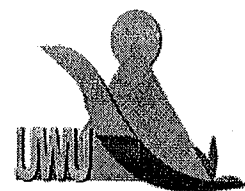


Uva Wellassa University, Sri Lanka
End Semester Examination – March 2011
SCT 341-3 Solid State Materials Science



Time: Three (03) hours

Total 06 questions
Answer all questions

- 01). i. Describe the characteristic properties of crystalline materials and explain how they differ from amorphous materials.
- ii. The “unit cell” of a crystal structure is its fundamental building block. Illustrate this statement using a simple 3-D lattice.
- iii. How do you distinguish between primitive and non-primitive unit cells? Explain using a 2-D lattice.
- iv. With an appropriate example, show how you would derive the Miller Index of a planar surface within a crystal.
- v. Prove that parallel planes within a crystal have the same Miller Index. (25 marks)
- 02). i. What are the assumptions of the atomic hard sphere model used in crystal studies.
- ii. Describe how cubic close packing (CCP) and hexagonal close packing (HCP) structures are generated by different stacking sequences of atoms.
- iii. Chromium has a Body Centered Cubic (BCC) crystal structure. Draw a schematic diagram to show the unit cell of chromium using atomic hard sphere model.
- iv. Show that the Atomic Packing Factor of a BCC crystal structure is smaller than that of a Face Centered Cubic (FCC) crystal structure.
- v. Derive expressions for the atomic linear density along [110] direction and planar density on (110) plane in FCC crystal structure in terms of atomic radius (R). (25 Marks)
- 03). i. Defects in crystals can be classified into four categories depending on their dimensions. Name these four main categories of defects, giving two examples for each category.
- ii. A heavier atom is added as a substitutional impurity to a crystal. Give schematic representations for this point defect in the crystal, using arrows to indicate the directions of the local stresses introduced by this point defect.

- iii. Calculate the energy for vacancy formation in silver, given that the equilibrium number of vacancies at 1073 K is $3.6 \times 10^{23} \text{ m}^{-3}$. The atomic weight and density of silver at 1073 K are 107.9 g/mol and 9.5 g/cm^3 , respectively.
- iv. Taking Wüstite (*ferrous oxide*) as an example, explain the term *nonstoichiometric materials*.
- v. What point defects are possible for CaO as an impurity in Al_2O_3 ? How many Ca^{2+} ions must be added to form each of these defects? Explain your answer. (25 Marks)
- 04). i. What are the two major components of a *solid solution*? Explain the term *secondary phase*, which is in the terminology of alloys.
- ii. Name three factors that determine the formation of solid solution with the addition of impurities.
- iii. With a schematic representation explain the formation of the interstitial solid solution of *steel* by adding C to $\alpha\text{-Fe}$. For this highly packed structure of $\alpha\text{-Fe}$, the voids (or interstices) between the Fe atoms are relatively small and it is a major limitation in the formation of any interstitial solid solution with $\alpha\text{-Fe}$. Explain how C fulfills this condition to form the interstitial solid solution of steel.
- iv. A slip system is a set of two components. Briefly explain these two components.
- v. A single crystal of a metal is oriented for a tensile test with its normal to slip plane making an angle of 71° with the tensile axis and slip direction making an angle of 29° with the same tensile axis. If the critical resolved shear stress is 7.3 MPa, what applied stress will be necessary to cause the single crystal to yield? (25 Marks)
- 05). i. What is the basic principle behind the mechanism for *strengthening polycrystalline materials* by *grain size reduction*.
- ii. The lower yield point for a polycrystalline material that has a grain diameter of $87 \mu\text{m}$ is 151 MPa. When the grain diameter is decreased to $39 \mu\text{m}$ the lower yield point increases to 307 MPa. At what grain diameter will the lower yield point be 250 MPa?
- iii. Define the term *dislocation density*.
- iv. Ancient Sri Lankans were world famous as manufacturers of strong and sharp metal tools. The secret behind this success was their expertise in a process now called as *forging*. Briefly explain how this forging process strengthens metals.
- v. Make a rough 3-dimensional sketch, to show the decreasing of ductility with the increasing of percent cold work in a metal that underwent work hardening. (25 Marks)

- 06). i. Very briefly explain how the addition of substitutional impurity atoms to a host matrix reduces the overall strain energy of the matrix, under the solid-solution strengthening mechanism.
- ii. With the help of schematic representation, show how to impose tensile strain by adding *lighter* (small) substitutional impurity atoms to a host matrix having an edge dislocation.
- iii. What are the driving forces for recrystallization and grain growth processes?
- iv. Name the two main factors that determine the extent of recrystallization.
- v. Compare the differences in grain structure for a metal that has been cold worked and then recrystallized.

(25 Marks)

