Homework 10.0

Carefully review chapter 10 lecture slides and, if time allows, read textbook sections (Askeland 10.1-10.5) and give an honor statement confirming the reading

Homework 10.1

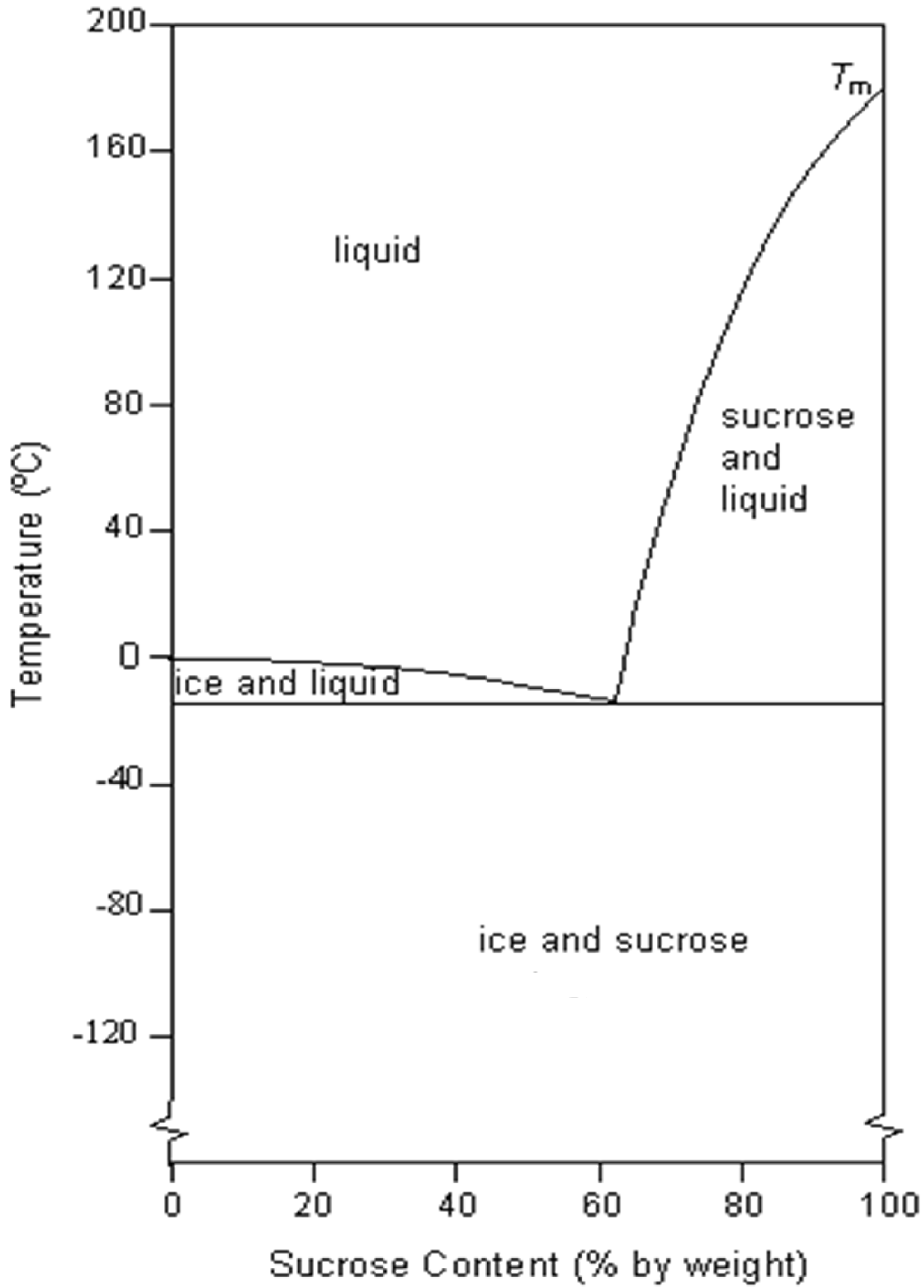
Consider the sucrose–water phase diagram:

(i) How much sugar can dissolve in 1000 g water at 80°C?

(ii) If the saturated liquid solution in (i) is cooled to 0°C, some sugar will precipitate out as a solid. What will be the composition of the saturated liquid solution (in wt% sucrose) at 0°C?

(iii) How much of the solid sugar will come out of solution upon cooling to 0°C?

(iv) What is roughly the melting point for sucrose?



Homework 10.1

(1) At 80^{o}C, phase diagram shows phase boundary or solubility at ~74 wt.% sucrose.
Suppose 1000 g water could dissolve x g of sugar (sucrose), we have

$$\frac{?}{?\ +??} = 0.74 \qquad x = \cdots = \mathbf{2846\ g}$$

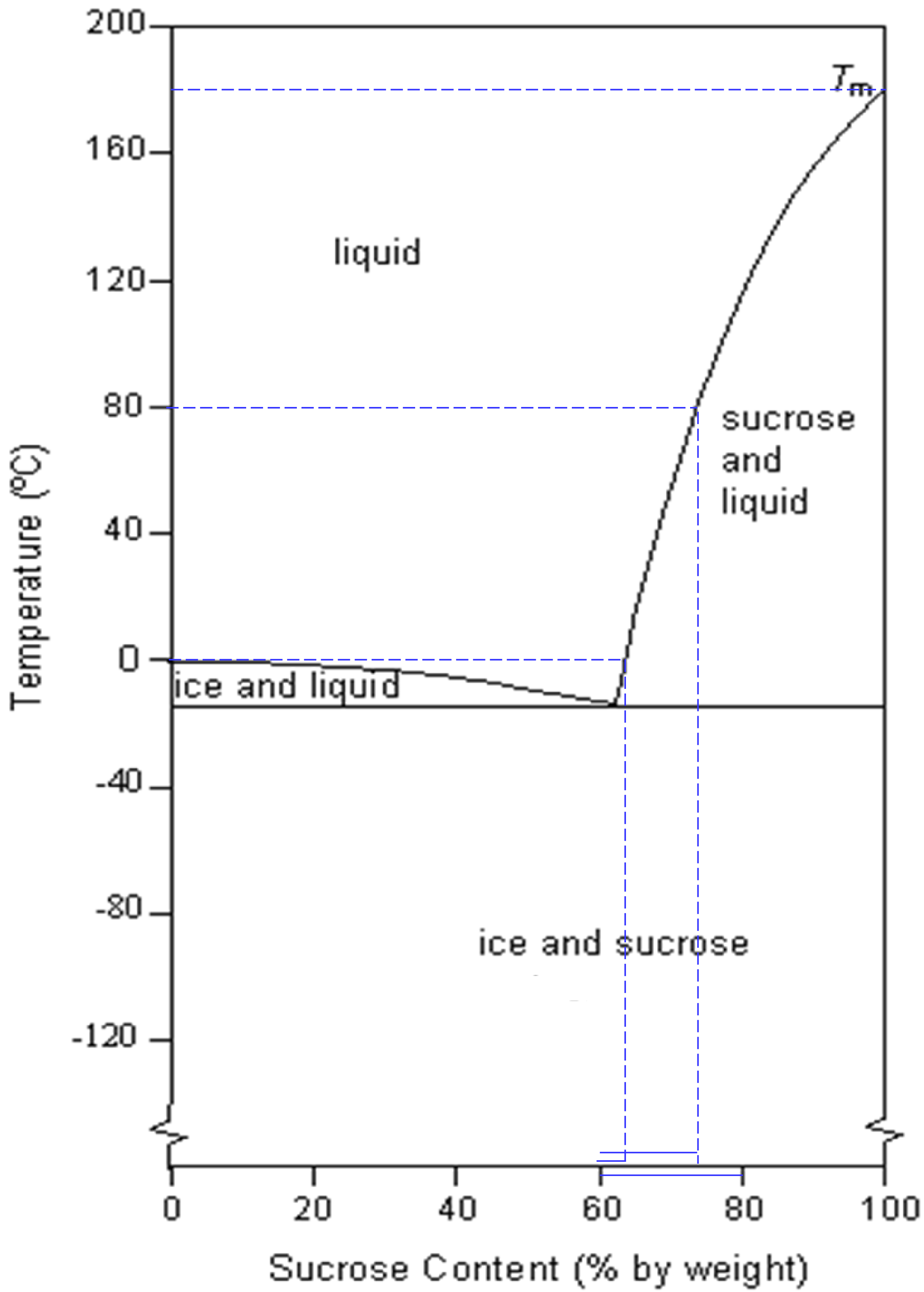
(2) When cooled to 0^{o}C, phase diagram shows that the composition of the saturated liquid is **~64 wt.% sucrose**.

(3) At 0^{o}C, 1000 g water could dissolve y g of sugar:

$$\frac{?}{?+??} = 0.64 \qquad y = \cdots = 1778\ g$$

Sugar coming out: $? - ?? = \mathbf{1068\ g}$

(4) Melting point for sucrose is **~180^{o}C**, from the phase diagram



Homework 10.2

A copper-nickel alloy with composition 60 wt% Ni-40 wt% Cu is heated slowly (i.e., always reaching equilibrium) from a temperature of 1200°C.

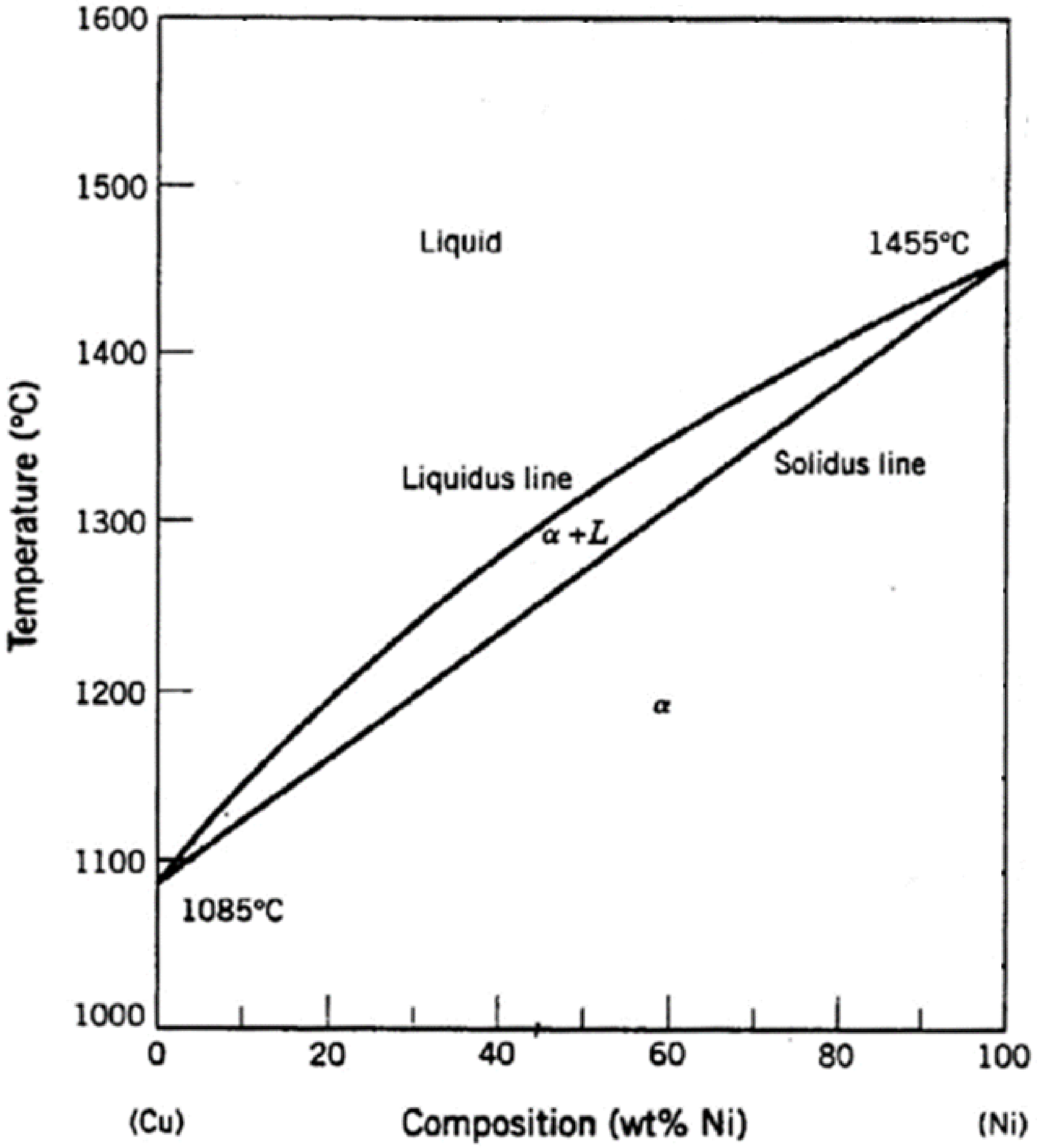
(a) At what temperature does the first liquid phase form?

(b) What is the composition of this initial liquid phase?

(c) At what temperature does <u>complete</u> melting of the alloy occur?

(d) What is the composition of the last solid remaining before complete melting?

(e) What are the melting points for pure Cu and pure Ni, respectively?



Homework 10.2

From the phase diagram, for 60 wt% Ni - 40 wt% Cu alloy heated from 1200°C:

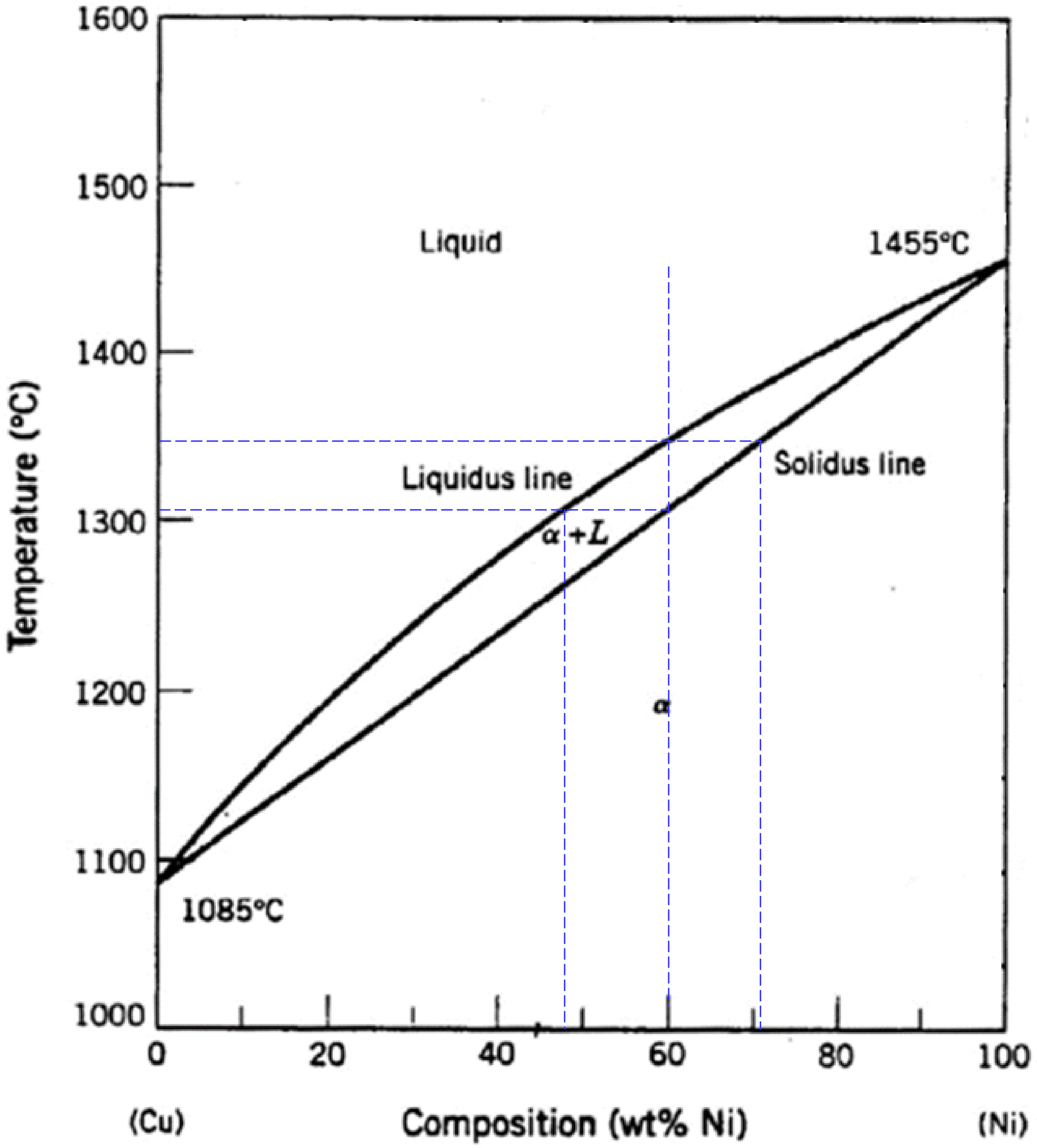
(a) First bit of liquid phase form at **~1310°C**

(b) Composition of the initial liquid: **~48 wt.% Ni**

(c) Complete melting occurs at **~1350°C**

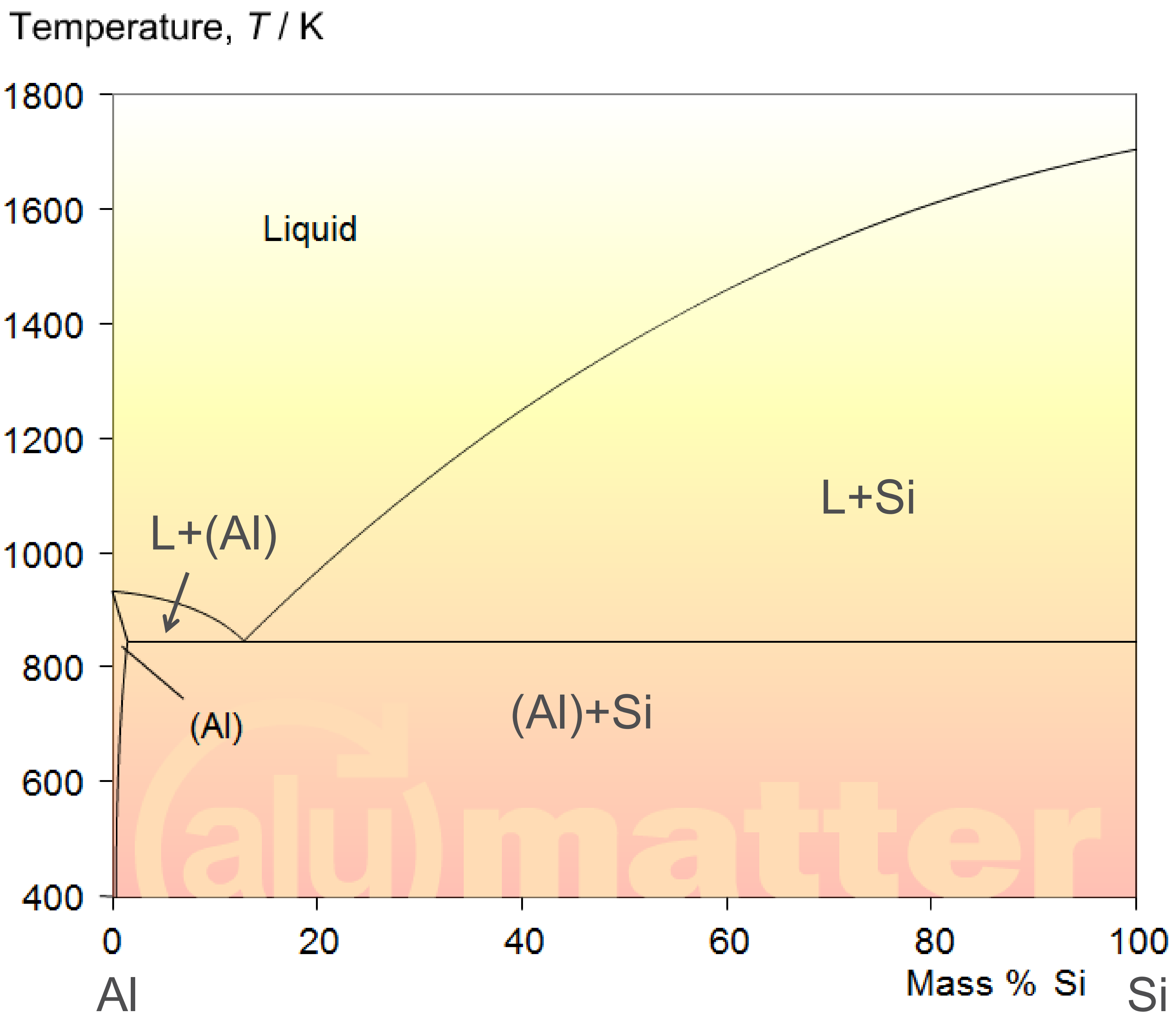
(d) Composition of the last solid remaining before complete melting: **~71 wt% Ni**

(e) Melting points for pure Cu and pure Ni: **1085°C** and **1445°C**, respectively?



Homework 10.3

1. What type of phase diagram is it?
2. How many components? What are they?
3. What are the single phases that can be present, based on the phase diagram?
4. How many two-phase regions and what are they?
5. What is roughly the eutectic temperature?
6. Write down the eutectic reaction and **the rough composition (in wt% Si) for each of the phase involved in the eutectic reaction**
7. What are the phases, the approximate composition (in wt% Si) for each phase, & relative amount (weight fraction) for each phase for alloy w/ 20 wt.% Si at equilibrium:
   a. When T = 400K
   b. When T is just **below** eutectic temperature
   c. When T is just **above** eutectic temperature
   d. When T = 1500 K



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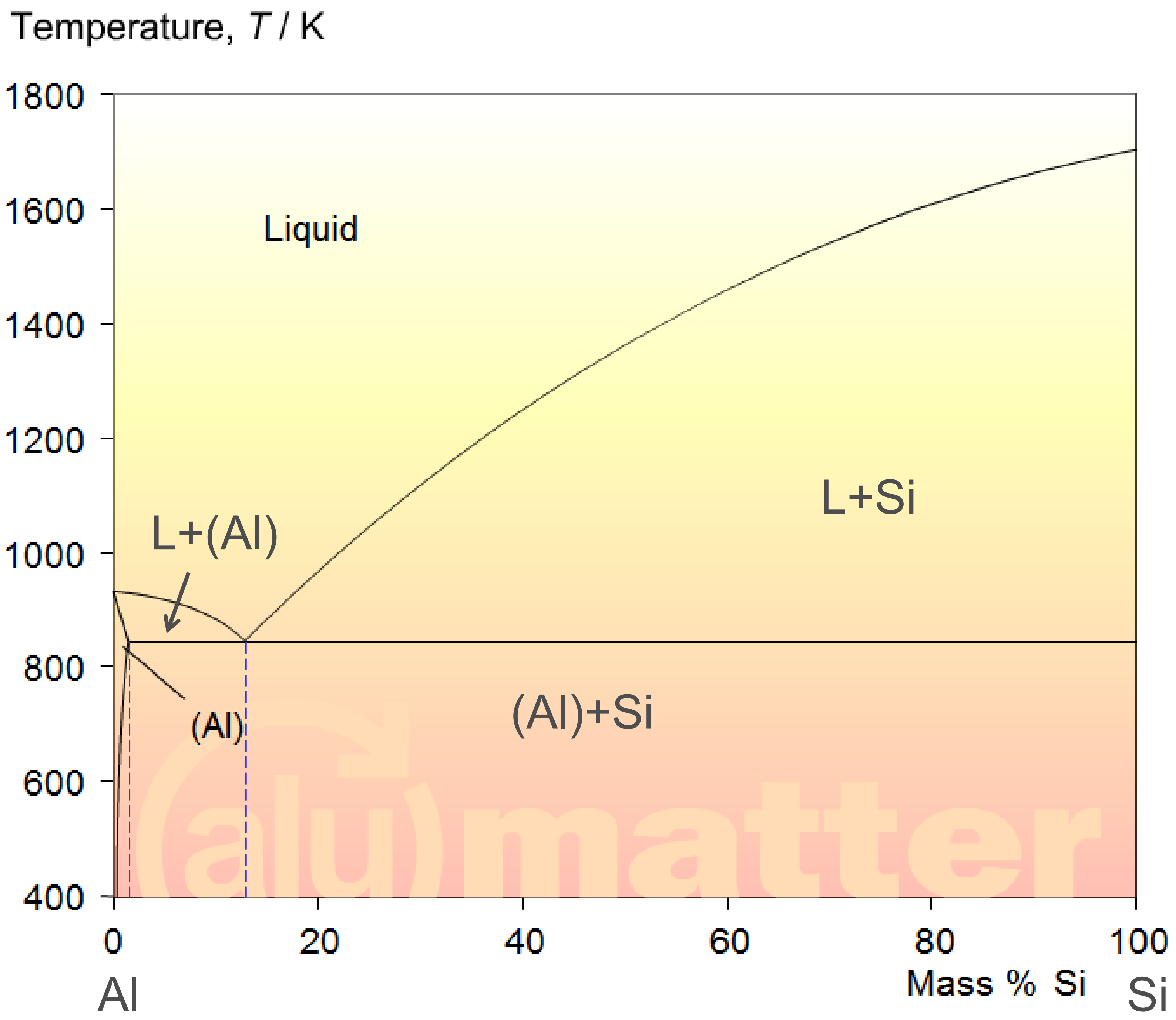
Homework 10.3

1. Binary eutectic phase diagram
2. Two (2) components: Al and Si
3. Single phases: Al solid solution (labelled as (Al)), Si (very low solubility of Al), Liquid
4. Three (3) two-phase regions:
   (Al) + L, (Al) + Si, L + Si
5. Eutectic temperature T_E ~ 850K (477°C)
6. Eutectic reaction: L = (Al) + Si
   Composition for each of phases involved:
   $C\,(L_E) \approx 13$ wt.% Si
   $C\,((Al)_E) \approx 2$ wt.% Si
   $C\,(Si_E) \approx 100$ wt.% Si
7. For alloy w/ 20 wt.% Si
   a. T = 400K
      Two phases: (Al) and Si
      $C((Al)) \approx 0.3$ wt% Si;
      $C(Si) \approx 100$ wt% Si
      $w_{(Al)} = \ldots = 80.2$ wt.%
      $w_{Si} = \ldots = 19.8$ wt.%
      $m_{(Al)} = \ldots =$ **401 g**
      $m_{Si} = \ldots =$ **99 g**



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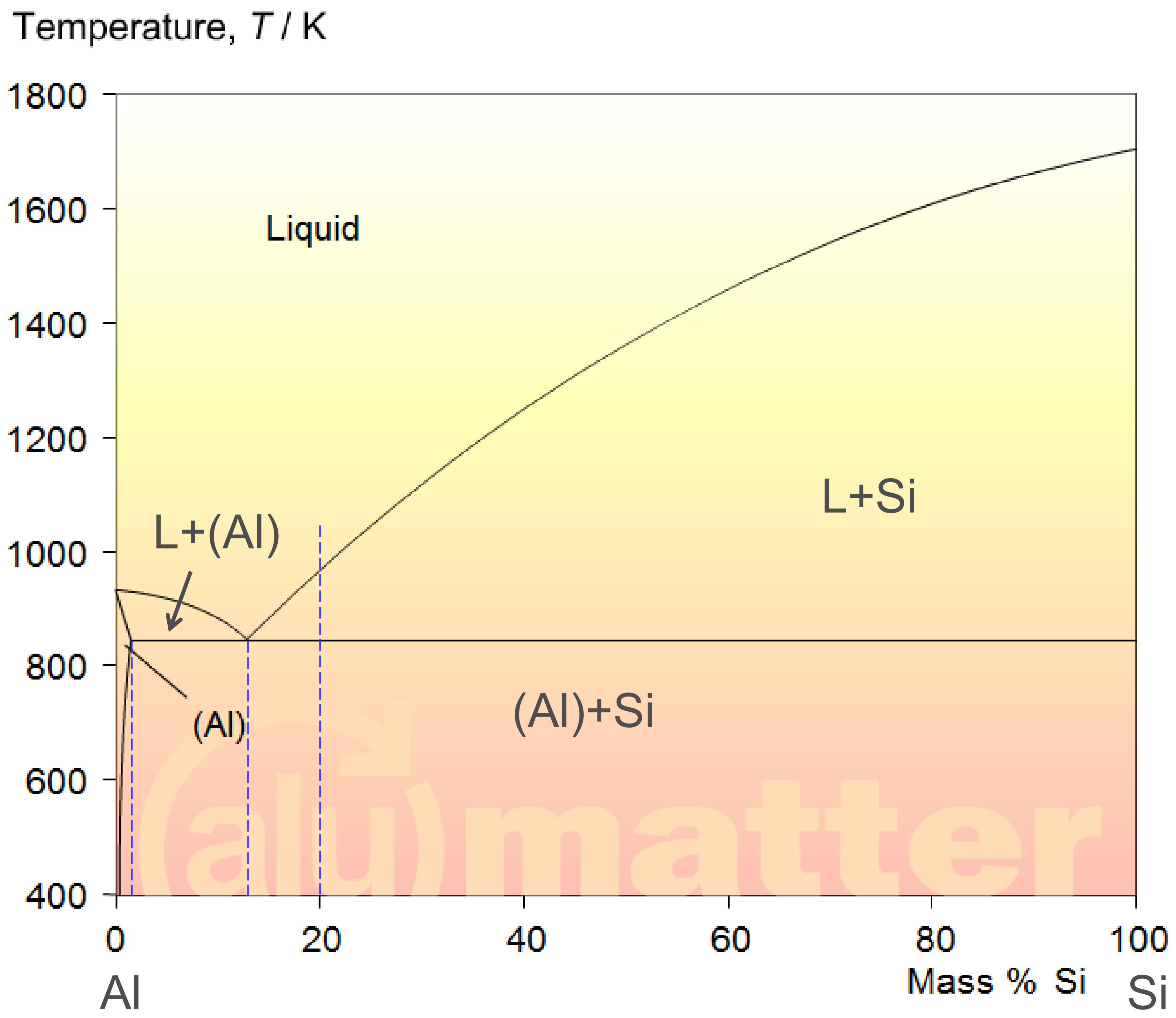
Homework 10.3

7. For alloy w/ 20 wt.% Si
   b. T just **below** eutectic temperature
      Two phases: (Al) and Si
      $C((Al)) \approx 2$ wt% Si;
      $C(Si) \approx 100$ wt% Si
      $w_{(Al)} = \ldots = 81.6$ wt.%
      $w_{Si} = \ldots = 18.4$ wt.%
      m(Al) = … = 408 g
      mSi = … = 92 g
   c. When T is just **above** eutectic temperature
      Two phases: L and Si
      $C(L) \approx 13$ wt% Si;
      $C(Si) \approx 100$ wt% Si
      $w_L = \ldots = 92.0$ wt.%
      $w_{Si} = \ldots = 8.0$ wt.%
      $m_L = \ldots = 460$ g
      mSi = … = 40 g
   d. When T = 1500 K
      One phases: L
      $C(L) \approx 20$ wt% Si
      $w_L = 100$ wt.%
      $m_L = \ldots = 500$ g



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Homework 10.4

1. Two (2) components: one is Al and the other Ni
2. Multiple single phases can be present, such as:
   a. Liquid,
   b. Fcc Al,
   c. Al_3Ni,
   d. Al_3Ni_2,
   e. B2 (essentially NiAl ordered phase),
   f. Al_3Ni_5,
   g. L12_FCC,
   h. Fcc Ni
3. Many 2-phase regions, such as:
   - L + Fcc Al
   - L + Al_3Ni
   - Fcc Al + Al_3Ni
   - L + Al_3Ni_2
   - …
4. T_m (pure Al) ≈ 660°C
   T_m (pure Ni) ≈ 1450°C
   T_{m_max} ≈ 1650°C, for B2 structure w/ composition of 68 wt% Ni

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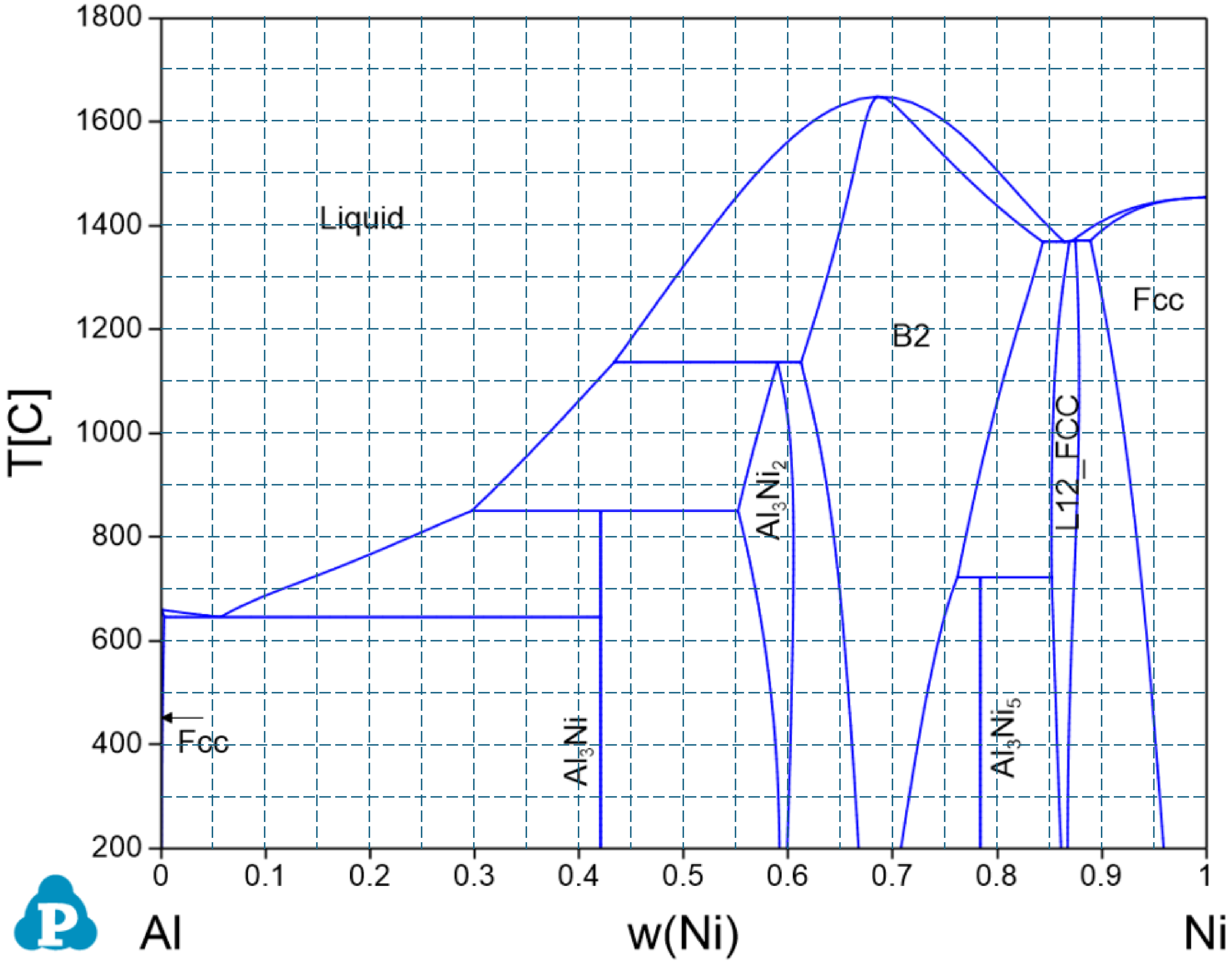

Note: in binary phase diagrams, between two neighboring single-phase regions, there would be a 2-phase region, but sometimes like the one above, 2-phase region are not labelled

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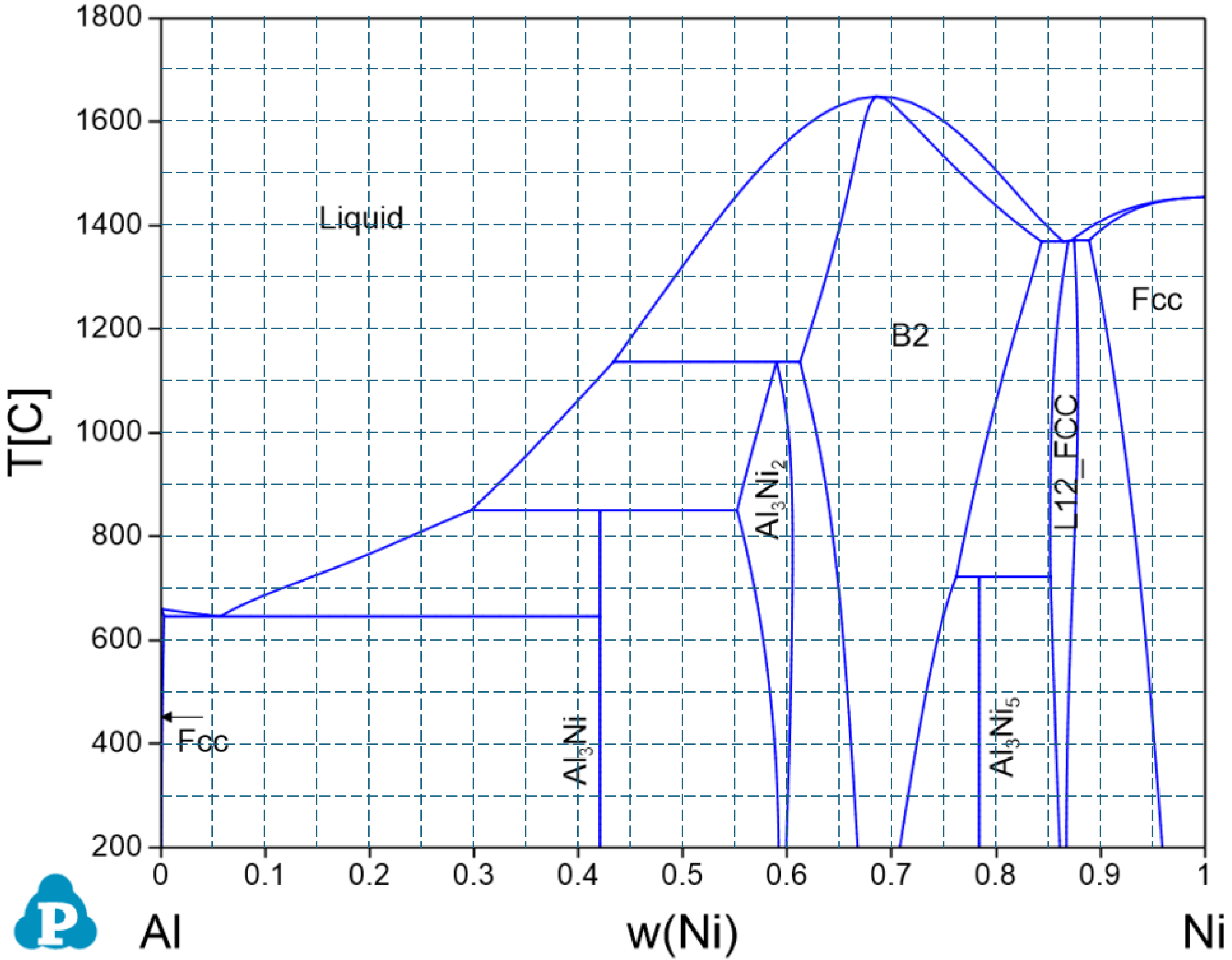
Homework 10.4

5. Eutectic reaction involving (near) pure Al
   L = Fcc Al + Ni_3Al
   Composition for each of phases involved:
   C_E (L) = 0.06 = 6%
   C_E (Fcc Al) = 0.0 = 0%
   C_E (Ni_3Al) = 0.42 = 42%
6. One peritectic reaction near 850°C:
   L + Al_3Ni_2 = Al_3Ni
   Composition for each of the phases involved:
   C_{Pc} (L) = 0.30 = 30%
   C_{Pc} (Al_3Ni_2) = 0.55 = 55%
   C_{Pc} (Al_3Ni) = 0.42 = 42%
7. One peritectoid reaction near 720°C:
   B2 + L12_FCC = Al_3Ni_5
   Composition for each of the phases involved:
   C_{Pd} (B2) = 0.76 = 76%
   C_{Pd} (L12_FCC) = 0.85 = 85%
   C_{Pd} (Al_3Ni_5) = 0.78 = 78%



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Homework 10.5

1. **1400°C** at equilibrium:
- One phase - liquid
- C_L = 50 wt% Ni
- w_L = 100%
- **m_L = 500 g × 100% = 500 g**

2. **1200°C** at equilibrium:
- Two phases – liquid + B2
- C_L = 46 wt% Ni; C_{B2} = 62.5 wt% Ni
- w_L = … = 75.8%
- w_{B2} = … = 24.2%
- **m_L = … = 379 g**
- **m_{B2} = … = 121 g**

3. Just **above** peritectic temperature near ~1140°C
- Two phases – liquid + B2
- C_L = 43 wt% Ni; C_{B2} = 62 wt% Ni
- w_L = … = 63.2%
- w_{B2} = … = 36.8%
- **m_L = … = 316 g**
- **m_{B2} = … = 184 g**

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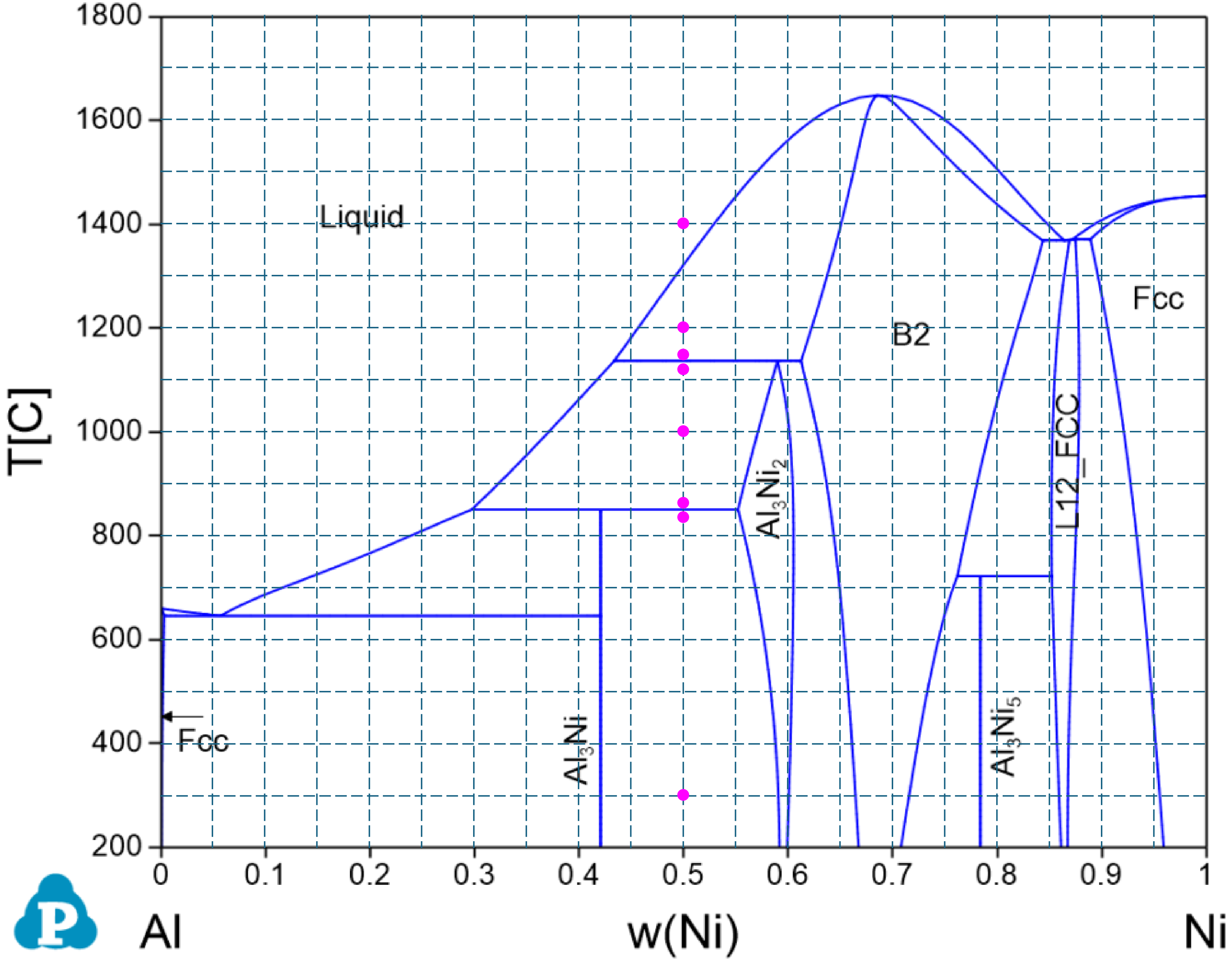

Note: in binary phase diagrams, between two neighboring single-phase regions, there would be a 2-phase region, but sometimes like the one above, 2-phase region are not labelled

Homework 10.5

4. Just **below** peritectic temperature near ~1140^oC
- Two phases – liquid + Al_3Ni_2
- C_L = 43 wt% Ni; C_{Al3Ni2} = 59 wt% Ni
- w_L = … = 56.2%
- w_{Al3Ni2} = … = 43.8%
- **m_L = … = 281 g**
- **m_{Al3Ni2} = … = 219 g**

5. **1000^oC:**
- Two phases – liquid + Al_3Ni_2
- C_L = 37.5 wt% Ni; C_{Al3Ni2} = 57.5 wt% Ni
- w_L = … = 37.5%
- w_{Al3Ni2} = … = 62.5%
- **m_L = … = 187.5 g**
- **m_{Al3Ni2} = … = 312.5 g**

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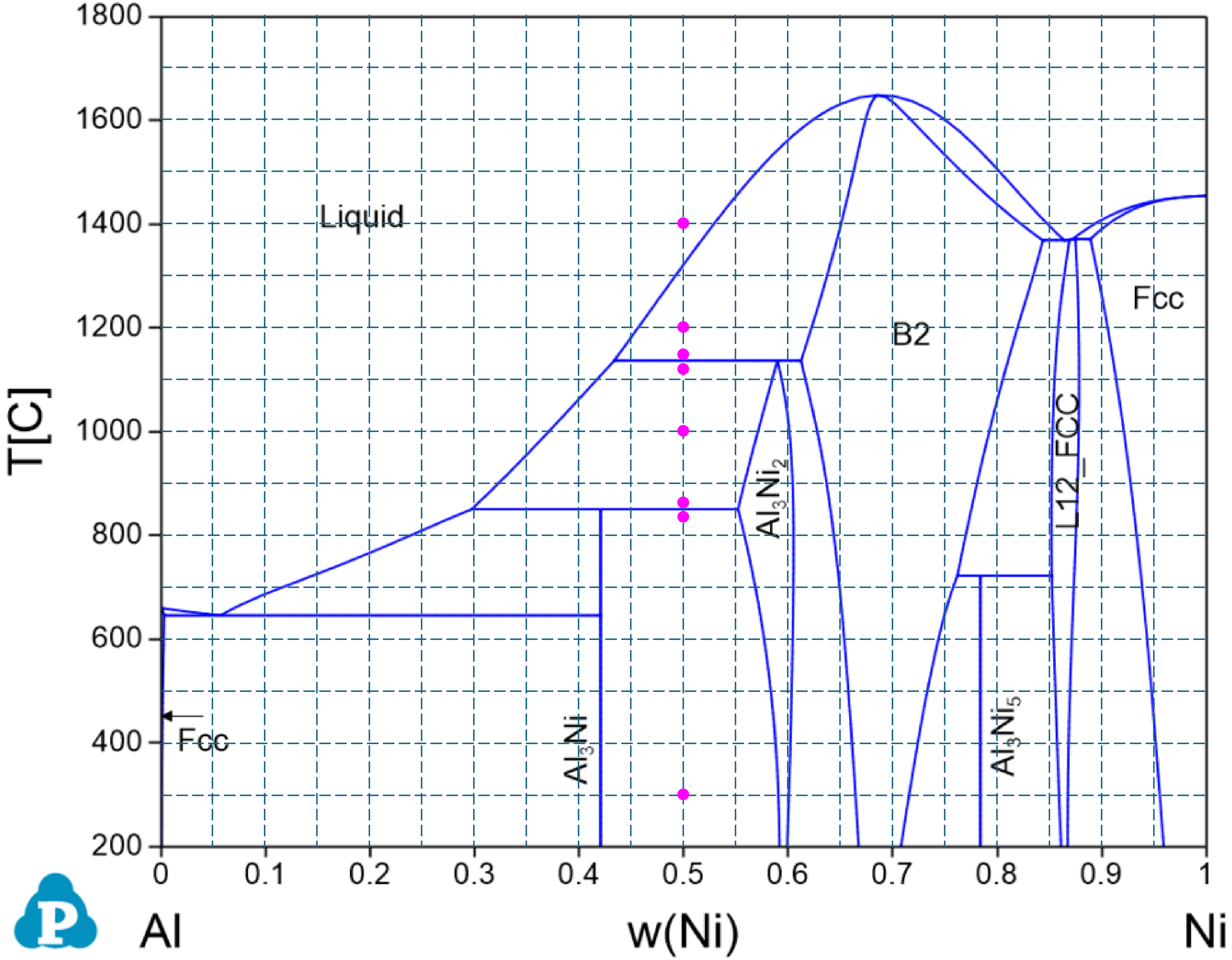

Note: in binary phase diagrams, between two neighboring single-phase regions, there would be a 2-phase region, but sometimes like the one above, 2-phase region are not labelled

Homework 10.5

6. Just **above** peritectic temperature near ~850°C
- Two phases – liquid + Al_3Ni_2
- C_L = 30 wt% Ni; C_{Al3Ni2} = 55 wt% Ni
- w_L = … = 20%
- w_{Al3Ni2} = … = 80%
- **m_L = … = 100 g**
- **m_{Al3Ni2} = … = 400 g**

7. Just **below** peritectic temperature near ~850°C
- Two phases – Al_3Ni + Al_3Ni_2
- C_{Al3Ni} = 42 wt% Ni; C_{Al3Ni2} = 55 wt% Ni
- w_{Al3Ni} = … = 38.5%
- w_{Al3Ni2} = … = 61.5%
- **m_{Al3Ni} = … = 192.5 g**
- **m_{Al3Ni2} = … = 307.5 g**

8. **300°C**
- Two phases – Al_3Ni + Al_3Ni_2
- C_{Al3Ni} = 42 wt% Ni; C_{Al3Ni2} = 59 wt% Ni
- w_{Al3Ni} = … = 52.9%
- w_{Al3Ni2} = … = 47.1%
- **m_{Al3Ni} = … = 264.5 g**
- **m_{Al3Ni2} = … = 235.5 g**

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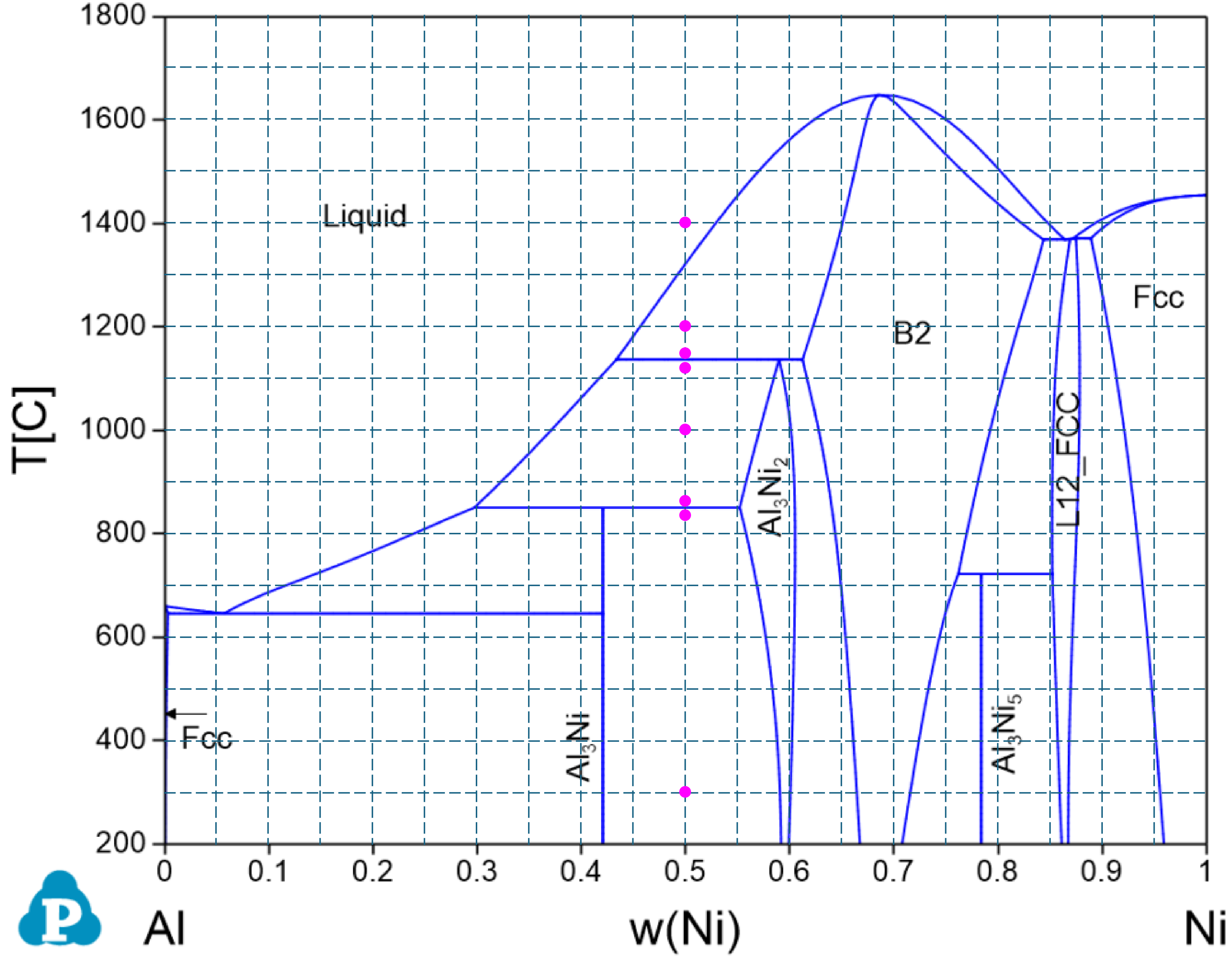

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