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Your Name Goes On This Line

E106 Final Examination
12, 13, or 14 December 2006
Exam Time: 3 hours.

In this examination you may use the class texts and *any notes* that you have taken in class or made in preparation for the exam. You may also use your homework and quizzes, and my homework solutions. There are two sections to the exam. The first section consists of six short problems, each worth 16 points. They are designed to be answered quickly, without a great deal of derivation or calculation. The second section consists of three problems each worth 35 or 34 points. The total possible for the exam is 200 points. Within each section, the problems are of equal weight but *not* of equal difficulty. There is partial credit. Please write neatly and ***on one side*** of your paper only. You may work on your problems in any order, but please assemble your completed exam with the problems in the correct order and in the correct section. For safety, you may want to write your name on every page.

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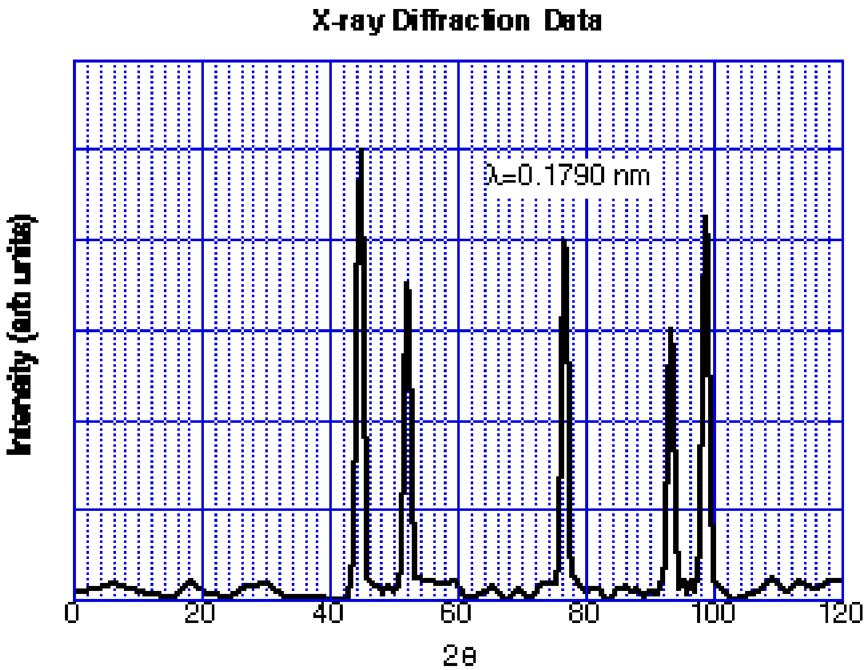
Section I – Skills Questions (16 Points Each)

1. For the diffaction data given below determine whether the material is FCC or BCC and the lattice constant, a. The x-ray wavelength is given on the graph.



2. A series of test samples of sintered silicon carbide with a volume of 200 mm^3 were run in a three-point bend-test apparatus. 36.8% of them survived to a stress level of 363 MPa or above. What is the maximum volume of the production samples if 67% of them survive to a stress level of 300 MPa? The Weibull modulus for this silicon carbide is 6.7.

3. 100 kg of a 20%Sn-80%Cu (composition on a mass basis) mixture is slowly cooled from $1100°C$ to $798°C$. Determine the phases present and their relative amounts. If you prefer, you may give the weights of the phases in kg. The Cu-Sn phase diagram in is Question 1 of the long questions.

4. 100 kg of a 20%Sn-80%Cu (composition on a mass basis) mixture is slowly cooled from $1100°C$ to $800°C$. Determine the most likely microconstituents present and their relative amounts. If you prefer, you may give the weights of the microconstituents in kg. The Cu-Sn phase diagram in is Question 1 of the long questions.

5. A sample of a 0.5 wt% plain-carbon steel (IT diagram below) is heated to above 770°C for 1000 hours, cooled rapidly to 700°C and held there for 30 seconds. It is then cooled rapidly to 400°C and held there for 13 seconds. It is then cooled rapidly to room temperature. Determine what microconstituents are present and their relative amounts.

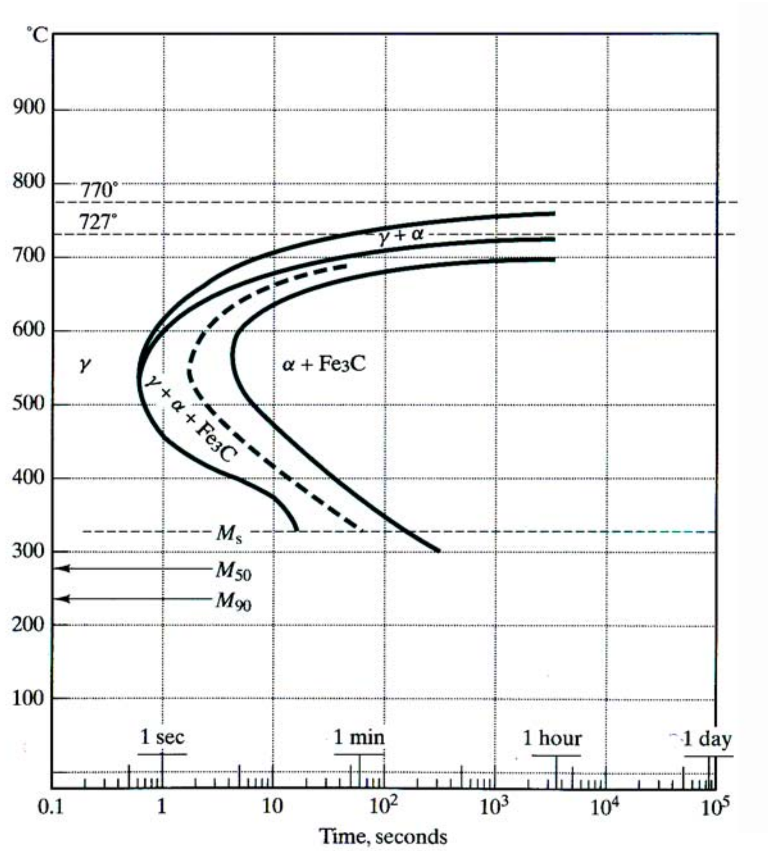


Figure 10-16 *TTT diagram for a hypoeutectoid composition (0.5 wt % C)*

6. Calculate the volume fraction necessary to create a continuous-and aligned glassfiber reinforced nylon 6,6 composite with a tensile strength of 344 ksi. The data are in Problem 15.12 on page 664 of *Callister*.

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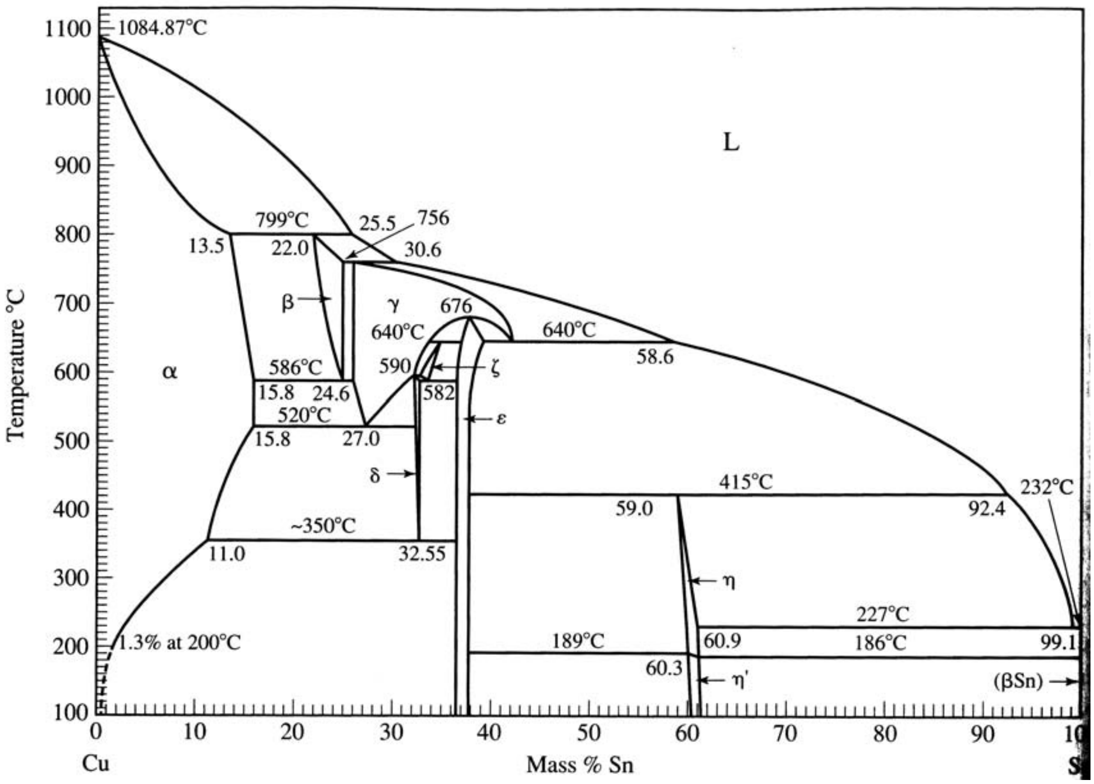
Section II – Long Question (34 or 35 Points Each)

1. The copper-tin phase diagram is shown below. All of the single-phase regions are labeled.



   a. Label all of the two-phase regions for tin compositions of 50 mass % Sn or greater (the right half of the diagram).
   b. Write down (e.g., $\alpha + \beta \rightarrow \gamma$) and label (e.g., eutectic) the three-phase invariant reactions occuring at $799°C$, $640°C$ (both), $586°C$, $520°C$, and $415°C$. One of the reactions is not on the list of reaction types. Identify it and invent a reasonable name for this type of reaction.
   c. 100 kg of a 20%Sn-80%Cu (all compositions on a mass basis) mixture is slowly cooled from $1100°C$ to $799°C$ and heat is removed until the mixture is 25%liquid. Give the number of phases present, the composition of each phase, and calculate the weight of each phase in kg.
   d. Convert the answers in part c to mole fraction and moles.

2. This problem examines some of the assumption in the nucleation discussion in Callister.
   a. Starting from the definition of Gibbs energy, $G \equiv H - TS$, show that as Callister states on page 422,

$$\Delta G_v = \frac{\Delta H_f(T_m - T)}{T_m}$$

   and state any assumptions you must make.
   b. For the conditions of Example Problem 11.1 on page 425 of Callister, calculate $K_1 K_2 K_3$

(treat the product as a single constant) in Equation (11.10) on page 424 assuming $\dot{N} = 1\times10^{6}\frac{\text{nuclei}}{\text{m}^3\text{s}}$ and the activation energy for self-diffusion in gold, $Q_d = 2.90\times10^{-19}\text{J}$.

c. Calculate $\dot{N}$ for gold at supercoolings of $220°\text{C}$ and $240°\text{C}$.
d. Comment on the accuracy of Figure 11.4 on page 423 of Callister.

3. A carbon-fiber reinforced epoxy is desired with standard-modulus fibers (data in Table 15.6 on page 650 of Callister) Parallel cylindrical fibers (all of equal diameter) are to be laid in the longitudinal direction.
   a. What is the maximum volume fraction possible for the fibers? Assume the diamter of the fibers is small compared to the size of the finished part. An answer at or in excess of 0.99 (99%) will result in an automatic score of 0 for the problem so don't be tempted.
   b. Assume that the actual volume fraction will be 80 percent of the maximum. Calculate the values of E_{cl} and E_{ct} for this composite. Again, an answer that uses $V_f \approx 0.8$ will result in an automatic score of 0 for the problem.