Exercises on Ch.12 *Sharp and gradual phase transformations*

12.2 *Characterization of phase transformations*

Exercise 12.2.1

What kind of transformation involving p phases will occur if $p - 3$ molar quantities and an appropriate number of potentials are kept constant and a potential is varied?

Hint

In order to get a one-dimensional diagram, the total number of constant (i.e. sectioned) variables must be $n_s = c$ if there are no projections.

Solution

There are $p - 3$ molar variables, $n_m = p - 3$, and we get $d = c + 2 - p - n_s + n_m = c + 2 - p - c + (p - 3) = -1$. There is thus a negligible chance to get a transformation involving p phases. We may only succeed by choosing a particular value for one of the potentials. We would then obtain a case of overlapping sharp transformations.

Exercise 12.2.2

A pure element under a constant pressure melts at a given temperature T if the temperature is increased gradually. Discuss how the melting will be affected if one were to keep the volume constant instead of the pressure.

Hint

In both cases $n_s = 1$. In the first instance of melting there can be no difference because the system does not 'feel' which variable is kept constant.

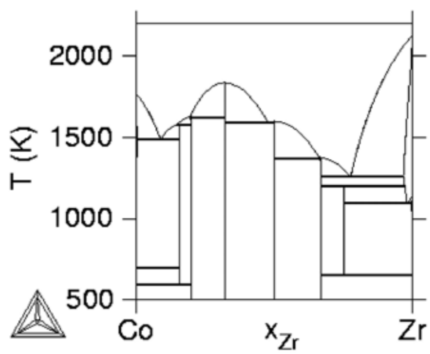
Solution

Melting starts at the same temperature but is no longer a sharp transformation. $d = c + 2 - p - n_s + n_m = 1 + 2 - 2 - 1 + 1 = 1$ shows that with a molar variable ($n_m = 1$) the melting

12.5 Classification of sharp phase transformations

Exercise 12.5.1

When a composite material, composed of many thin alternating layers of pure Zr and pure Co, was heat treated at 573 K for 10 hours, an amorphous Co–Zr phase was formed. Study the Co–Zr phase diagram and explain how this transformation can be thermodynamically possible. How should one classify this reaction?



Hint

We are not asked to discuss how it can be kinetically possible to avoid the formation of a series of stable intermetallic phases. We can accept the experimental result and simply consider the three phases under discussion, solid Zr, solid Co and the liquid (which is described as an amorphous phase because of its high viscosity due to the low temperature).

Solution

The reaction observed is the reverse of a eutectic one, Zr + Co → L and may be called eutectic melting but is really of a peritectoid type. A sketch of the diagram with all the other phases excluded would show a deep eutectic. Even though it is uncertain how to extrapolate the two liquidus curves below the glass transition (where the viscosity rises to very high values), it is evident that the eutectic point may very well fall below 573 K. From the experimental result we may conclude that this is actually the case.

12.8 Gradual phase transformations at fixed composition

Exercise 12.8.1

Alkemade's rule states that L moves away from the α–β line for a reaction L → α + β in a ternary system. Examine if the same rule, or maybe its opposite, applies to L in a peritectic reaction, L + α → β.

Hint

If L precipitates a β phase, its composition must move away from β. If an α phase is dissolved, that reaction will move the composition of L towards α.

Solution

The net change in composition of L must fall within the angle between the two changes caused by the interactions with α and β, respectively. A sketch shows that the net change may be in a direction of (1) away from or (2) towards the extension of the α–β line.