UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2008/2009

November 2008

EBB 512/3 - Phase Diagram and Phase Equilibria

Duration : 3 hours

Please ensure that this examination paper contains SEVEN printed pages and FIVE pages APPENDIX before you begin the examination.

This paper contains SEVEN questions.

Instructions: Answer **FIVE** questions. If a candidate answers more than five questions only the first five questions in the answer sheet will be graded.

Answer to any question must start on a new page.

All questions must be answered in English.

1. Shown in Figure 1 below is the free energy of mixing versus composition of the A-B binary system at the temperature T and the pressure P. The diagram shows two terminal phases α and β, and one intermediate phase γ. If the overall composition of the system is given by point X shown in the diagram, find the stable equilibrium phase(s) at T and P.

(20 marks)

2. [a] Use the phase diagram for the Ni - Ti binary system Figure 2 to answer the following questions

(i) Name all of the INVARIENT and CONGRUENT points showing in this portion of the diagram. List them by composition, temperature of reaction, type of reaction, and the phase changes that occur on the cooling through the temperature.

(ii) Describe the equilibrium cooling process and likely microstructure for an alloy of Ni-50 wt%Ti.

(iii) Describe the equilibrium cooling process and likely microstructure for an alloy of Ni-35 wt%Ti.

(iv) What is the chemical stoichiometry (eg. Ni_xTi_y) of the intermetallic gamma-phase?

(20 marks)

[b] Figure 3 shows the continous cooling transformation diagram for a 1.13 wt%C iron - carbon alloy. Sketch and label on this diagram the continous cooling curves to yield the following microstructure,

(i) Fine pearlite and proeutectoid cementite
(ii) Martensite
(iii) Martensite and proeutectoid cementite
(iv) Coarse pearlite and proeutectoid cementite
(v) Martensite, fine pearlite and proeutectoid cementite.

(Detach Figure 3 and submit together with the answer script)

(10 marks)

...3/-

3. [a] The metals X and Y form an ideal liquid solution but are almost immiscible in the solid state. The entropy of fusion of both A and B is 4 J mol^{-1} K^{-1}, and the melting temperatures are 1800K and 1500K respectively. Assuming that the specific heats of the solid and liquid are identical, calculate the eutectic composition and temperature in X-Y-B phase diagram.

(12 marks)

[b] The solid solubility of silicon in aluminium is 1.25 at % at 550°C and 0.46 at % at 450°C. What solubility would you expect at 200°C. The relevant Si-Al phase diagram is in Figure 4.

(8 marks)

4. For the following questions, refer Pb-Sn phase diagram in Figure 5.

(a) A lead-tin alloy is slowly cooled from 350°C, and it is noted that the composition of the first solid α phase to solidify is 13 wt% Sn-Pb. This alloy is further cooled to 100°C. Calculate the mass fractions of the α and β phases at 100°C.

(8 marks)

(b) For an alloy composition of 80 wt% Sn-Pb at 180°C, determine the relative amounts (in terms of volume fraction) of the phases.

$$\rho_{sn} = 7.22 \text{ g/cm}^3; \rho_{Pb} = 11.20 \text{ g/cm}^3$$

(12 marks)

5. [a] The rate of recrystallisation of pure copper at several temperature are given as follows:

Temp (^{o}C)	Rate (min)$^{-1}$
135	0.105
119	4.4 x 10^{-2}
113	2.9 x 10^{-2}
102	1.25 x 10^{-2}
88	4.2 x 10^{-3}
43	3.8 x 10^{-5}

(i) Determine the activation energy for this recrystallisation process.

(ii) By extrapolation, estimate the length time required for 50% recrystallisation at room temperature.

(15 marks)

[b] Briefly explain why a proeutectoid phase forms along austenite grain boundaries.

(5 marks)

6. [a] Explain the typical presentation of ternary phase diagram. How much information can you get from the diagram?

(20 marks)

[b] A mixture represented by point P in Figure 6 is to be prepared by mixing the mixtures X and Y. Determine the ratio of X to Y to obtain the right composition. The composition of each point is given in the following table:

(40 marks)

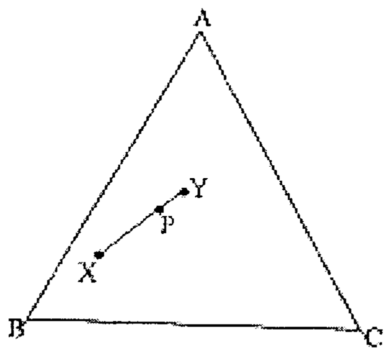

Figure 6 - ternary diagram for ABC system

Table : composition of point P, X and Y

	A	B	C
P	35%	40%	25%
X	20%	70%	10%
Y	40%	30%	30%

[c] A ternary system ABC shows complete solubility in the liquid state and contains only two solid phases, which are solid solutions designated α and β respectively. The melting points of components A, B and C are 1100°C, 900°C and 650°C respectively. The binary system BC shows complete solid solubility, while systems AB and AC each contain an invariant reaction as follows:

...6/-

	Temperature of invariant reaction	Compositions of the phases involved in the invariant reaction		
		α	β	Liquid
System AB	850°C	95%A, 5%B	10%A, 90%B	50%A, 50%B
System AC	600°C	97%A, 3%C	12%A, 88%C	60%A, 40%C

Sketch and label the possible liquidus and solidus projections for the ternary system.

(40 marks)

7. [a] Figure 7 is a phase diagram of ABC ternary system which forms two binary compounds, AC and BC.

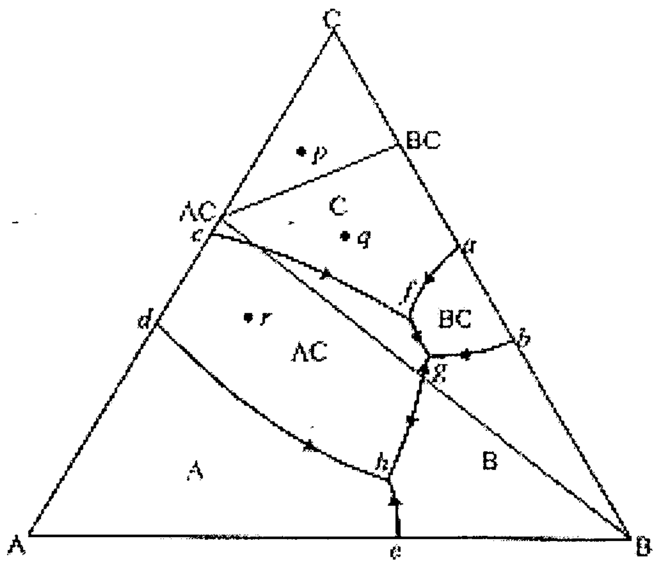

Figure 7 - ternary diagram for ABC system with AC and BC compound

(i) Why is an Alkemade line connecting A and BC is not drawn?

(ii) Describe the crystallization paths of liquid compositions *p, q* and *r*.

(iii) Describe heating paths of mean solid compositions of *p, q* and *r*.

(iv) Would the compounds AC and BC melt congruently or incongruently?

(60 marks)

[b] Figure 8 is a ternary system Forsterite-Anorthite-Silica phase diagram. What are the final solids and their proportions to form from composition W?

(40 marks)

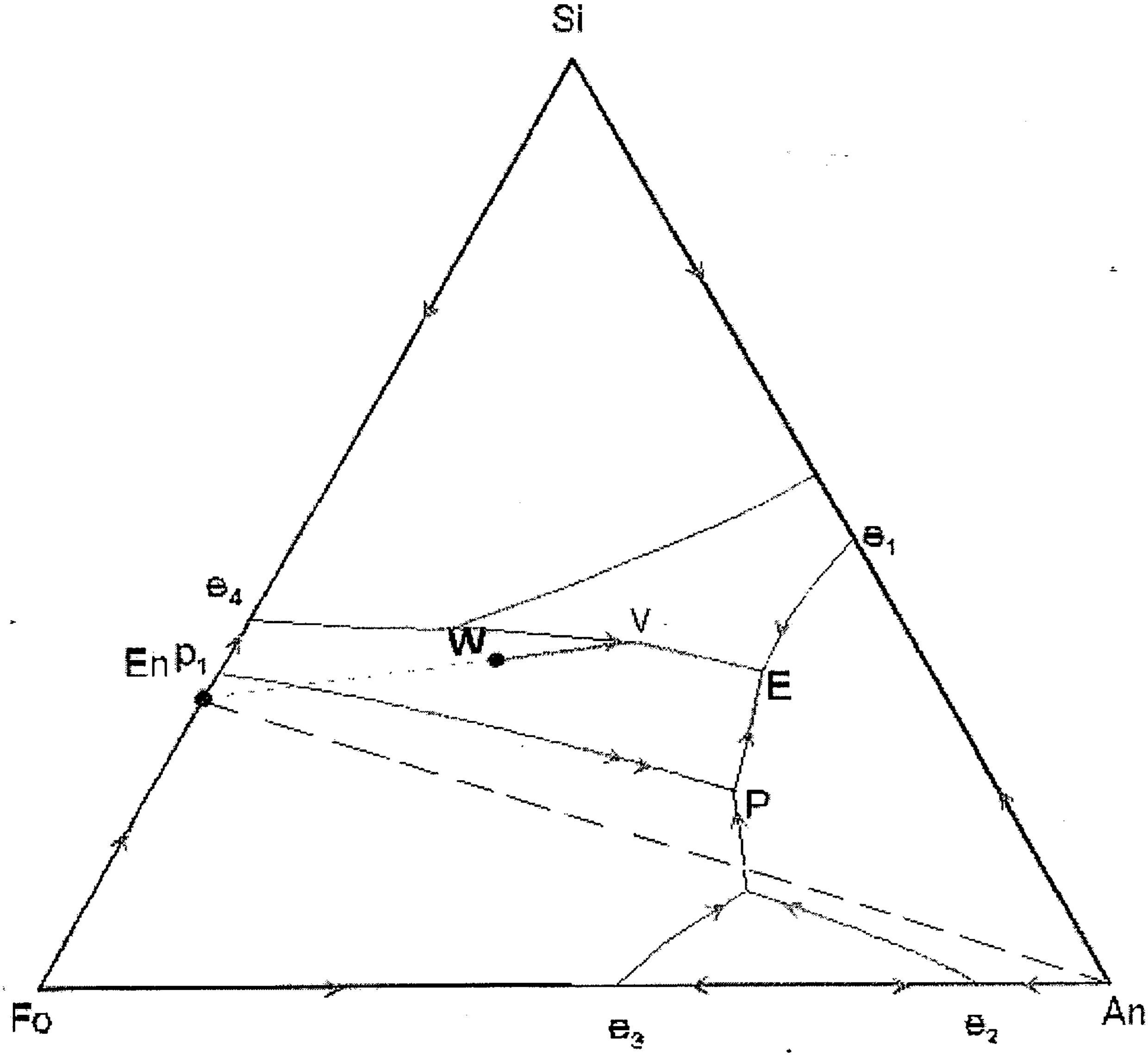

Figure 8

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Appendix 1

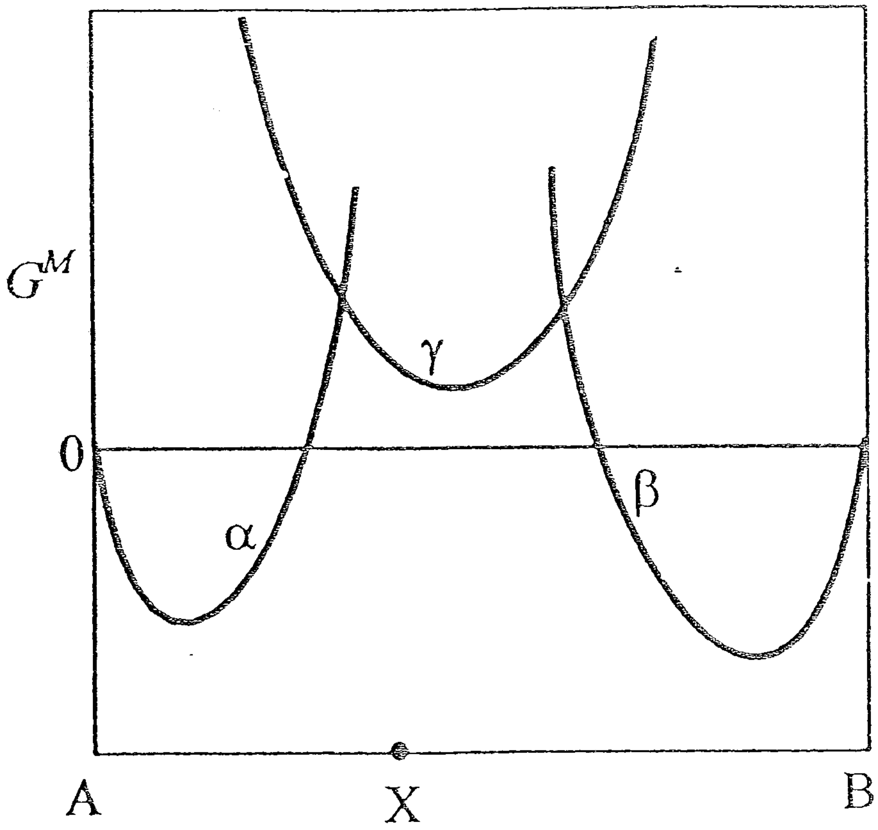

Figure 1

Appendix 2

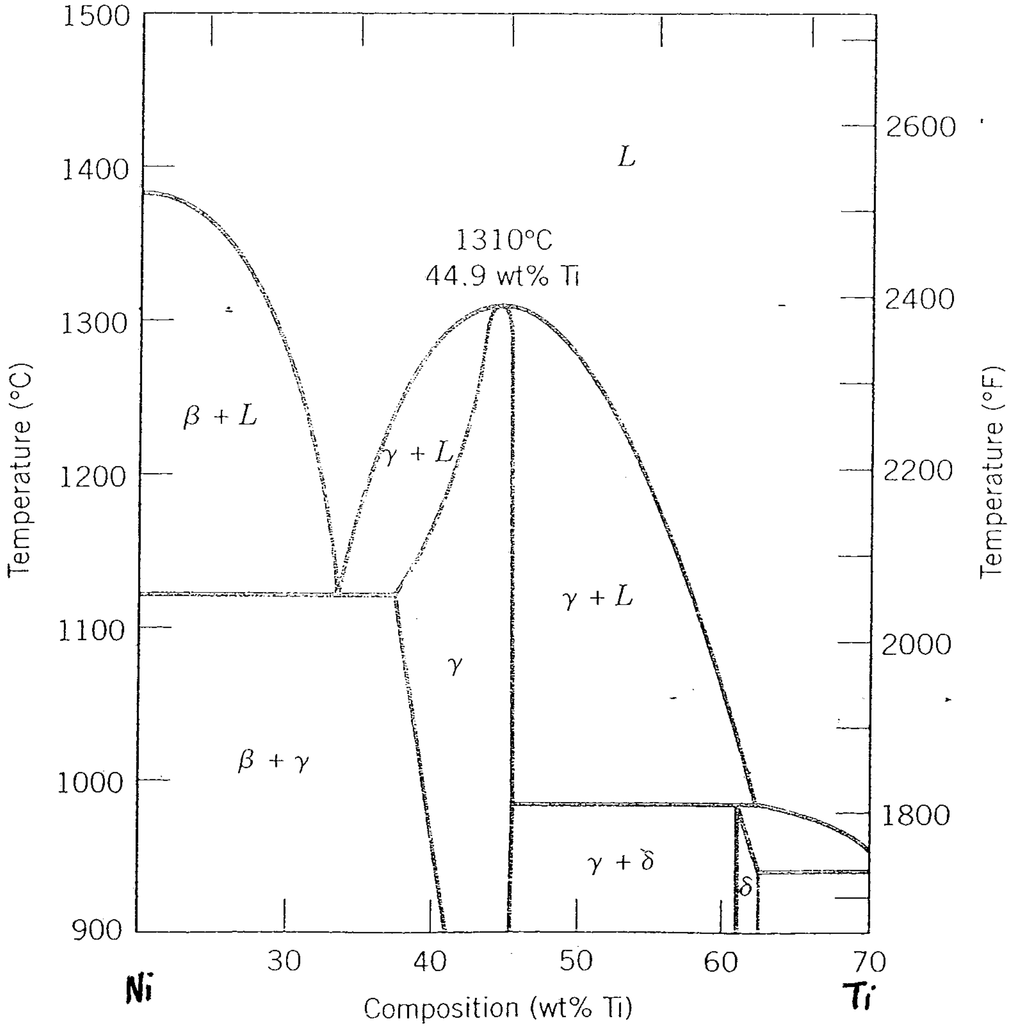

Figure 2

Appendix 3

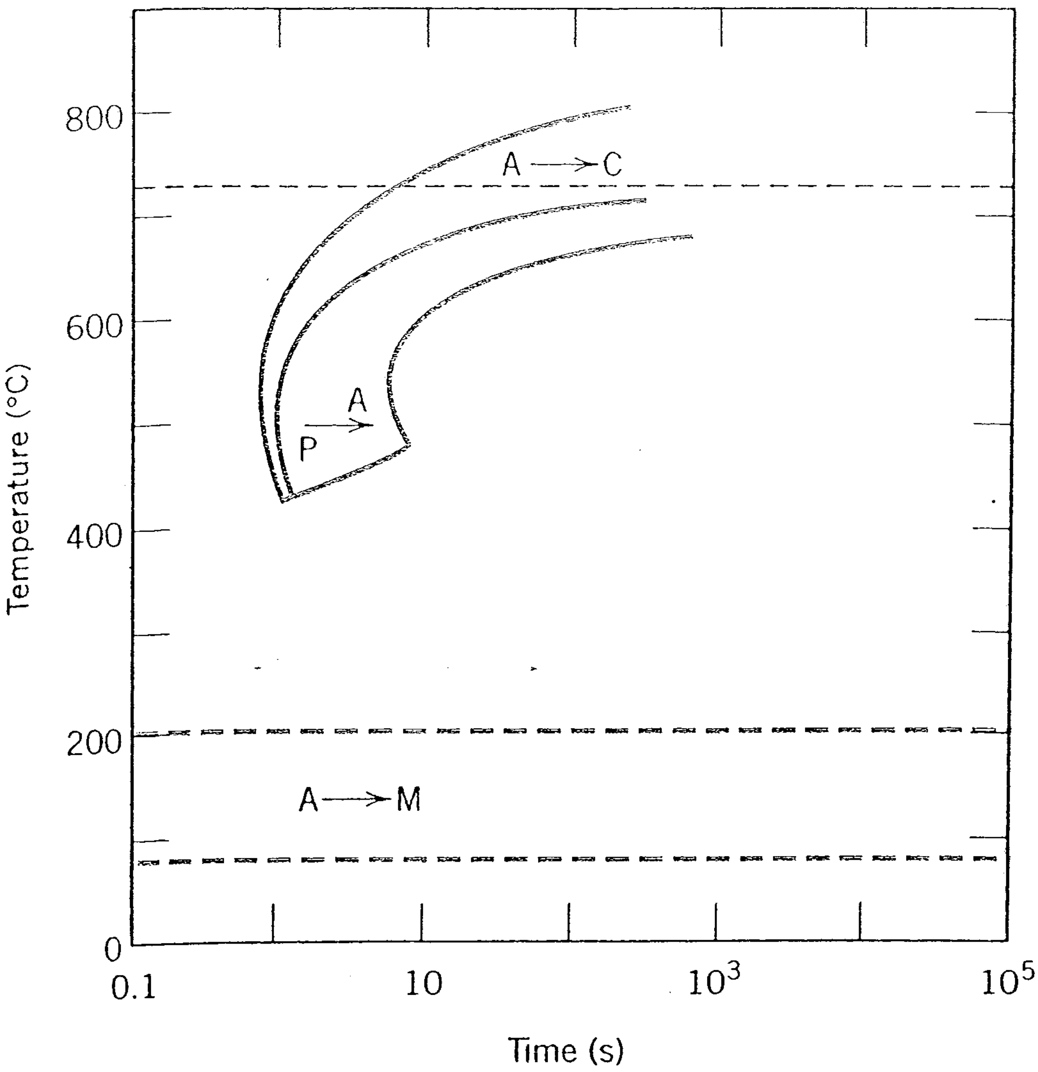

Figure 3

Appendix 4

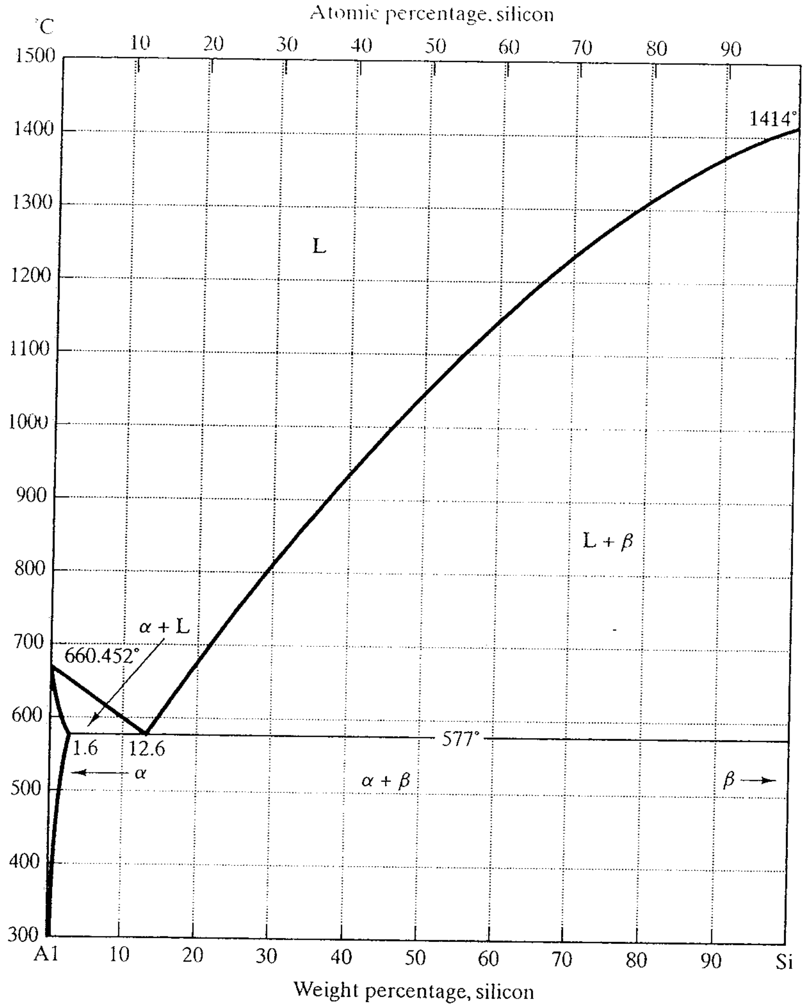

Figure 4

Appendix 5

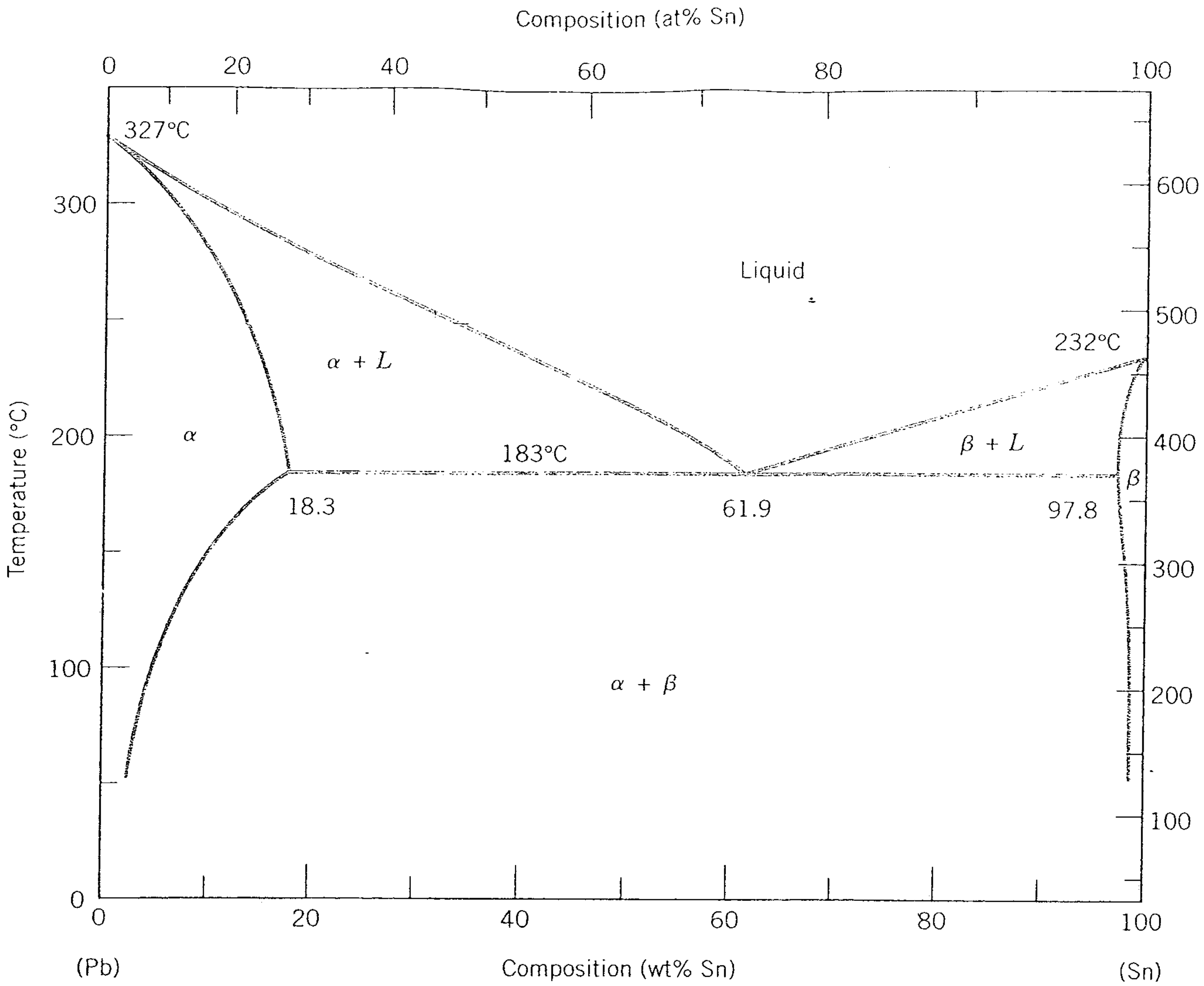

Figure 5