Ph.D. Qualifying Examination

Materials Science

Spring 2008

Notes:

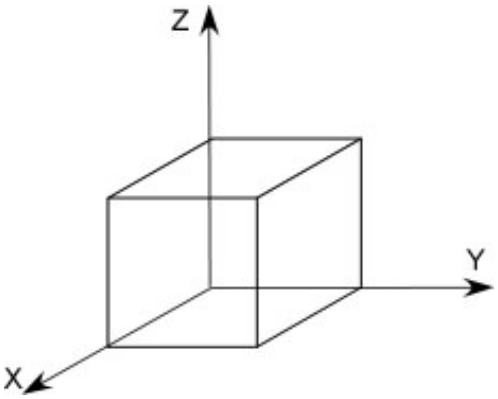
- There are a total of 4 problems.
- Time allowed: 2 hours.
- Exam is closed book and closed-notes.
- Problems count 25 points each (total=100 points).
- Show your work on these exam sheets. (Add additional sheets, if needed.)
- You may use a calculator.
- Laptops and cell phones are not allowed.

Problem 1

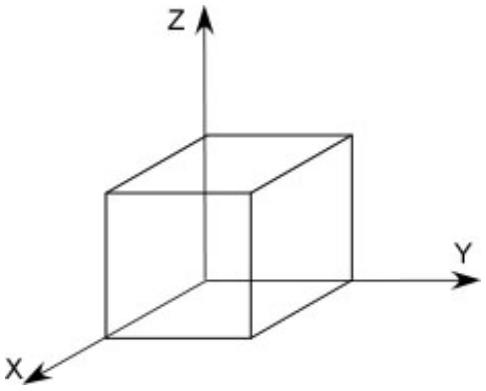
1) Consider diamond (C), Al, and H_2O. State the type of bonding expected for each of the three types of materials. Next, rank the bonding energies from each of these types of bonds from strongest to weakest.

2) Sketch the following planes on the diagrams below:

a. $(00\bar{1})$



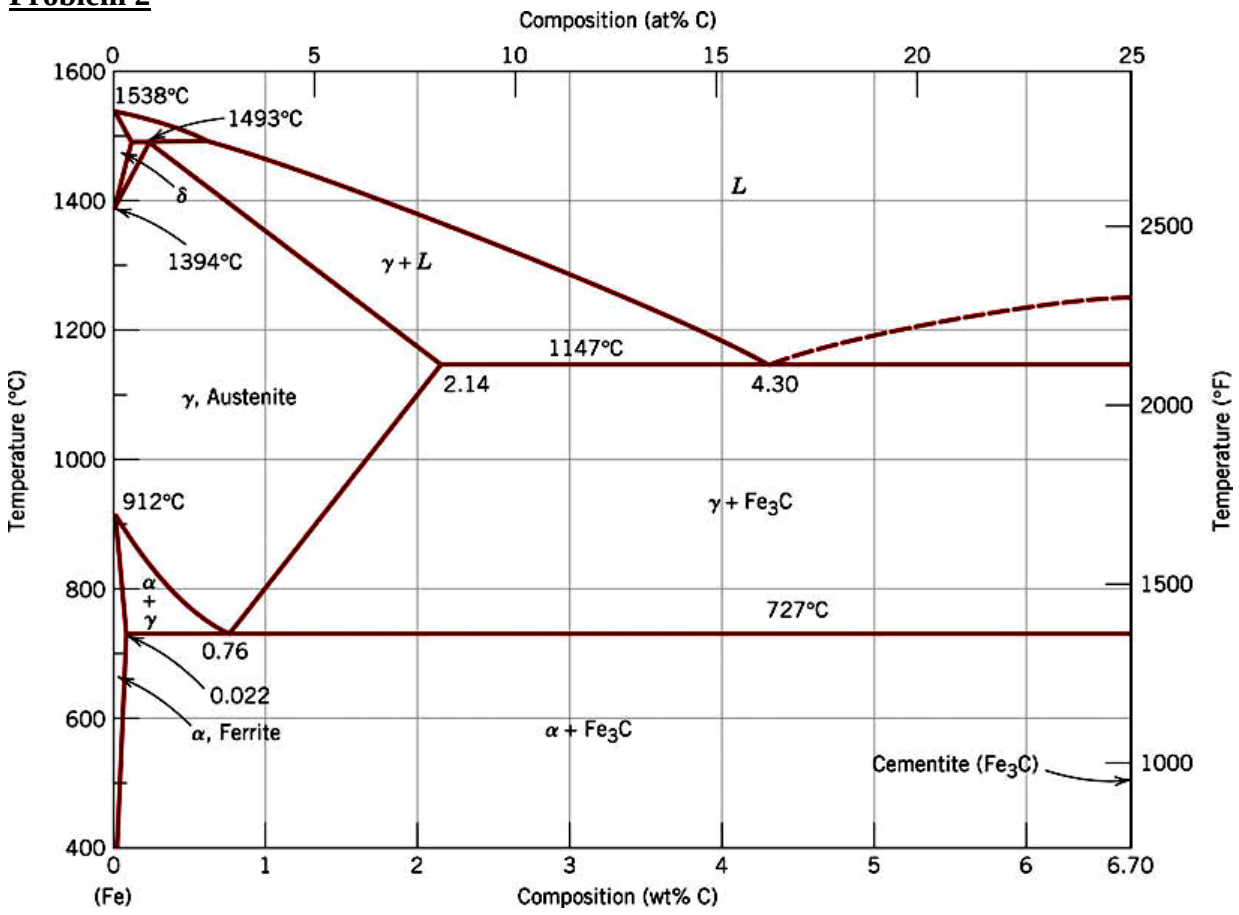
b. (112)



3) Consider a face-centered cubic crystal structure, and answer the following:
    a. Compute the atomic packing fraction.

    b. Compute the theoretical density of an FCC material given:
        i. Atomic Weight = 63.5 g/mol
        ii. R = $1.28 * 10^{-8}$ cm

Problem 2



Consider 3.5 kg of austenite containing 0.95wt% C, cooled to below 727°C (1341°F).

a. What is the proeutectoid phase?
b. How many kilograms will each of total ferrite and cementite form?
c. How many kilograms will each of the pearlite and the proeutectoid phase form?
d. Schematically sketch and label the resulting microstructure.

Problem 3

(a) Explain why an elastomer (like rubber) has to have a lightly cross-linked molecular chain structure?

(b) Are elastomers typically crystalline, semicrystalline or non-crystalline?

(c) A typical rubber band is made of an elastomer. Is room temperature below, above or approximately equal to its glass transition temperature? Explain.

Problem 4

You are given a piece of polycrystalline metal with a certain grain size. What can you do to increase the grain size? What can you do to reduce the grain size? (Whatever you propose to do, melting the metal is not allowed.)