

## **Study Guide for Phase Diagram and Solidification**

### **Fundamentals of Materials Science, Spring, 2017**

This study guide provides you with the important concepts and knowledge points for the last two chapters, i.e., phase diagram, and solidification theory. The guidelines for earlier chapters have been posted during the semester. Please refer to those for the review of final exam.

Always remember lecture notes, quizzes, homework problems are important sources for exam problems. Also, don't forget the website of this textbook. There are a few self-assessment problems for you to work on.

This is your **LAST** chance to improve your final score of this course!

### **General Phase Diagrams:**

1. For important terms and concepts, please see the end of the chapter. These terms may be used for you to fill in the blanks.
2. What is the definition of a phase? Its characteristics...
3. What is the definition of component?
4. What is unary, binary, ternary, and quaternary system?
5. What is phase equilibrium? How is phase equilibrium related to the energy state of the system, say free energy?
6. What is the definition of metastable system? How is metastable state related to free energy of the system?
7. What is the definition of microstructure?
8. What is the definition of phase diagram?
9. For binary isomorphous system, you need to be able to read the phase diagram. For example, where are the single phases, and where is the two phase region, which is the liquidus and solidus line, where is the melting points of the components, etc. You need to be able to determine the concentration of the components in the phases. You need also to be able to calculate the phase fractions using lever rule.
10. How is isomorphous and eutectic system related to solubility of solute atoms in solvent?
11. Do you know how to derive lever rule?
12. Lever rule is analogous to what calculation? --- mass balance!
13. How is microstructure in isomorphous system developed under equilibrium and non-equilibrium cooling conditions? This involves a lot of concepts, such as cored structure, microsegregation, premature mechanical failure, interdendritic segregation, hot shortness, etc. How to minimize microsegregation by heat treatment? What is that heat treatment called? What temperature should the heat treatment be?
14. In the eutectic system, you need to review the same contents as listed in item 9.
15. What is the microstructure development of the four typical compositions in the

eutectic phase diagram?

16. How is the eutectic structure formed? What is the feature of the eutectic structure? What is the mechanism of formation?
17. Calculation of the fraction of different phases in eutectic system. Calculation of the fraction of different microconstituents in eutectic system. The fraction of primary  $\alpha$ , total  $\alpha$ , and  $\beta$  phase...
18. What is the definition of eutectoid and peritectic reaction? You should be able to recognize them in the phase diagram.
19. What's the difference between solid solution and intermediate phases or compound? What is intermetallic compound? Can you give some examples of intermetallic compound? What is considered non-metallic compound?
20. What are the characteristics of intermetallic compound?
21. What is the definition of congruent phase transformation and incongruent phase diagram? Can you give examples of both phase transformations?
22. Ceramic phase diagrams were not tested last year, how about this year?
23. What is Gibbs Phase Rule? You are expected to be able to calculate the degree of freedom using a phase diagram, such as a eutectic phase diagram.

### **Fe-Fe<sub>3</sub>C Phase Diagram:**

24. What are  $\alpha$ -ferrite, austenite, and  $\delta$ -ferrite? What are the characteristics of them?
25. What is cementite? What are the characteristics of cementite?
26. What are magnetic characteristics of ferrite and austenite?
27. How do people categorize iron-carbon alloys based on the carbon composition, such as pure iron, steels, and cast irons?
28. What is considered as eutectoid steel, hypoeutectoid steel, and hypereutectoid steel?
29. What is defined as eutectic cast iron, hypoeutectic cast iron, and hypereutectic cast iron?
30. You need to be able to draw the Fe-C phase diagram by yourself and label all the composition, temperature, liquidus and solidus lines, solvus lines, as well as understand their meanings.
31. What are the three most important reactions in the Fe-C diagram? What are the reaction temperatures and compositions? What are the reaction products?
32. What are Fe<sub>3</sub>C<sub>I</sub>, Fe<sub>3</sub>C<sub>II</sub>, and Fe<sub>3</sub>C<sub>III</sub>? Where do they come from?
33. You need to know the microstructural evolution under the six typical C compositions and their room temperature equilibrium microstructure. This is very very important!!!
34. What is pearlite? How is pearlite formed?
35. What is defined as microconstituents?
36. You need to know how to use lever rule to calculate the room temperature phase fractions under any carbon composition of Fe alloys.
37. What is ledeburite? Where does it come from?
38. What can be affected by adding alloying elements to the Fe alloys?
39. You need to know all the terms in Fe-C system in both English and Chinese.

## 纯金属及固溶体的凝固理论：

40. 纯金属结晶的两个阶段：形核和长大都什么意思。凝固的热力学条件和结构条件。
41. 形核包括哪两种？分别什么意思？形核需要满足的条件？
42. 均匀形核系统自由能由哪两部分组成，分别怎么变化，系统自由能怎么变化？会推导临界晶核半径下的形核功么？
43. 过冷度和形核速率，长大速率以及组元大小的关系。控制机理（nucleation, diffusion）
44. 长大机制都有什么？它们和温度梯度的关系是什么？
45. 孕育处理的相关技术和主要概念
46. 枝晶大小怎么表示？
47. 铸锭组织由哪三部分组成？怎样获得等轴细晶组织？
48. 快速凝固技术都有什么？
49. 固溶体结晶的特点，平衡结晶和非平衡结晶的微观机理
50. 显微偏析和区域偏析的形成机理，区域提纯技术
51. 成分过冷的概念，成分过冷的形成条件及判定，不同成分过冷程度对显微组织的影响。