UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2011/2012

January 2012

EBB 512/3 – Phase Diagram and Phase Equilibra

Duration : 3 hours

Please ensure that this examination paper contains SIX printed pages before you begin the examination.

This paper consists of SEVEN questions.

Instruction: Answer **FIVE** questions. If 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] Why is it difficult to measure the absolute value of internal energy even in case of simple elements?

(20 marks)

[b] In the following reaction:

$$2Al\ (298K, 1atm) + 3/2\ O_2(298K, 1atm) = Al_2O_3\ (298K, 1atm)$$

Change of enthalpy at 298K = -400kcal and change of entropy at 298K = -74.8 cal/deg

The entropy change is negative yet the reaction is spontaneous. Justify why this reaction is spontaneous despite of negative change in entropy and also why it does not violate the second law of thermodynamics that requires increase in entropy for the reaction to be spontaneous.

(40 marks)

[c] In the T-T-T curve shown in Figure 1 for a 0.8% C steel name the phases expected at the end of transformations labeled as: a, b, c, d, e, f and g.

(40 marks)

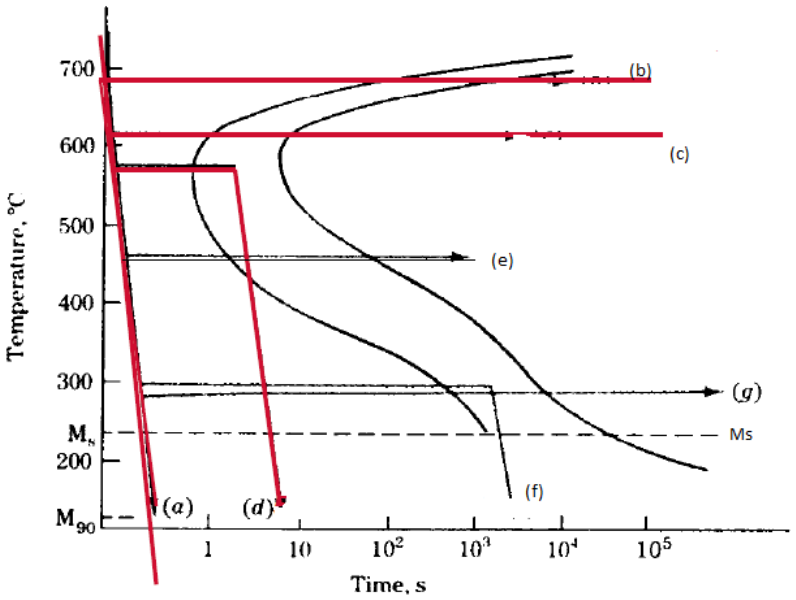

Figure 1

…3/-

2. [a] State and derive phase rule.

(60 marks)

[b] Comment on the key issue considered by Gibbs that helped in derivation of the phase rule.

(10 marks)

[c] Using phase rule prove that the following reaction points (in a binary system) should be invariant. You can make suitable assumptions as required.

(i) Eutectic

(ii) Peritectic

(iii) Eutectoid

(30 marks)

3. [a] A rigid container is divided into two compartments of equal volume by a partition. One compartment contains 1 mol of ideal gas A at 1 atm., and the other contains 1 mol of an ideal gas B at 1 atm.

(i) Calculate the increase in entropy which occurs when the partition between the two compartments is removed.

(20 marks)

(ii) If the first compartment had contained two moles of ideal gas A what would have been the increase in entropy when the partition was removed?

(20 marks)

(iii) Calculate the corresponding increase in the entropy in each of the above situations if both the compartments contained ideal gas A only.

(20 marks)

[b] The specific heat of solid copper above 300K is given by: $Cp = 22.64 + 6.28 \times 10^{-3}$ TJ/mol/K. By how much does the entropy of copper increases on heating from 300 to 1358K?

(40 marks)

…4/-

4. [a] In the equilibrium phase diagram of Pb-Sn (Figure 2) calculate

(i) For an alloy of 20% Sn held at 250°C, what are the weight fractions of the different phases present. If a microstructure of the alloy could be drawn at that temperature how would it look like.

(30 marks)

(ii) Do the above exercise for an alloy with 90% Sn alloy held at 100°C. You can calculate the results based on the data as best as you can read from the phase diagram.

(30 marks)

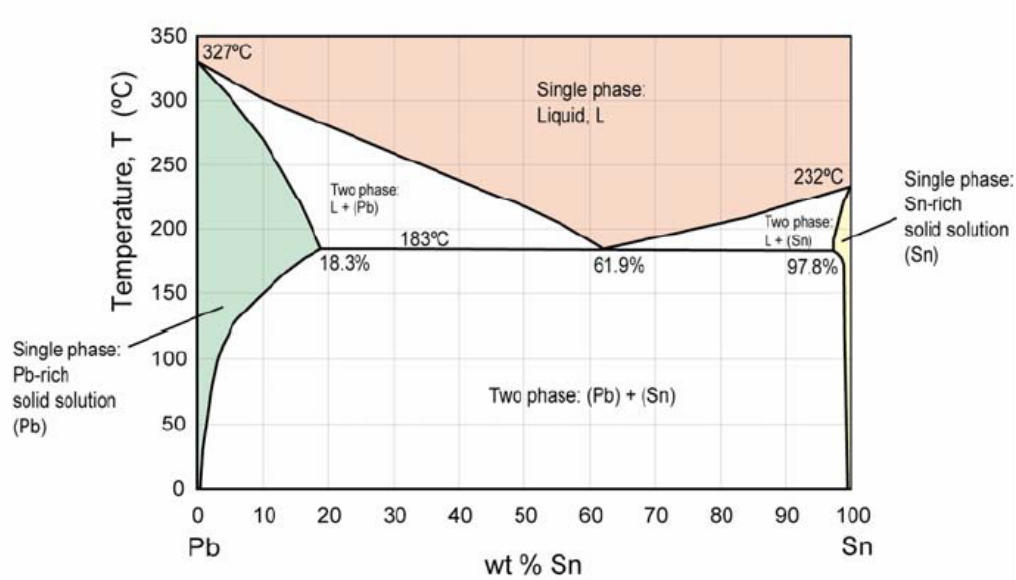

Figure 2

[b] (i) Draw schematically the graph showing the free energy change of mixing of an ideal solution of two components A and B having same crystal structure.

(20 marks)

(ii) How the above graph structure gets modified if the two components A and B have different equilibrium crystal structures?

(20 marks)

5. [a] In the Fe-C system Fe_3C is only a metastable phase while graphite is the most stable carbon rich phase. By drawing schematic free energy composition diagrams show how the Fe-graphite phase diagram compares with the Fe- Fe_3C phase diagram for 0-2 wt. % carbon.

(50 marks)

[b] For a 0.8% plain carbon steel on cooling to room temperature at slow rate what is the percentages of different phases?

(25 marks)

[c] Do the same exercise for 0.2% carbon steel.

(25 marks)

6.

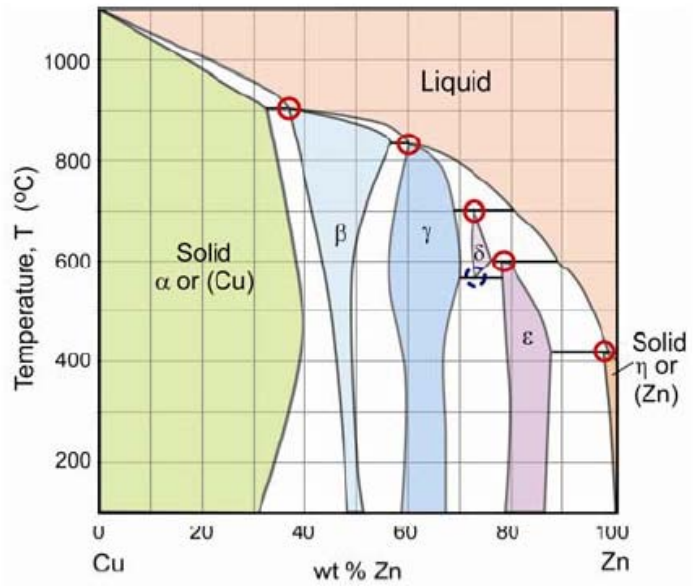

Figure 3

[a] In the phase diagram of Cu-Zn (Figure 3) what is the nature of the reaction depicted in the points circled with full circle ○ and broken circle ◌ ?

(50 marks)

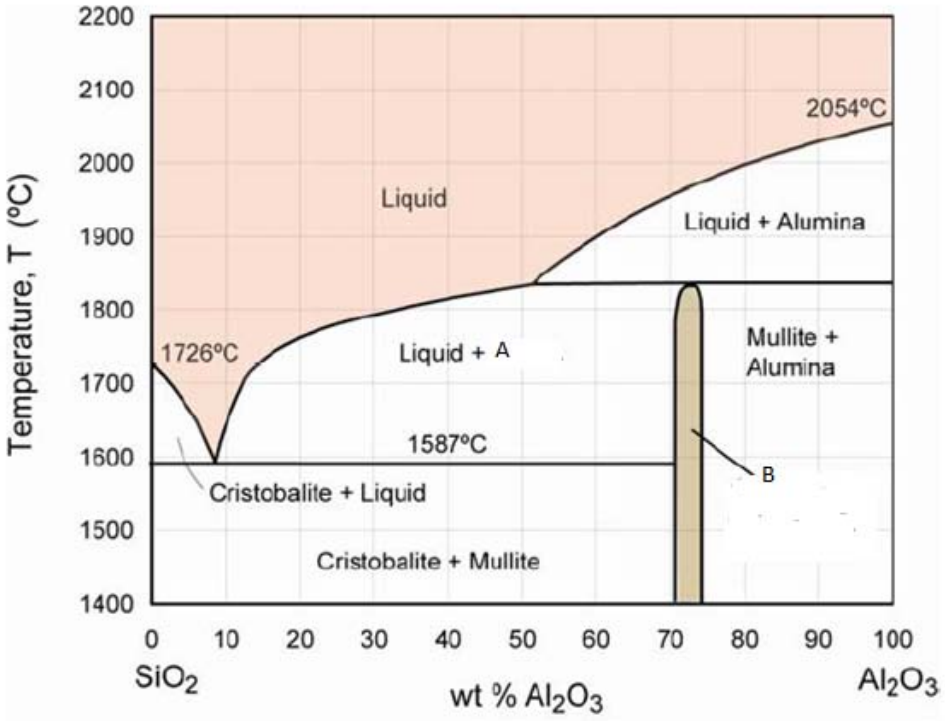

Figure 4

[b] In the phase diagram (Figure 4) identify the phases labeled as 'A' and 'B'. How many invariant point you identify in the above phase diagram?

(50 marks)

7. [a] For a hypothetical ternary system with components A, B and C where all 2 components are binary eutectic draw the two dimension projection showing the boundary curves and the temperature profiles.

(50 marks)

[b] Can you show schematically how this ternary phase diagram would look in three dimensions?

(50 marks)

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