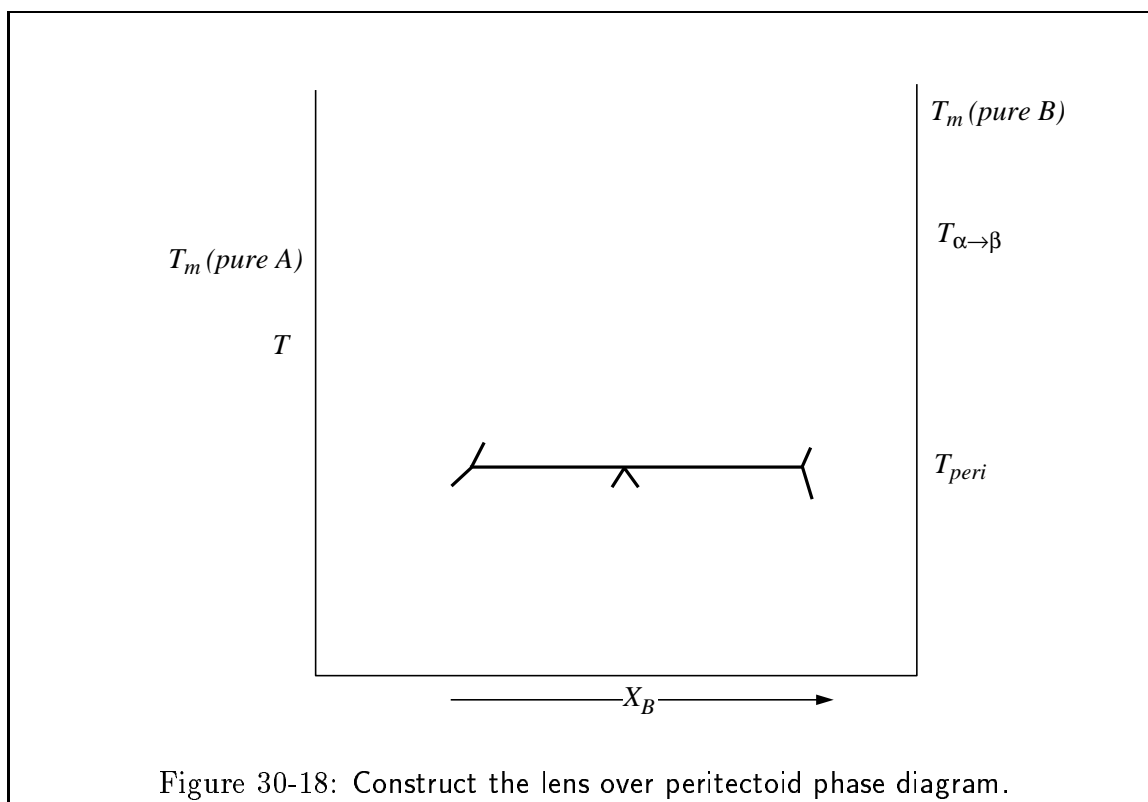


Figure 30-16: Construct the rest of the Eutectic-type phase diagram by connecting the lines to the appropriate melting points.



These diagrams can be combined and drawn:



In all cases, you should be able to predict how the phase fractions and equilibrium compositions change as you reduce the temperature at equilibrium.

