UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session of 2005/2006

November 2005

EBB 512/3 - Phase Diagram and Phase Equilibria

Time : 3 hours

Please check that this examination paper consists of SEVEN pages of printed material and THREE pages APPENDIX before you begin the examination.

This paper is made up of SEVEN questions.

Answer any FIVE questions. If a candidate answers more than five questions, only the first five answered will be examined and awarded marks.

Submit Figure 2, together with the answer script.

Answer to any question must start on a new page.

All questions should be answered in English.

...2/-

1. [a] The metals A and B form an ideal liquid solution but are almost immiscible in the solid state. The entropy of fusion of both A and B is 8.4 J mol^{-1} K^{-1} and the melting temperatures are 1500K and 1300K respectively. Assuming that the specific heats of the solid and liquid are identical, calculate the eutectic composition and temperature in A-B phase diagram.

(50 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°.

Compare your answer with this value obtained from a phase diagram. Explain the differences.

(50 marks)

2. For the following questions, refer Figure 1.

(a) For an alloy of composition 75 wt % Sn-Pb at 175°C determine the relative amounts (in terms of volume fractions) of the phases

ρ_{sn} = 7.22 g/cm^3 ; ρ_{Pb} = 11.20 g/cm^3

(30 marks)

(b) Is it possible to have a lead-tin alloy which at equilibrium, consists of an α phase of composition 10wt % Sn-Pb and a liquid phase of composition 35 wt % Sn-Pb? If so, what will be the approximate temperature of the alloy? If this is not possible, then explain why.

(20 marks)

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

(50 marks)

...3/-

3. [a] What is the difference between the states of equilibrium and metastability?

(15 marks)

[b] What is the difference between a phase and a micro constituent?

(15 marks)

[c] In a hypoeutectoid steel both eutectoid and proeutectoid ferrite exist. Explain the difference between them. What will be the carbon concentration in each?

(20 marks)

[d] Briefly explain why a proeutectoid phase (in Fe-C system) forms along austenite grain boundaries.

(30 marks)

[e] The development of microstructure in metal alloys is by diffusion process. The driving force of steady-state diffusion is concentration gradient but this is absent in microstructure development. Explain.

(20 marks)

...4/-

4. [a] Name the two stages involve in the formation of particles of a new phase. Briefly describe them.

(15 marks)

[b] Fraction recrystallized-time data for the recrystallization at 600°C of a previously deformed steel are tabulated below.

Fraction Recrystallized	Time (min)
0.20	13.1
0.70	29.1

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

(ii) By extrapolation, estimate the length of time required for 50% recrystallization at room temperature, 20°C.

(35 marks)

[c] By referring to Figure 2, the isothermal transformation diagram for a 0.45 wt% C iron-carbon alloy, sketch and label on this diagram the time-temperature paths to produce the following microstructures (starting from 845°C).

(i) 42% pro eutectoid ferrite and 58% coarse pearlite

(ii) 50% fine pearlite and 50% bainite

(iii) 100% martensite

(iv) 50% martensite and 50% austenite

(50 marks)

...5/-

5. A ternary system ABC shows complete liquid solubility and contains only two solid phases, namely two solid solutions designated α and ß coexisting in equilibrium at the temperatures shown:

Temperature (°C)	Compositions		
	Liquid	α	ß
550	69% A, 19% B, 12% C	57% A, 41% B, 2% C	20% A, 78% B, 2% C
520	66% A, 18% B, 16% C	56% A, 40% B, 4% C	19% A, 78% B, 3% C
500	63% A, 17% B, 20% C	55% A, 39% B, 6% C	18% A, 78% B, 4% C

(a) Calculate the equilibrium percentages of liquid, α and ß respectively, present in an alloy containing 44% A, 50% B and 6% C at 520°C.

(60 marks)

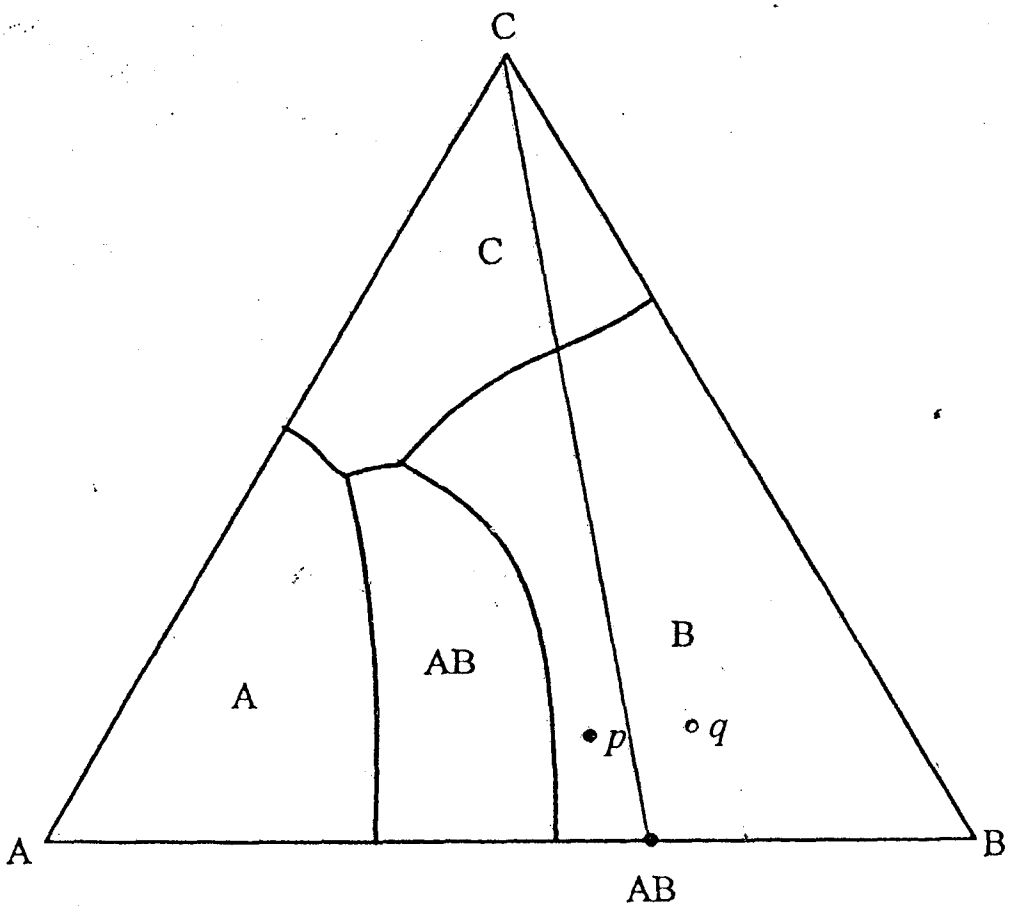
(b) Deduce, giving your reasoning, the nature of the three phase reaction undergone by the alloy containing 44% A, 50% B and 6% C during solidification.

(40 marks)

...6/-

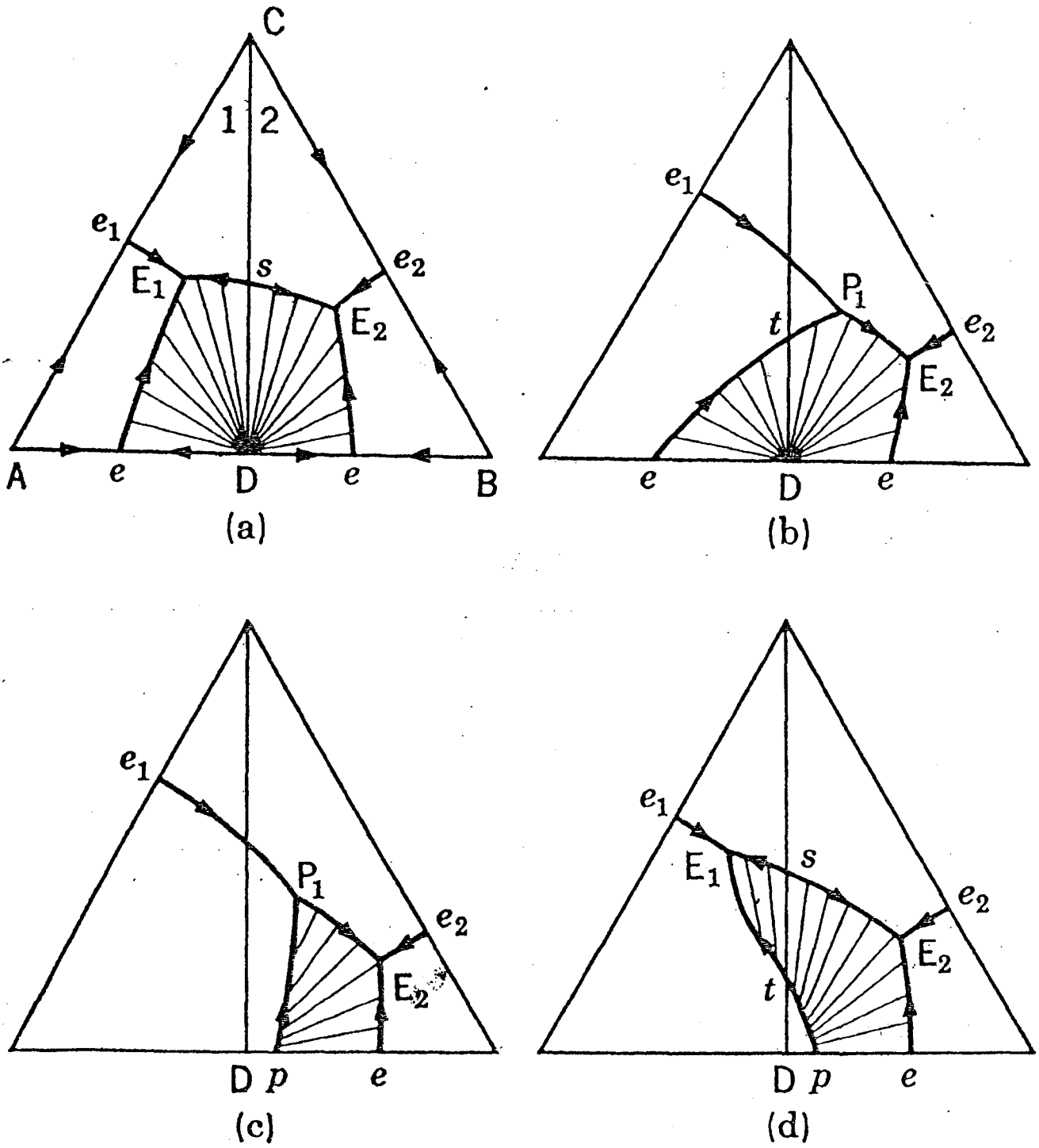
6. Discuss the crystallization paths of the overall liquid compositions *p* and *q* in the following ternary phase diagram:

(100 marks)



7. Construct the vertical cross-sections of the four ternary ABC systems shown below from corner C to the mid-point of side AB.

(100 marks)



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APPENDIX

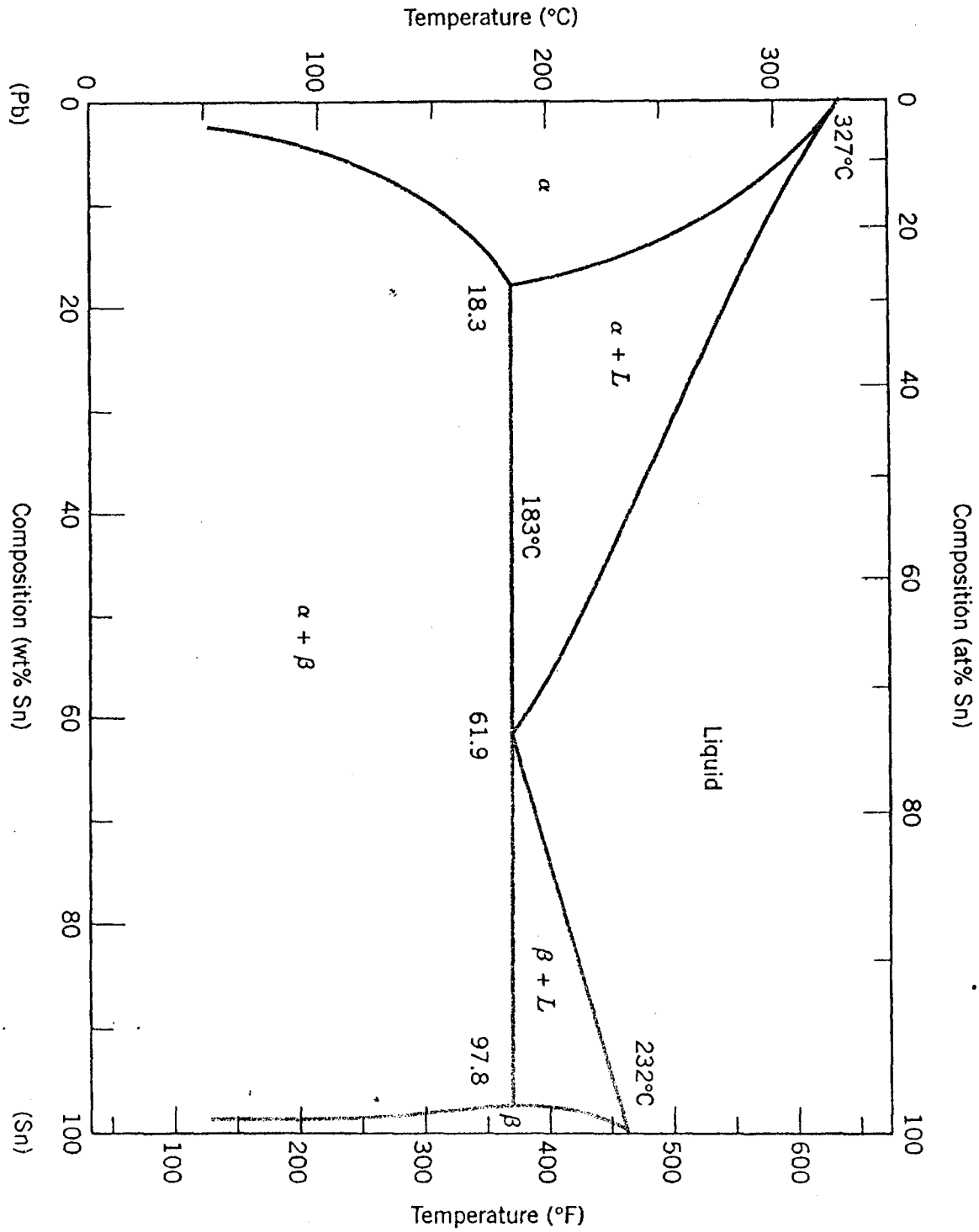

Figure 1 The lead–tin phase diagram. (Adapted from *Binary Alloy Phase Diagrams*, 2nd edition, Vol. 3, T. B. Massalski, Editor-in-Chief, 1990. Reprinted by permission of ASM International, Materials Park, OH 44073-0002.)

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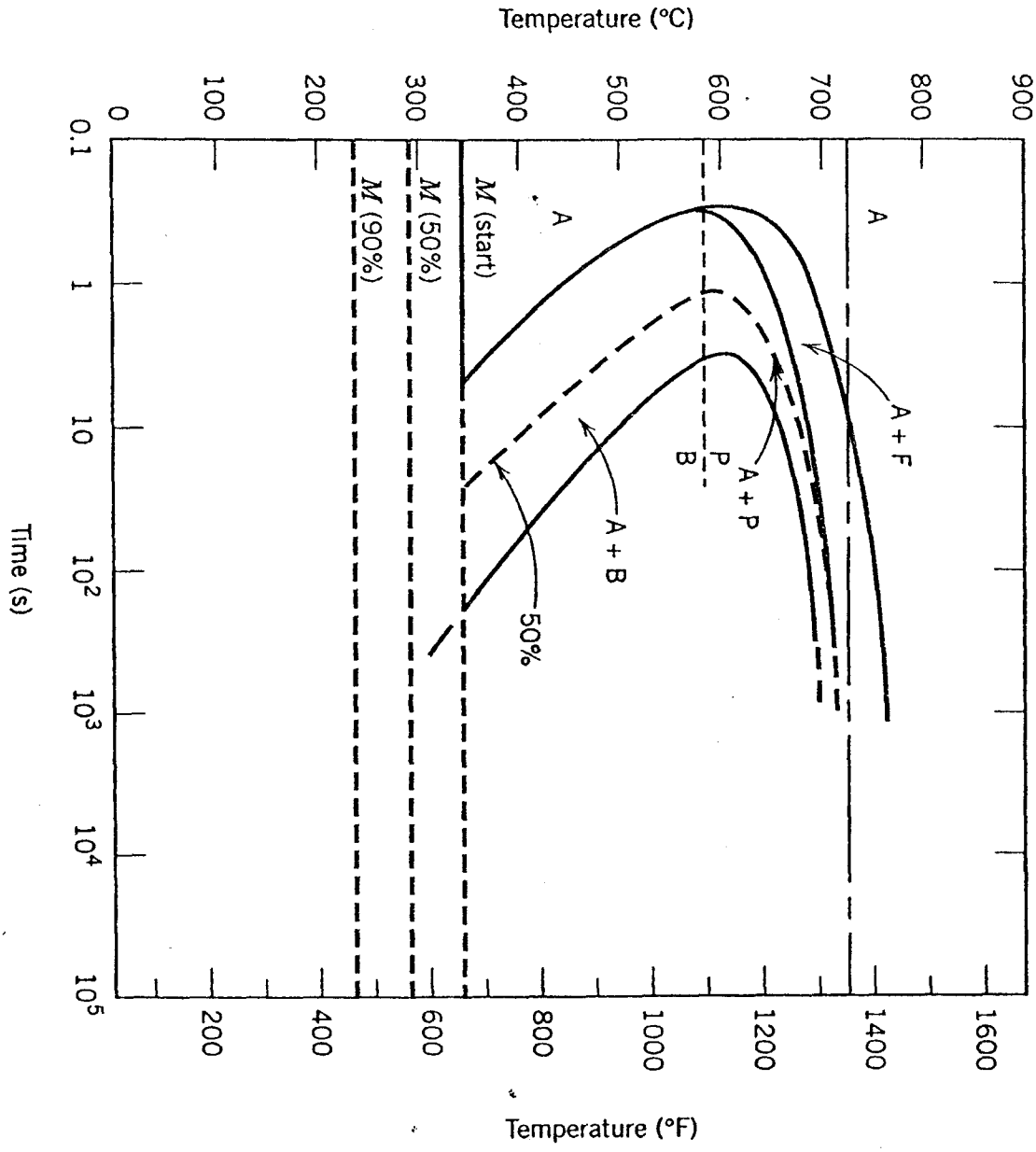

Figure 2 Isothermal transformation diagram for a 0.45 wt% C iron–carbon alloy: A, austenite; B, bainite; F, proeutectoid ferrite; M, martensite; P, pearlite. (Adapted from *Atlas of Time-Temperature Diagrams for Irons and Steels*, G. F. Vander Voort, Editor, 1991. Reprinted by permission of ASM International, Materials Park, OH 44073-0002.)

APPENDIX