Mata Kuliah : Material Teknik per3

PLS1 : Lanjutan

Cooling Curve for Pure Metal

(a)

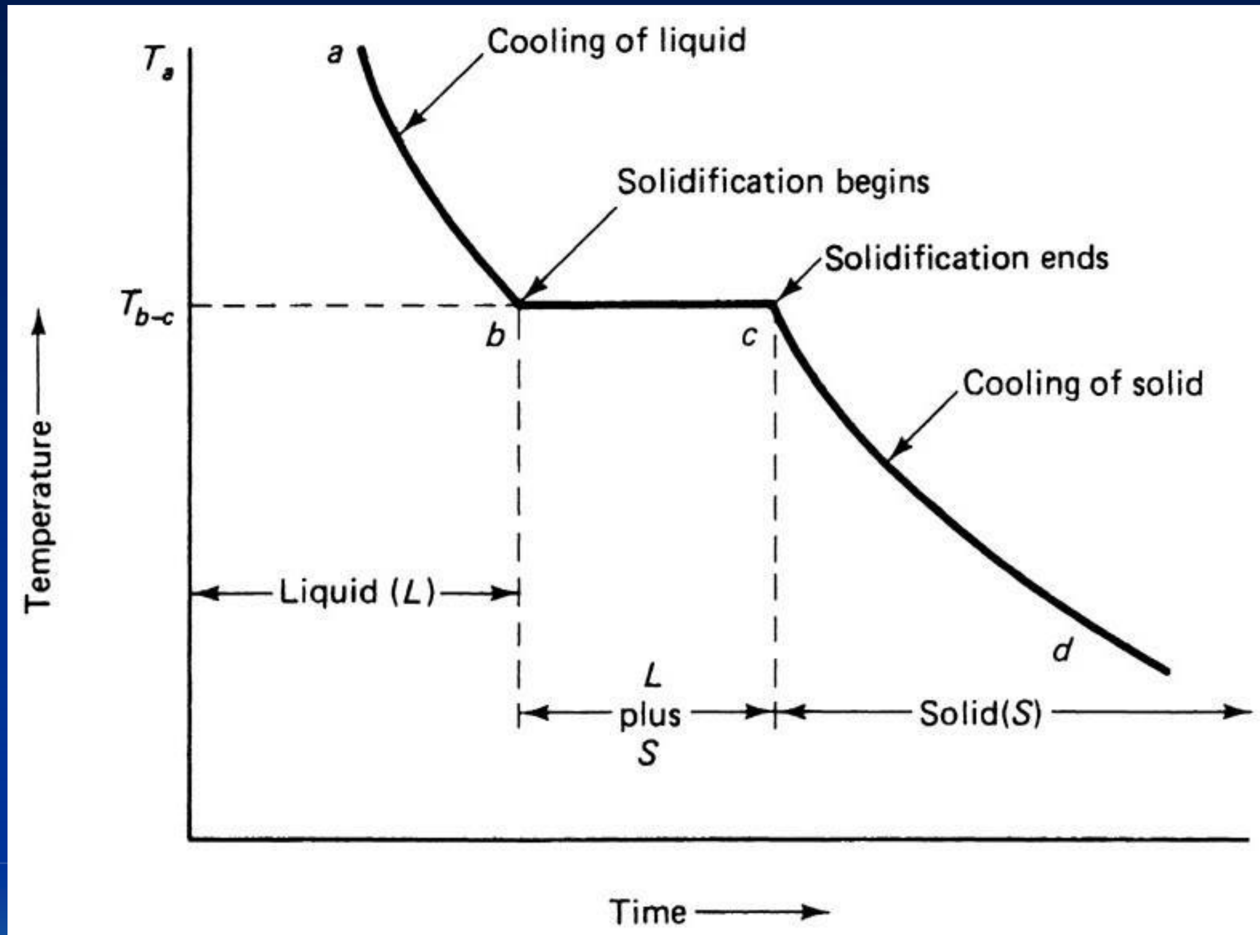


FIG. 3-50 (1) Heat pure metal to point T_a; (2) cooling of liquid metal *a*–*b*; (3) at point *b*, pure metal starts to *precipitate* out of solution; (4) point *c*, pure metal completely solid; curve from *b* to *c* straight horizontal line showing constant temperature $T_{b\text{-}c}$ because thermal energy absorbed in change from liquid to solid; (5) more cooling of solid pure metal from *c* to *d* and temperature begins to fall again.

Cooling Curve for Pure Iron

(b)

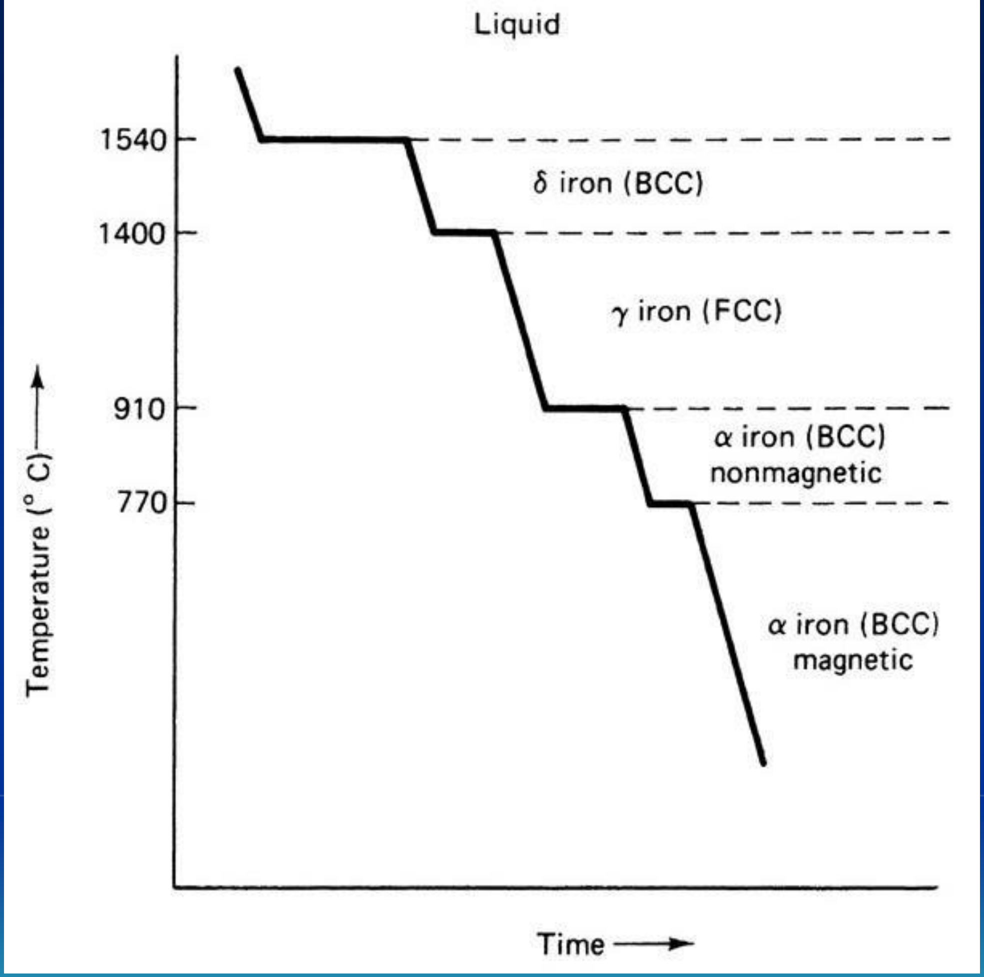
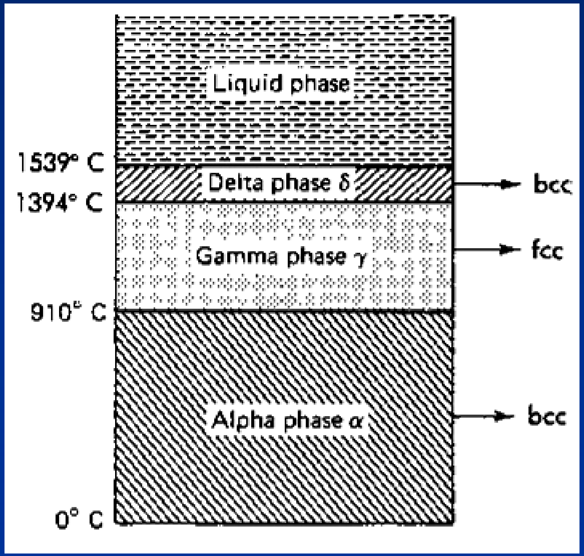


FIG. 3-50 (b) Cooling curve for pure iron.

Allotropic Forms of Iron



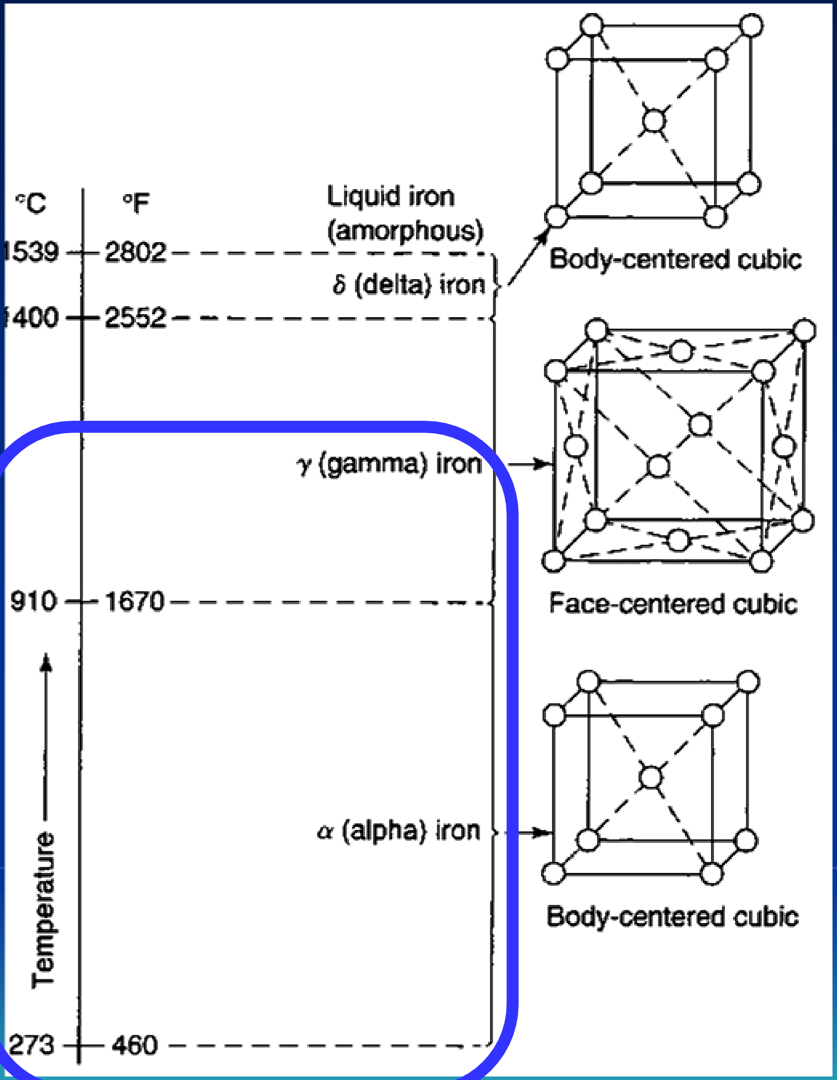


FIG. 3-54 Allotropic forms of iron (three phases: bcc, fcc, bcc)

Cooling Curve for a Metal Alloy

(c)

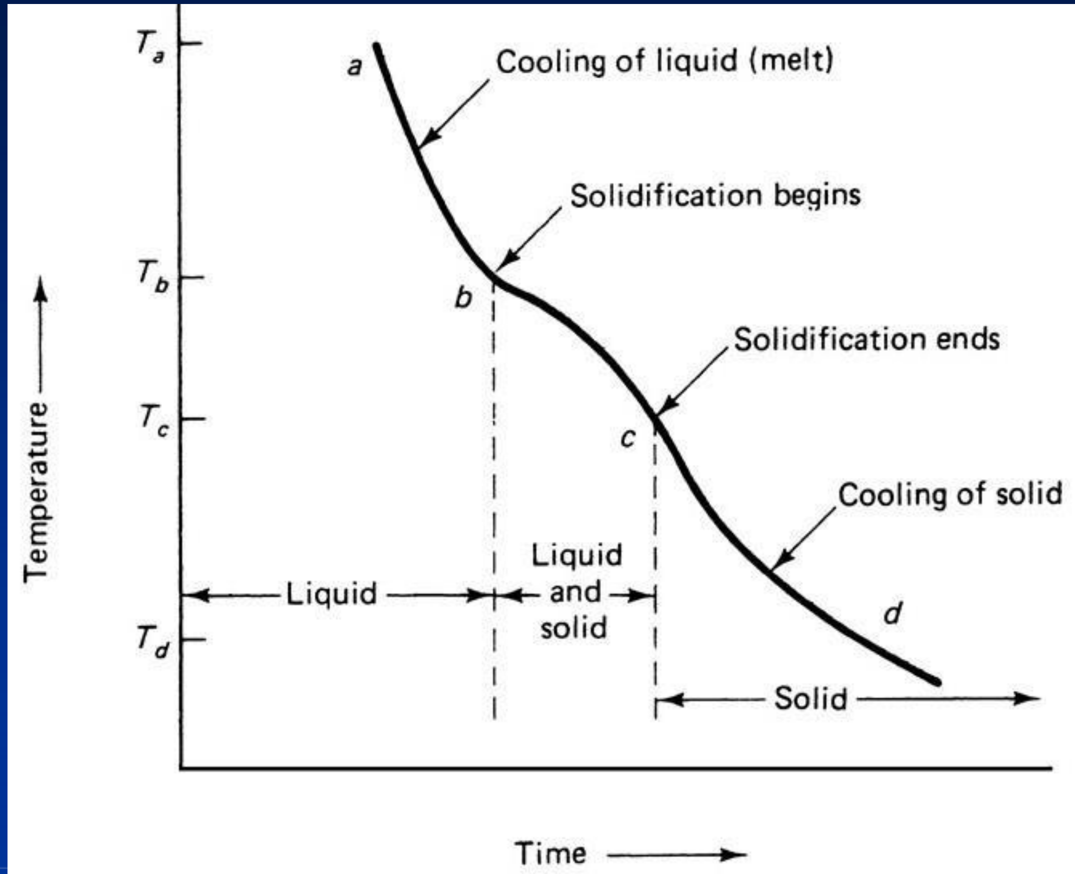


FIG. 3-50 (c) Cooling curve for a metal alloy: (1) The alloy A-B heated to point *a* (liquid phase, with both metals soluble in each other); (2) cooling of alloy in liquid phase; (3) point *b*, solidification begins; (4) point *c*, solidification complete; sloped *b – c* due to changing from liquid to solid over the temperature range T_b to T_c because components *A* and *B* have different melting/cooling temperatures; (5) further cooling from *c* to *d* of solid-state metal alloy.

Klasifikasi Diagram Kesetimbangan Fasa

1. Larut sempurna dalam keadaan cair dan padat.
2. Larut sempurna dalam keadaan cair, tidak larut dalam keadaan padat (reaksi eutektik).
3. Larut sempurna dalam keadaan cair, larut sebagian dalam keadaan padat (reaksi eutektik).
4. Larut sempurna dalam keadaan cair, larut sebagian dalam keadaan padat (reaksi peritektik).
5. Larut sempurna dalam keadaan cair, tidak larut dalam keadaan padat dan membentuk senyawa.
6. Larut sebagian dalam keadaan cair (reaksi monotektik).
7. Tidak larut dalam keadaan cair maupun padat.

1. Larut sempurna dalam keadaan cair dan padat

Biasa disebut ***binary isomorphous alloy systems***, kedua unsur yang dipadukan larut sempurna dalam keadaan cair maupun padat. Pada sistem ini hanya ada satu struktur kristal yang berlaku untuk semua komposisi, syarat yang berlaku adalah:

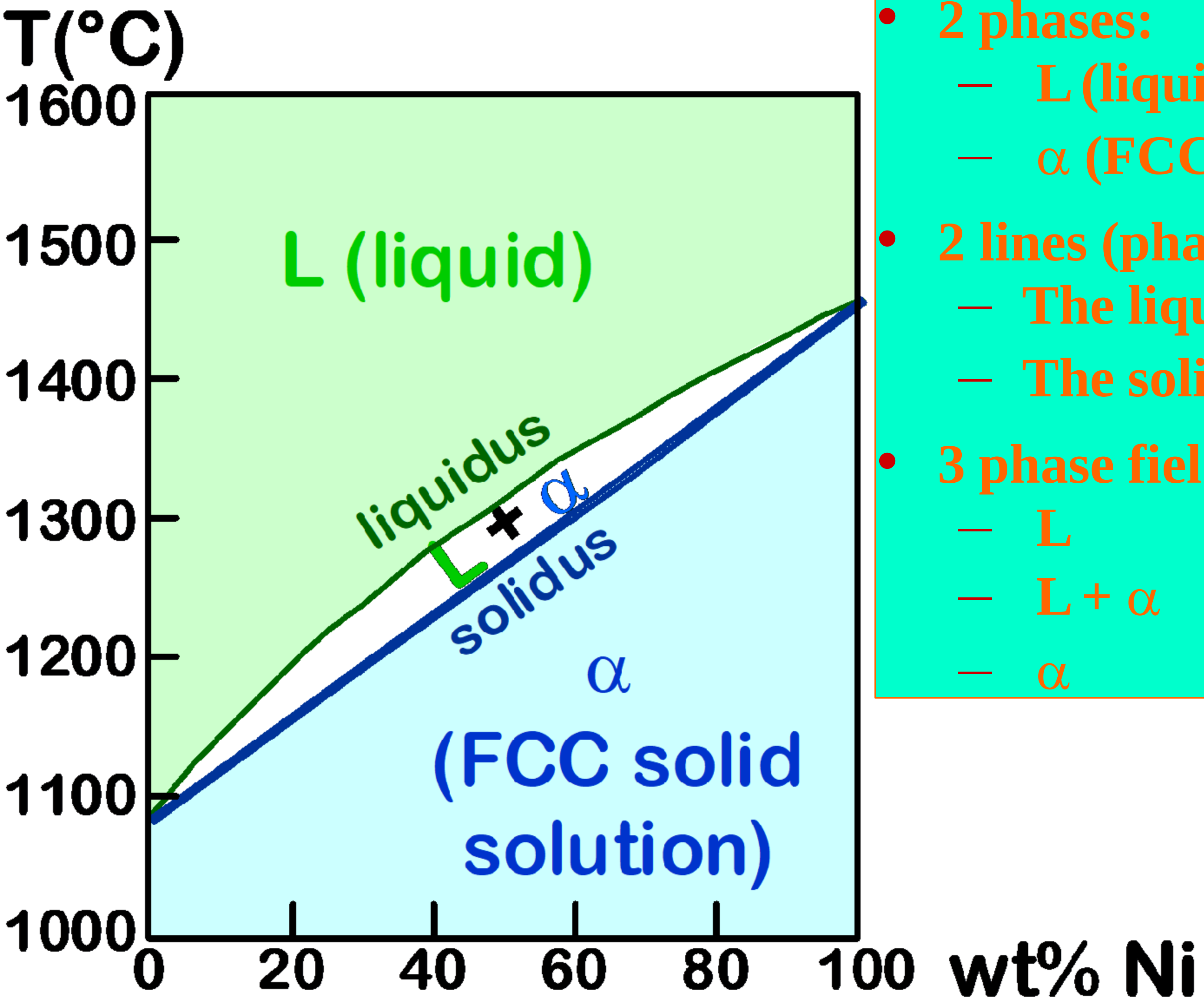
a. Struktur kristal kedua unsur harus sama.

b. Perbedaan ukuran atom kedua unsur tidak boleh lebih dari 15%.

c. Unsur-unsur tidak boleh membentuk senyawa.

d. Unsur-unsur harus mempunyai valensi yang sama.

Contoh klasik untuk jenis diagram fasa ini adalah diagram fasa Cu-Ni.



- 2 phases:
  - L (liquid)
  - α (FCC solid solution)
- 2 lines (phase boundaries):
  - The liquidus line (L/L+α)
  - The solidus line (α/L+α)
- 3 phase fields:
  - L
  - L + α
  - α

Rules of Determining Number & Types of Phases (The lever arm rule/Aturan kaidah lengan)

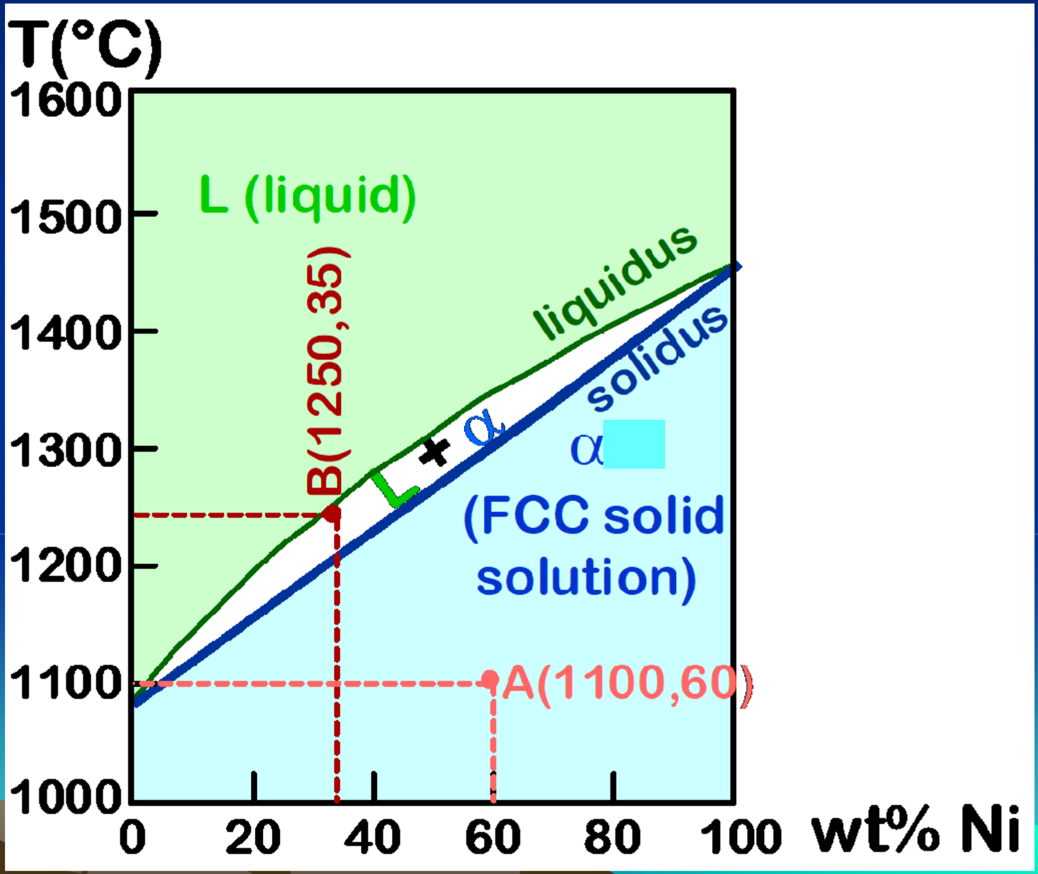
- **aturan 1: jika diketahui T dan C_o (komposisi), maka**
  - **akan diketahui jumlah dan jenis fasa**

Lihat gambar disamping

- **contoh:**

A (1100°C, 60wt% Ni):
1 phase: α

B (1250°C, 35wt% Ni):
2 phases: L + α



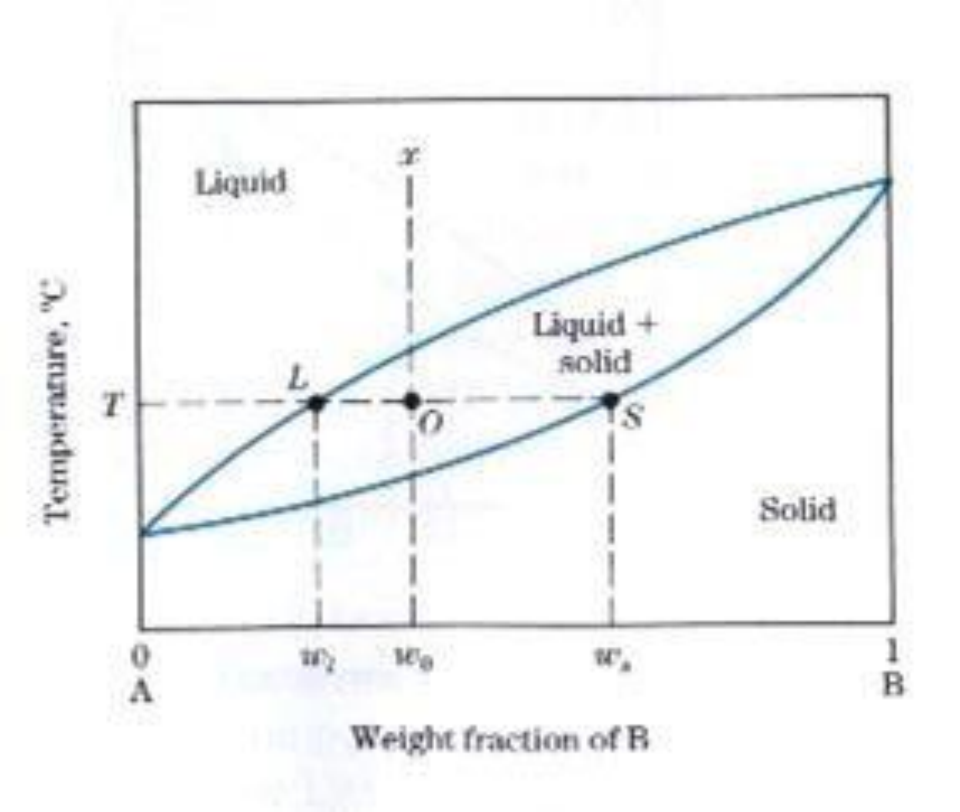
Aturan kaidah lengan/the lever arm rule

Untuk menghitung persentase fasa-fasa yang ada pada komposisi tertentu, digunakan metoda kaidah lengan.

x adalah komposisi paduan yang akan dihitung persentase fasa-fasanya pada temperatur T, maka tarik garis yang memotong batas kelarutannya (garis L-S).

Jika $x = w_o$; $L = w_l$ dan $S = w_s$

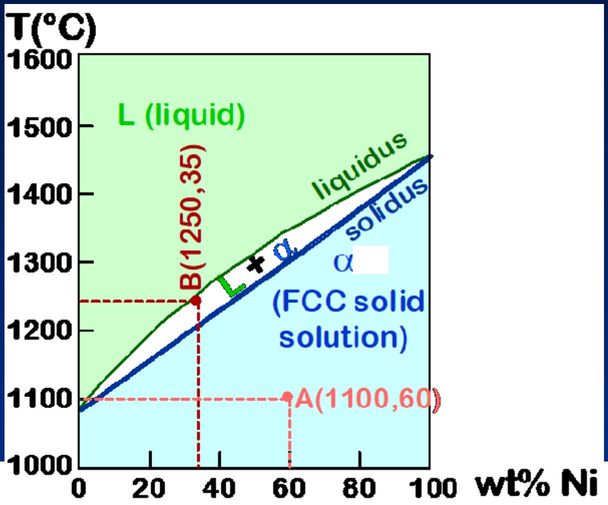
maka % fasa cair dan padat :



$$L = \frac{w_s - w_o}{w_s - w_l} x100\%$$

$$S = \frac{w_o - w_l}{w_s - w_l} x100\%$$

- aturan 2: jika diketahui T dan C_o, maka
  - akan diketahui komposisi dari fasa

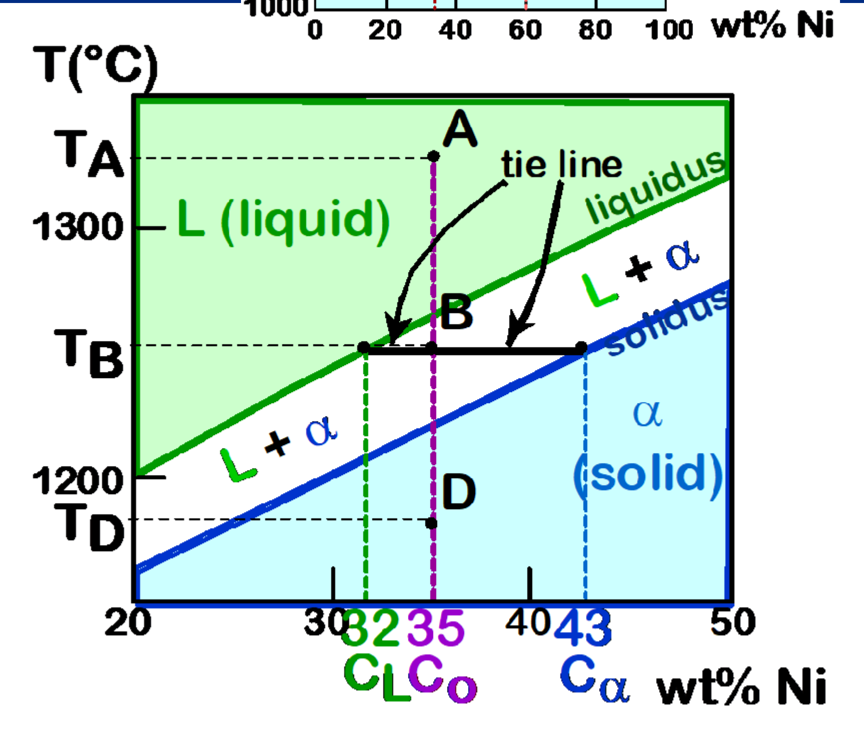


- contoh: C_0 = 35 wt%Ni

  At T_A:
  Only Liquid (L)
  $C_L = C_0$ = 35 wt%Ni

  At T_D:
  Only Solid (α)
  $C_\alpha = C_0$ = 35 wt%Ni

  At T_B:
  Both α and L
  $C_L = C_{Liquidus}$ = 32 wt%Ni
  $C_\alpha = C_{Solidus}$ = 43 wt%Ni



w_l (32%) w_o(35%) w_s(43%)

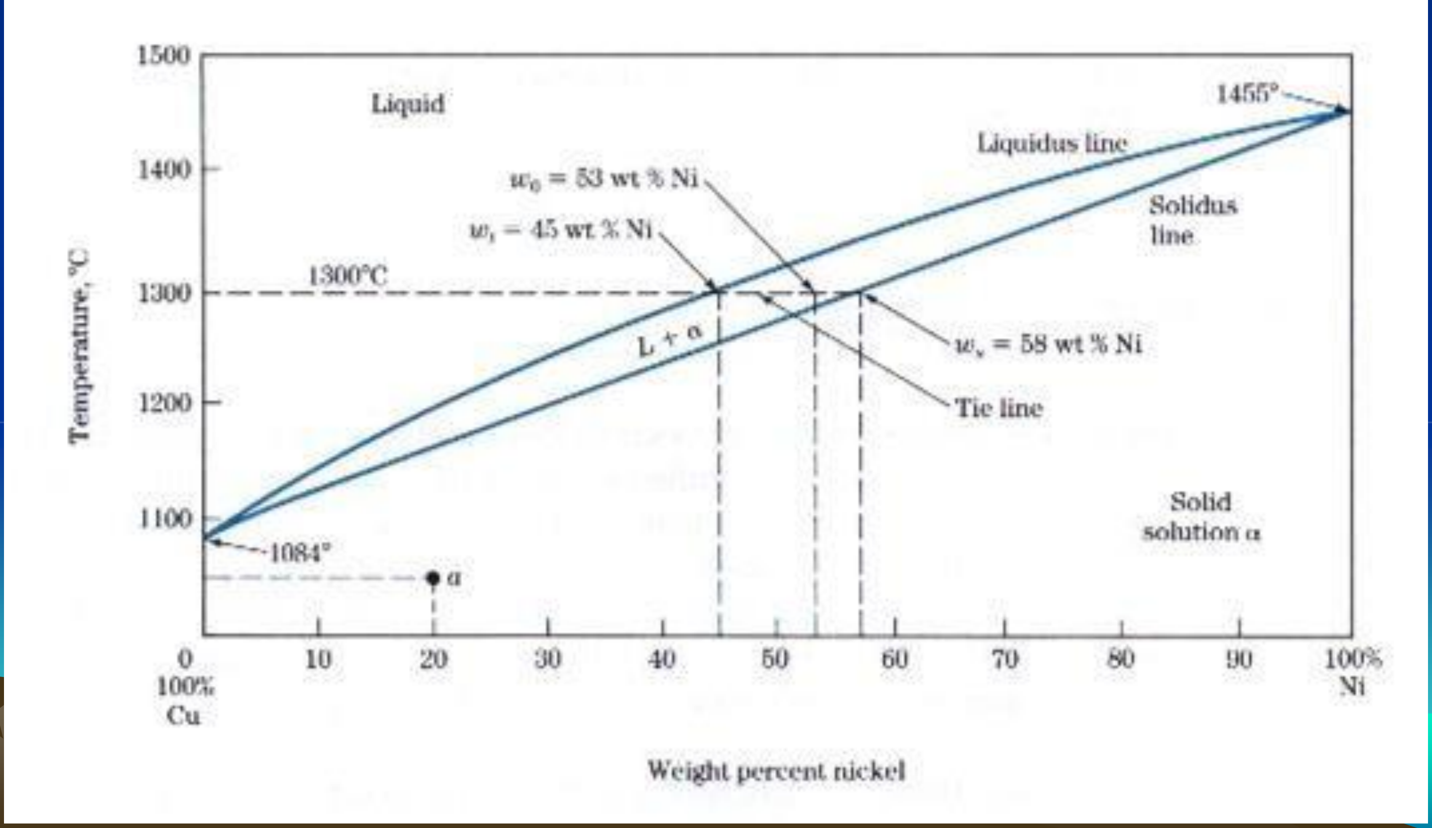
$$L = \frac{43-35}{43-32} x100\%$$

$$L = 72,7\%$$

$$S = \frac{35-32}{43-32} x100\%$$

$$S = 27,3\%$$

Contoh lain: pada w_o= 53% Ni



% fasa cair dan padat:

w_l (45%) w_o(53%) w_s(58%)

$$L = \frac{58-53}{58-45} x100\%$$

$$L = 38\%$$

$$S = \frac{53-45}{58-} x$$

$$S =$$

Example: Determine the phase(s) that are present and the composition of the phase(s)

For the alloys listed below:

60 wt% Ni-40 wt% Cu at 1100°C

35 wt% Ni-65 wt% Cu at 1250°C

(1) **Phase(s) that are present**

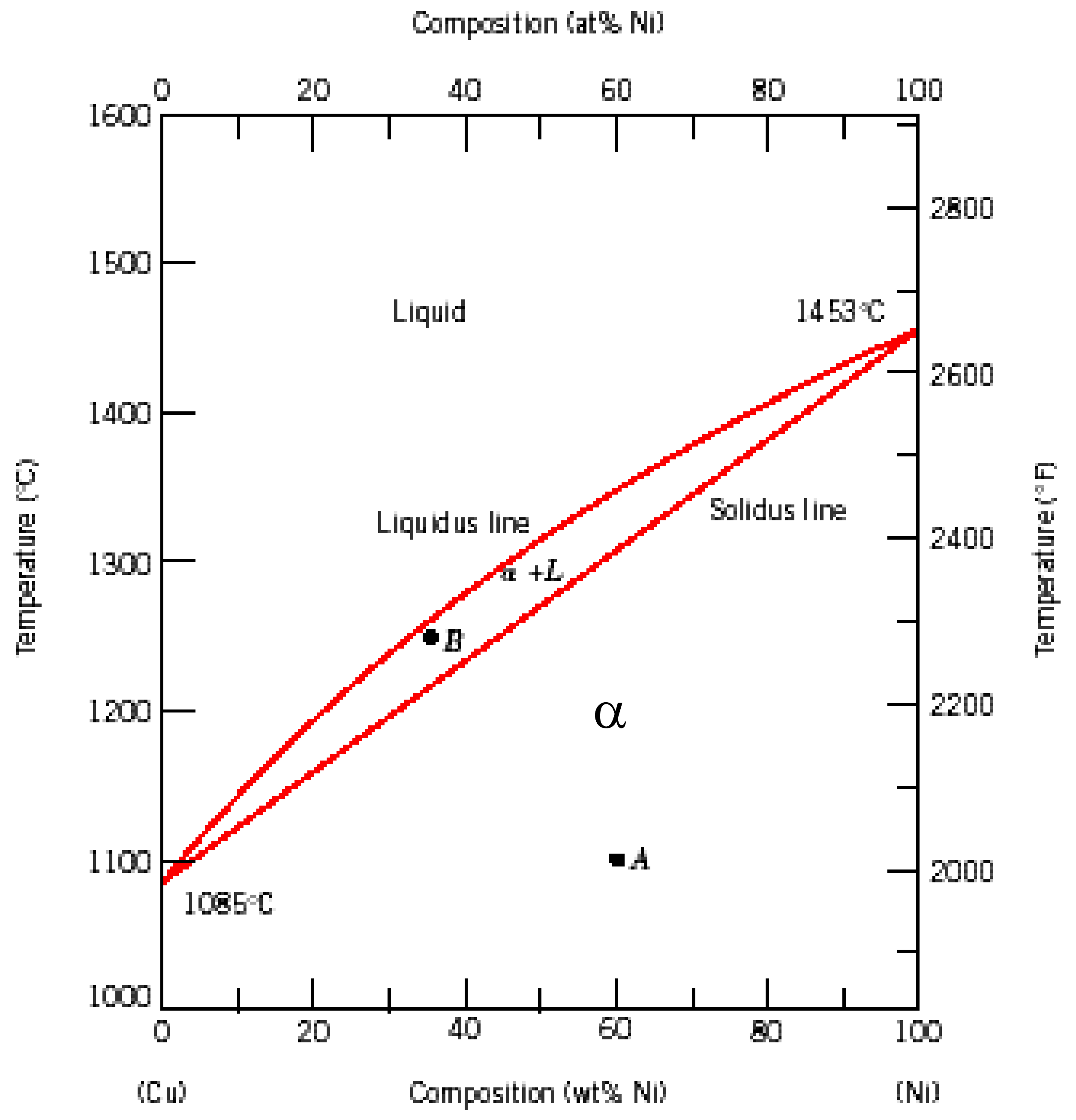
(2) **The composition of each phase**

(1) Determine the phase(s) that are present

60 wt% Ni-40 wt% Cu at 1100°C

Point A:

α phase

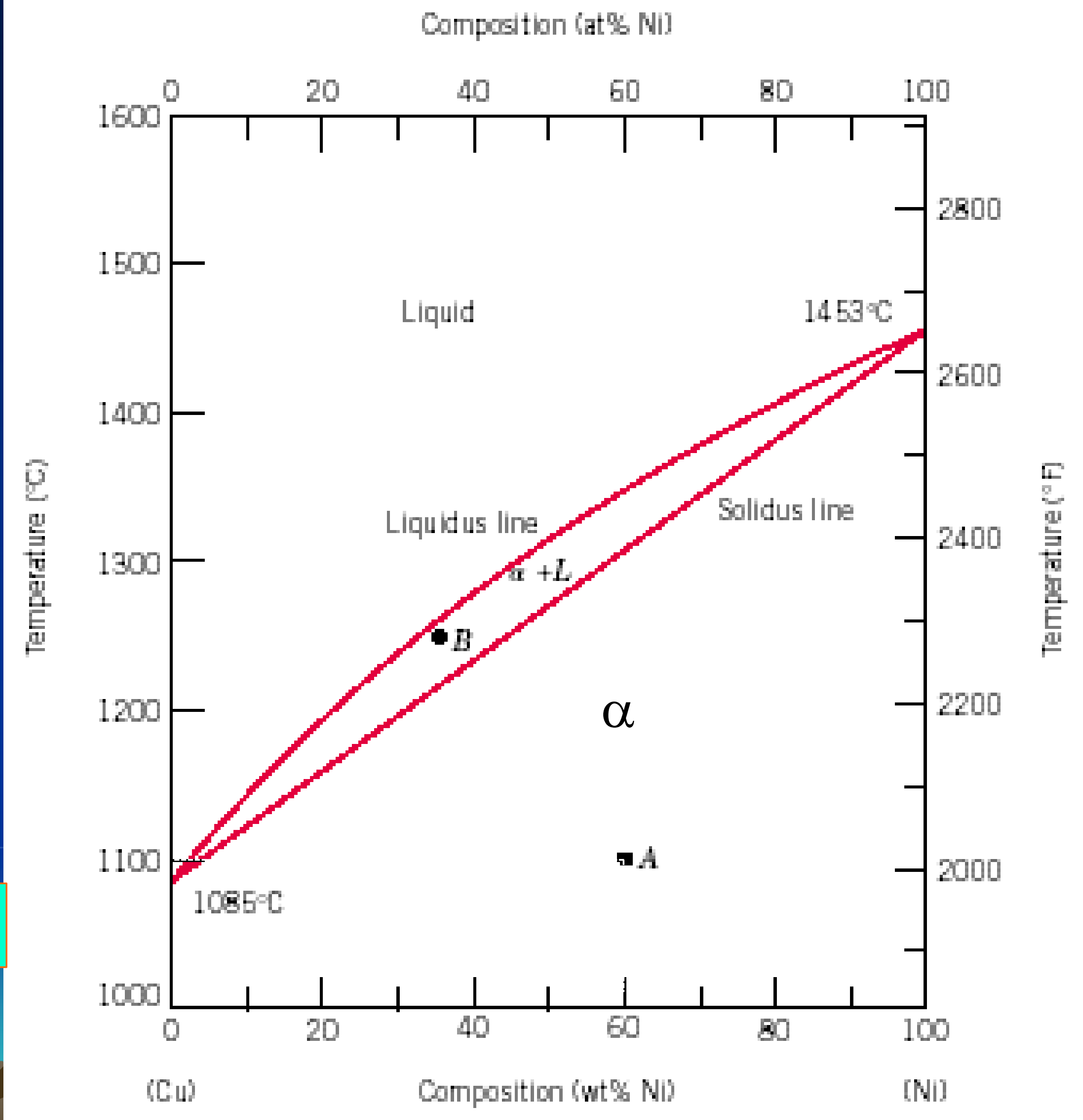


(2) Determine the composition of each phase

60 wt% Ni-40 wt% Cu at 1100°C (Point A):

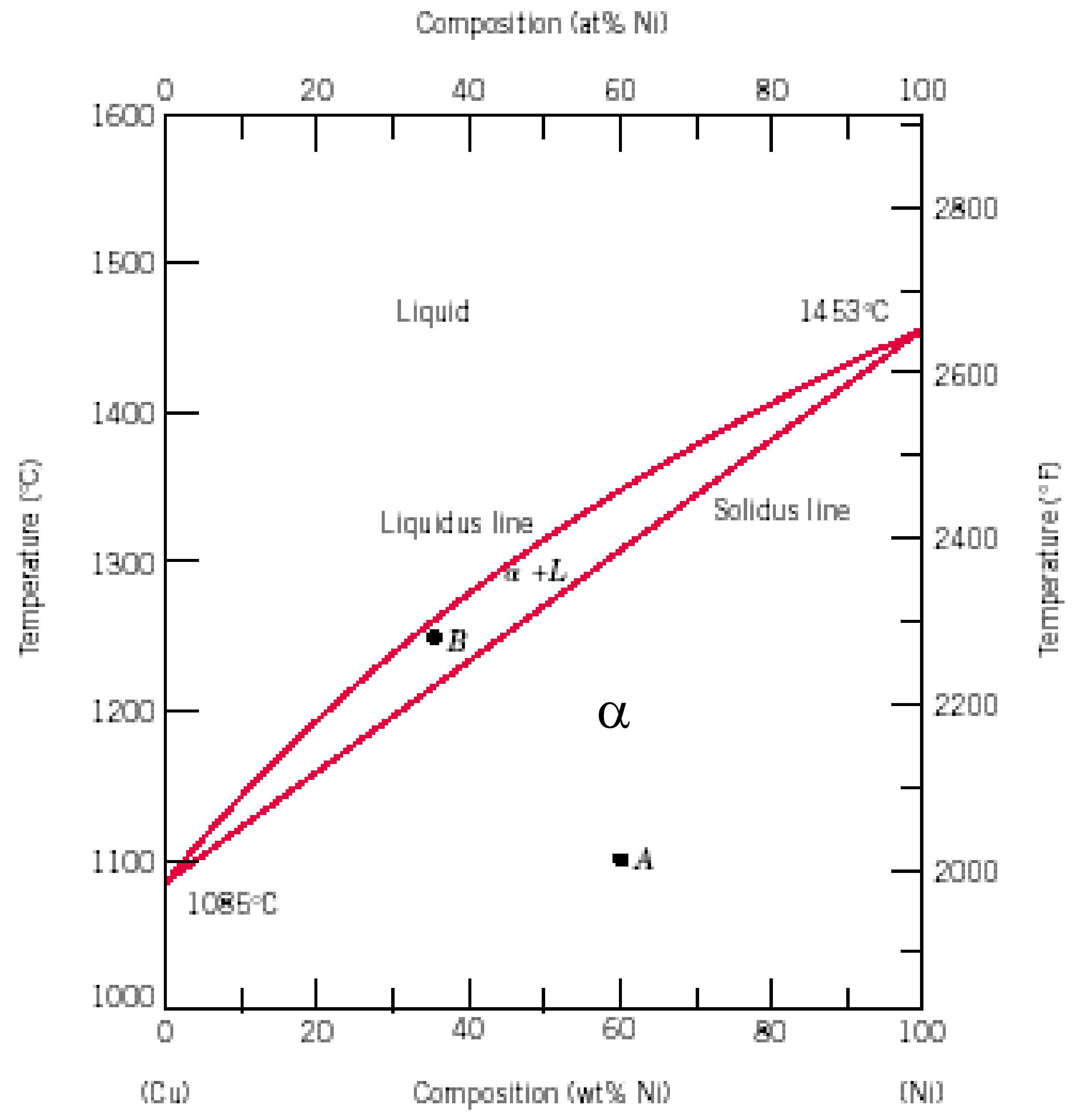
α

$C_\alpha = C_0 = 60$ wt% Ni



(1) Determine the phase(s) that are present

35 wt% Ni-65 wt% Cu at 1250°C



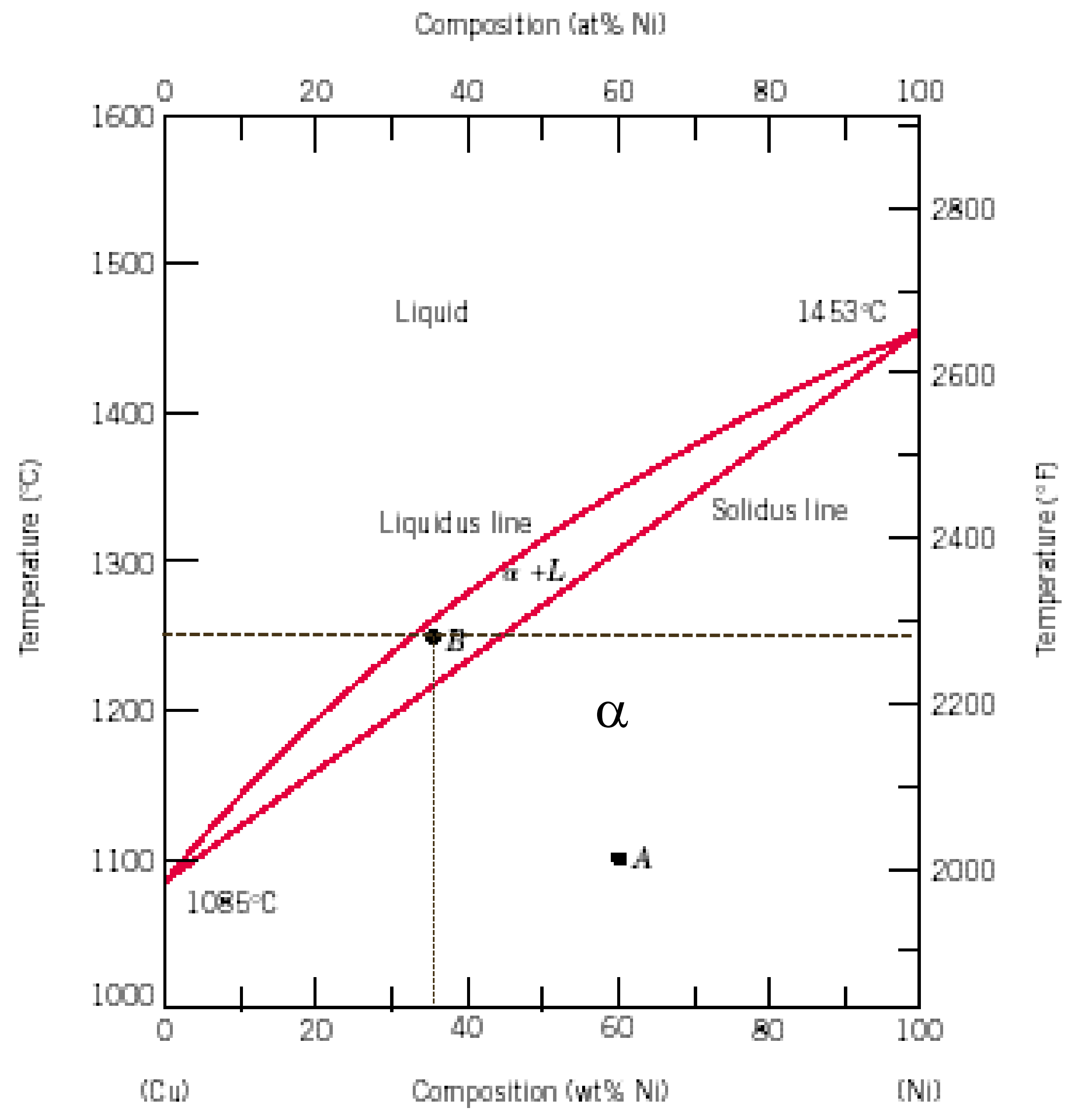
Point B

α + L phases

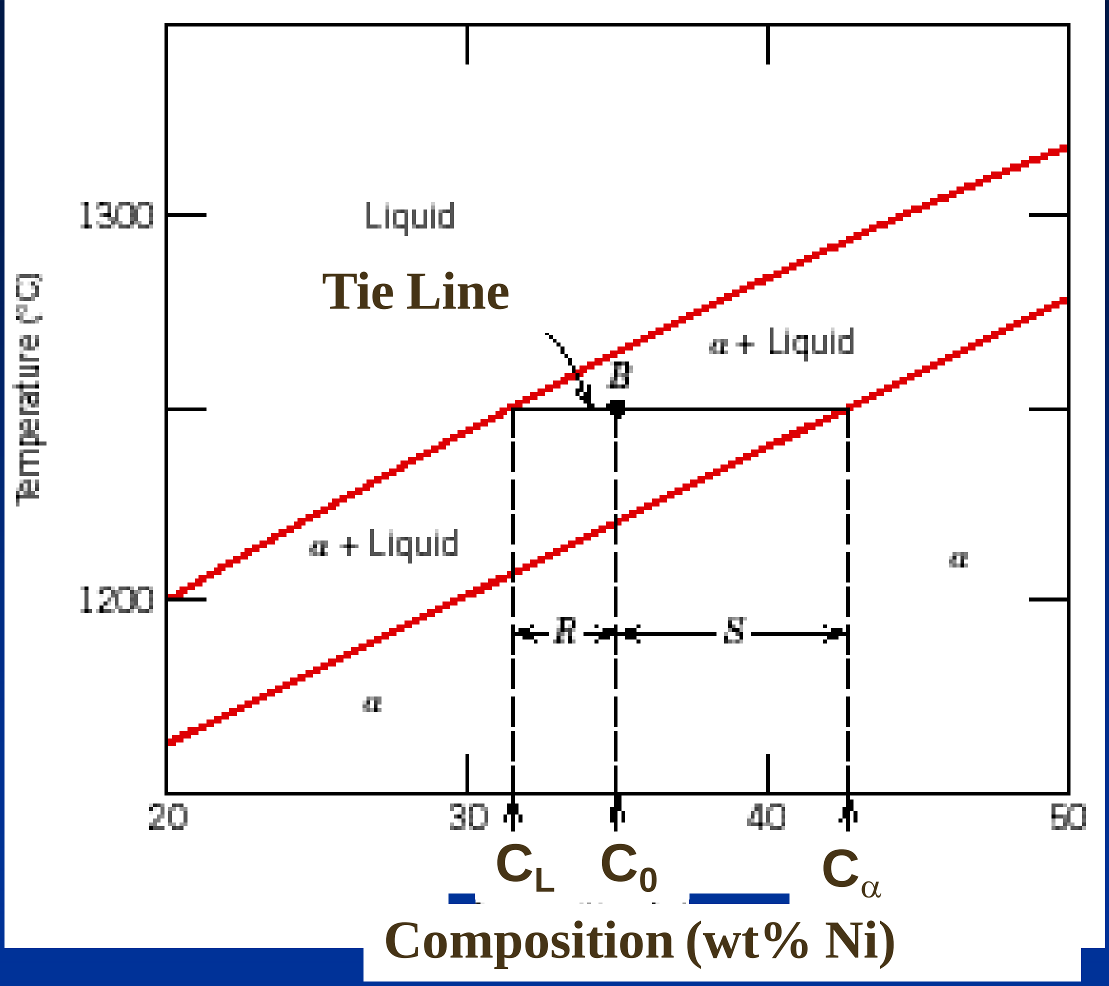
(2) Determine the composition of each phase

35 wt% Ni-65 wt% Cu at 1250°C (Point B):

α + L



(2) Determine the composition of each phase



- 35 wt% Ni-65 wt% Cu at 1250°C (Point B): in two phase (α + L) region

Draw a tie line

Composition of a: intersection L/α+L — C_α = 42.5wt% Ni

Composition of L: intersection α/α+L — C_L = 31.5 wt% Ni

Equilibrium Cooling in a Cu-Ni Binary System

- Consider
  C_o = 35wt%Ni
- Upon cooling
  - L
    35wt% → 32wt% → 24wt%
  - α
    46wt% → 43wt% → 36wt%
- Equilibrium cooling
  Sufficiently slow cooling rate gives enough time for composition readjustments