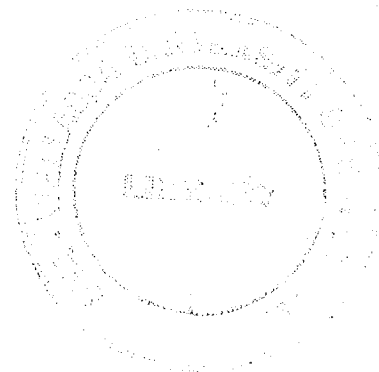


Uva Wellassa University, Sri Lanka
 Btech. Science and Technology
 End Semester Examination - Semester 1
 December-2008

CHE 351-3 – Solid State Materials Science



Answer both Part A and Part B

Time: Three (03) hours

Part A : Answer three questions only

1. (a). Define the terms; *lattice* and *unit cell*.
 (b). List the three main symmetry operations and their respective symmetry elements.
 (c). Name the seven crystal systems giving only the relevant essential symmetries.
 (d). Briefly explain the terms; *Polymorphism*, *Allotropy* and *Anisotropy*.
 (e). Sketch and label all the possible symmetry axes in a hexagonal unit cell. Also show how to calculate the net number of lattice points per hexagonal close-packed unit cell.

2. (a). What are Miller indices?
 (b). List the main steps to follow when labeling a plane or a set of parallel planes.
 (c). Draw and label the set of planes parallel to the (330) plane in a cubic unit cell.
 (d). Show how to label the direction between the origin and the point (1/2, 1, 1/3), in a cubic unit cell.
 (e). Define the term *linear density*. Calculate the linear density of the [110] direction for the Face Centered Cubic crystal structure.

3. (a). Write down the close-packed stacking sequences for the Face Centered Cubic (FCC) and Hexagonal close-packed (HCP) crystal structures.

- (b). List the point coordinates for all atoms in a Body Centered Cubic (BCC) unit cell.
 - (c). Derive the relation between the unit cell edge length and the atomic radius for the BCC crystal structure.
 - (d). Show that the atomic packing factor for BCC is 0.68.
 - (e). Calculate the theoretical density of Fe (α) having a BCC crystal structure. Its atomic weight and atomic radius are 55.85 g/mol and 0.124 nm, respectively.
4. (a). State the main features of powder X-ray diffraction techniques used in crystal structure determination.
- (b). State and give an expression for Bragg's law.
 - (c). Briefly relate the properties of a crystallographic unit cell (size, geometry, atomic arrangement) to the features of an X-ray diffractogram (2θ positions, peak intensity)
 - (d). Give an expression for the inter-planar spacing between the two closest parallel planes with the same Miller indices of the cubic crystal system.
 - (e). Rh has a FCC crystal structure. If the angle of diffraction for the (311) set of planes occurs at 36.12° (first order reflection) with monochromatic ($\lambda = 0.0711$ nm) X-ray, compute
 - i). The interplaner spacing for this set of planes.
 - ii). Atomic radius of Rh atom.

Part B : Answer three questions only

5. (a). Name four main types of point defects that can exist in a crystal.
- (b). Explain the terms *Schottky* and *Frenkel defects* with the help of a schematic representation.
 - (c). What does the term *nonstoichiometric material* mean?
 - (d). Give an expression for the variation of the equilibrium number of vacancies for a given quantity of material, with the temperature.
 - (e). Calculate the fraction of atom sites that are vacant for Pb at 327°C . The energy for vacancy formation for Pb is 0.55 eV/atom and the Boltzmann's constant is 8.62×10^{-5} eV atom⁻¹ K⁻¹

6. (a). Briefly explain the terms *interstitial* and *substitutional solid solutions* with the help of appropriate examples and schematic representation.
- (b). List four main factors that decide the high solubility in solid solution formation.
- (c). If Li^+ substitutes for Ca^{2+} , when Li_2O is added as an impurity to CaO . What kind of vacancy can be expected to form? How many of these vacancies are created for every Li^+ added.
- (d). What does the term *grain boundary* mean?
- (e). Determine the composition in atom percent of an alloy that consists of 97 wt% Al and 3 wt% Cu.
7. (a). Define the terms; *slip plane*, *slip direction* and *slip system*?
- (b). Give expressions for the critical resolved shear stress for a single crystal to yield.
- (c). A single crystal of a metal is oriented for a tensile test with its normal to slip plane making an angle of 60° with the tensile axis and slip direction making an angle of 35° with the same tensile axis. If the critical resolved shear stress is 6.2 MPa, what applied stress will be necessary to cause the single crystal to yield?
- (d). Very briefly explain how strain hardening improves the strength of materials.
- (e). A cylindrical specimen of strain hardened Fe has a ductility of 15%. If its strain hardened radius is 20 mm, what was its radius before deformation?
8. (a). Briefly cite the differences between *recovery* and *recrystallization* processes.
- (b). What are the driving forces of recrystallization and grain growth processes?
- (c). Name three mechanisms of strengthening in single-phase metals.
- (d). Write down the Hall-Petch equation related to strengthening of crystalline materials by grain size reduction.
- (e). The lower yield point for an Fe that has a grain diameter of 5×10^{-2} mm is 135 MPa. When the grain diameter is decreased to 8×10^{-3} mm the lower yield point increases to 260 MPa. At what grain diameter will the lower yield point be 205 MPa?

