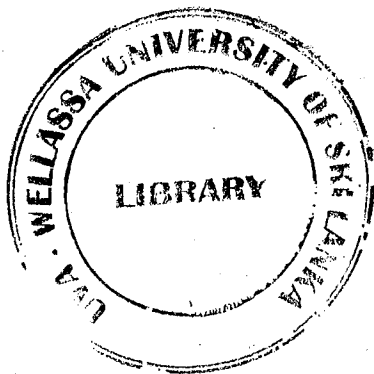




Uva Wellassa University, Sri Lanka
Faculty of Science and Technology
Science and Technology Degree Programme
1st Semester Examination – March/April 2013



SCT 341-3 Solid State Materials Science

Number of questions: Six (06)

Answer **all** questions

Time allocation : Three (03) hours

Total marks : 150

1.
 - a. Derive the Miller Index of a planar surface in a crystal that intersects +a axis at two unit lengths, +b axis and -c axis at a unit length each.
 - b. Show that any plane parallel to the above will have the same Miller Index. The second plane should also intersect +a, +b and -c axes.
 - c. Labeling three orthogonal *a*, *b*, and *c* axes with unit lengths, indicate $[1\bar{2}\bar{3}]$ and $[\bar{1}03]$ directions in a cubic crystal.
 - d. Illustrate the concepts of unit cell and lattice.
 - e. Distinguish between the primitive unit cell and a non-primitive unit cell in a 2-D lattice.

(25 Marks)
2.
 - a. Briefly explain how the combination of 2-D motif symmetries (planar point groups) and plane lattices (2-D nets) generates plane groups.
 - b. Describe the symmetry content of a cubic crystal.
 - c. Illustrate how cubic close packing (CCP) structure is generated in a monoatomic crystal.
 - d. Show that increasing atomic radius ratio increases the coordination number.
 - e. Derive the atomic packing factor (APF) of a body centred cubic (BCC) structure.

(25 Marks)
3.
 - a. What causes crystals to be *imperfect*?
 - b. With rough sketches, explain the existence of *Frenkel* and *Schottky* defects in ionic crystals.
 - c. Can *Schottky defects* exist in Na_2O ? Explain the answer.

- d. Determine the *equilibrium number of vacancies* for Ag at 900 °C, considering the energy needed for vacancy formation for this metal as 0.83 eV/atom at the given temperature. The atomic weight and the density of Ag at 900 °C, are 107.9 g/mol and 9.5 g/cm³, respectively. The Avogadro's number and the Boltzmann constant are 6.023×10^{23} atoms/mol and 8.62×10^{-5} eV/K, respectively.
- e. What are the two main mechanisms by which the *nonstoichiometric* solids maintain their charge balance?
(25 Marks)
4. a. Explain the four main factors that determine the high solubility in *substitutional solid solutions*.
- b. Briefly explain the formation of *interstitial solid solutions* using the crystal structure of *steel* as an example.
- c. Draw the two symbols used to denote *edge* and *screw* dislocations.
- d. What does *grain boundary* mean?
- e. List the four main categories of *bulk (volume) defects* occurring in crystalline solids.
(25 Marks)
5. a. Explain the term *slip system* in the crystallographic terminology.
- b. State the expression for the *critical resolved shear stress* for a single crystal to yield. In tensile testing of a pure mineral, a single crystal is oriented for the test with its normal to slip plane making an angle of 51.7° with the tensile axis and slip direction making an angle of 43.9° with the same tensile axis. The critical resolved shear stress for this crystal is already known as 9.75×10^6 Pa. Calculate the *applied stress* needed for this crystal to start plastic deformation.
- c. What is the basic principle behind the mechanism of *strengthening by grain-size reduction*?
- d. What is the reason for *high-angle grain boundaries* to be more effective in blocking dislocations than the *low-angle grain boundaries*?
- e. Make a rough sketch to explain the expected variation of the *tensile strength* with the increase of the *solute content* under the solid-solution strengthening mechanism.
(25 Marks)

6. a. What are the other two terms analogues to *strain hardening* used in materials terminology?
- b. Ancient Sri Lankans had been world famous for producing strong and sharp metal tools by increasing the dislocation density (a process now called *forging*). Explain how this forging process strengthens metals.
- c. A cylindrical specimen of strain hardened steel has a ductility of 23.5%. If its strain hardened radius is 47.9×10^{-3} m, what was its radius before deformation?
- d. Write down the main steps of the *recovery* process.
- e. Make a rough sketch to show the expected variation of recrystallization temperature with percent cold work (%CW) for a metal.

(25 Marks)

