UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2012/2013

January 2013

EBB 512/3 – Phase Diagram and Phase Equilibra

Duration : 3 hours

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

This paper consists of SEVEN questions.

Instruction: Answer **FIVE** questions. If a candidate answers more than five questions only the first five questions answered in the answer script would be examined.

The answers to all questions must start on a new page.

All questions must be answered in English.

1. [a] Consider the phases α and β which are in equilibrium. Using the fundamental equations derived the Clapeyron equation.

(50 marks)

[b] Shown in Figure 1 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.

(50 marks)

Figure 1

2. [a] Liquids A and B exhibit a miscibility gap shown in the following phase diagram. A mixture of 60 mol% of B was prepared at 600^{o}C. Calculate the mole fraction of the liquid rich in A. Refer to Figure 2.

(20 marks)

Figure 2

[b] Describe the cooling behaviour of the liquid d, e, f as shown in Figure 3.
(80 marks)

Figure 3

3. [a] Is it possible to have a 50 wt% Mg – 50 wt% Pb alloy for which the mass fraction of α and Mg_2 Pb phases are 0.25 and 0.75 respectively? If so give the approximate temperature of the alloy. If this is not possible than state why? Refer to Figure 4.

(50 marks)

Figure 4

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

(20 marks)

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

(30 marks)

4. [a] For some metal alloy it is known that the kinetics of recrytallisation obey the Avrami equation, and that the value of k in the exponential is 1.2×10^{-6}, for time in seconds. If, at some temperature, the rate of recrystallisation is 5×10^{-3} s^{-1}, what total-time is recrystallisation reaction to go to 95% completion?

(60 marks)

[b] Figure 5 shown a continous cooling transformation diagram for a 0.35 wt% C iron-carbon alloy. A specimen of this alloy is austenized at $900^{o}C$ and then continuously cooled to room temperature. Two cooling curves are noted and labeled on this Figure – corresponding to the cooling of center and surface regions. Also included are plots of hardness versus carbon concentration of fine pearlite, coarse pearlite, spheroidite and martensite (Appendix 1 and 2). On the basis of the information provided in these plots specify the hardness at each of the surface and center positions. (**IMPORTANT**: Indicate your work in Figure 6 and 7 and submit them together with your answer script).

(40 marks)

Figure 5

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5. [a] Based on the free energy curves given below, sketch the possible phase diagram of this binary system.

(35 marks)

Figure 8

[b] Calculate the phase present, compositions and the amount (in weight percent) for the microstructure at 1000^{o}C for a spinel ($MgO.Al_2O_3$) refractory with 1 wt% excess MgO (i.e. 1 g MgO per 99 g $MgO.Al_2O_3$). Refer to Figure 9.

(45 marks)

Figure 9

[c] Briefly explain why upon solidification an alloy of eutectic composition forms a microstructure consisting of alternating layers of two solid phases.

(20 marks)

6. [a] Figure 8 (A) below shows the composition triangle of the ABC ternary system. Determine the composition of the mixture represented by the point P.

(40 marks)

(A) (B)

Figure 8

[b] A mixture represented by the point P in Figure 8 (B) above 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 Table 1:

Table 1

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

(60 marks)

7. Shown below is the phase diagram of the SiO_2-CaO-Al_2O_3 system. Discuss solidification paths for the compositions p, q and r indicated on the diagram.

(100 marks)

Figure 11

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