MatE 115 G. Selvaduray
Fall 2004 November 17, 2004

SECOND MID-SEMESTER EXAMINATION

There are 5 questions. Please answer all questions. Answers to questions must be supported by evidence, either in the form of calculations or reasoning and logic. One word or single number answers ***will not*** receive any credit.

Each question is worth 20 points. The maximum points for this examination is 100 points. There is a Bonus Question, which is worth an extra 5 points.

You are permitted to use your textbook, class notes, homeworks and homework solutions, and class handouts from this semester only. ***No other material may be used.***

1. Please refer to the CaF_2 structure.

   (a) What is the crystal structure? *(5 points)*
   (b) What is the Bravais lattice? *(5 points)*
   (c) What is the coordination number? *(5 points)*
   (d) How many CaF_2 molecules are there in the unit cell? *(5 points)*

2. A small amount of KF is dissolved in CaF2.

   (a) Will any defects be created? If yes, please identify it/them. If no, please explain why. *(10 points)*

   (b) After dissolution, the temperature is raised from 25oC to 250oC. How will the defect concentration vary as a result of this temperature increase? *(10 points)*

3. For copper, the activation energy to generate vacancies is 20,000 cal/mole.

   (a) Calculate the vacancy concentration in copper, at room temperature, in terms of number of vacancies per cm^3. The lattice parameter of copper is 0.36151 nm, its atomic number is 29, its atomic weight is 63.5 and Avogadro's number is 6.023×10^{23}. *(5 points)*

   (b) An engineer wishes to increase the strength of the copper by increasing the vacancy concentration. Is this a reasonable aspiration? *(5 points)*

   (c) Determine a heat treatment temperature that will lead to a vacancy concentration 1000 times higher than at 25^oC. Briefly describe the heat

treatment procedure. *(10 points)*

4. Zinc has the hexagonal close packed structure at temperatures below 865^{o}C, called α-Zn, and the body centered cubic structure at temperatures above 865^{o}C, called β-Zn.

   (a) Draw a sketch of the unit cell for zinc at room temperature. *(3 points)*
   (b) Identify the slip plane for zinc at room temperature. *(3 points)*
   (c) Determine if titanium can be combined with zinc to form a single phase alloy, regardless of the overall composition. *(4 points)*
   (d) A scientist is doing some fundamental research on the mechanical properties of zinc single crystals. This scientist obtains stress strain data and calculates the elastic modulus for zinc and finds that the elastic modulus is different in all the directions a_1, a_2, a_3 and z. Do you agree with the scientist? *(3 points)*
   (e) Is the α-Zn to β-Zn phase transformation a first order or a second order phase transformation? *(3 points)*
   (f) Is this an enantiotropic or monotropic phase transformation? *(4 points)*

5. For a metal with a face centered cubic crystal structure,

   (a) Identify the slip plane. *(5 points)*
   (b) Identify the slip direction. *(5 points)*
   (c) How many slip systems are there? *(5 points)*
   (d) This metal has some residual carbon in it. Where in the crystal structure would you expect to find the carbon? *(5 points)*