MSE-S304

Phase Transformation in Metals

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Driving force for solidification

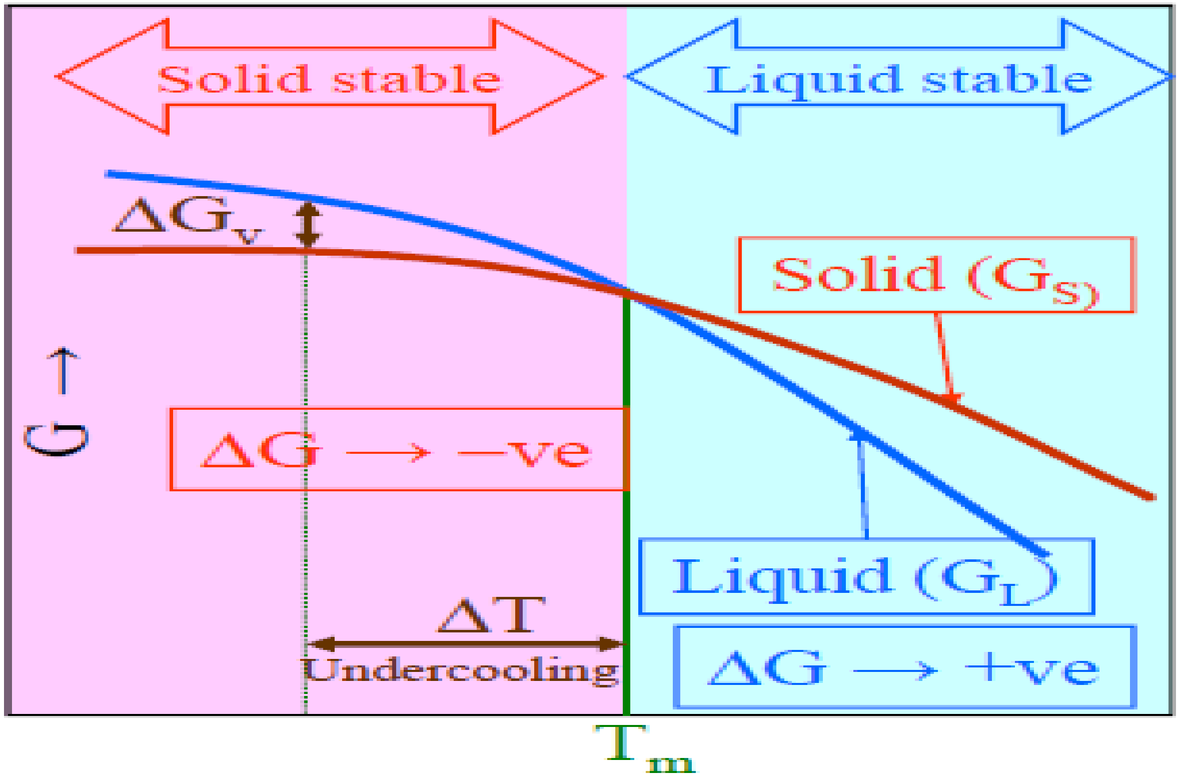
- **In Phase Transformations, we are often concerned with the *difference* in *Gibbs Free Energy (G)* between two phases at temperatures away from the equilibrium temperature.**

Example

- **If a liquid metal is *under cooled* by *ΔT below Tm* before it solidifies, solidification will be accompanied by a *decrease* in *Gibbs Free Energy (G) (J/mol).***

Driving force for solidification

- **Decrease in *Gibbs Free Energy (G)* provides the *driving force* for *solidification*.**



Driving force for solidification

- **The magnitude of this change can be obtained as follows.**

- **The free energies of the liquid and solid at a temperature *T* are given by -**

$$G^L = H^L - TS^L$$

$$G^S = H^S - TS^S$$

Driving force for solidification

Therefore, at a temperature *T*

$$\Delta G = \Delta H - T\Delta S \quad \rightarrow ①$$

Where,

$$\Delta H = H^L - H^S \quad and \quad \Delta S = S^L - S^S$$

Driving force for solidification

- **At the equilibrium melting temperature (*Tm*), the *Gibbs Free Energy (G)* of *solid* and *liquid* are *equal*, i.e., *ΔG = 0*.**

Consequently,

$$\Delta G = \Delta H - T_m \Delta S = 0$$

Driving force for solidification

Therefore at *Tm*,

$$\Delta S = \frac{\Delta H}{T_m} = \frac{L}{T_m} \rightarrow ②$$

This is known as the *entropy of fusion*.

- **It is observed experimentally that the entropy of fusion is a constant ≈ *R* for most metals.**
- ***(8.3 J/mol . K)***

Driving force for solidification

- **For *small undercooling's (ΔT)* the difference in the specific heats of the liquid and solid can be ignored.**
- **On Combining equations *1* and *2* thus gives,**

$$\Delta G \cong L - T\frac{L}{T_m}$$

i.e., for *small ΔT*

$$\Delta G \cong \frac{L\Delta T}{T_m}$$

***Turnbull's* approximation**