

Uva Wellassa University of Sri Lanka
Faculty of Science and Technology
Department of Science and Technology
300 level 1st Semester Examination – July/ August 2016
SCT 341-3 Solid State Materials Science



Instructions to candidates

Duration: 03 hours
Number of questions: 05
Mark allocation: 120
Answer all questions

Avogadro constant (N_A) = $6.023 \times 10^{23} \text{ mol}^{-1}$

1.
 - a. According to the regularity of the atoms, molecules or ions, solid state materials can be mainly categorized as **crystalline** or **amorphous**. Describe briefly the differences between these two using appropriate examples. (6 marks)
 - b. What are the differences between single crystals and polycrystalline materials? (3 marks)
 - c. Define the terms **crystal**, **lattice**, and **motif** and give their relationship. (4 marks)
 - d. In crystallography, we use atomic hard sphere model. What is this model? (3 marks)
 - e. Give definitions of the following two terms.
 - i. Primitive unit cell (2 marks)
 - ii. Non-primitive unit cell (2 marks)
 - f. According to the geometry, there are seven (07) crystal systems into which all crystals are classified. Write down any four (04) systems and give the relationship between lattice parameters (a , b , c and α , β , γ) for each system. (10 marks)
2.
 - a. Define the following two terms.
 - i. Coordination Number (CN) (2 marks)
 - ii. Atomic Packing Factor (APF) (2 marks)
 - b. Fill the following table for simple cubic (SC), body centred cubic (BCC) and face centred cubic (FCC) lattices. Where n is the number of atoms per unit cell, a is the lattice constant, and R is the atomic radii. (16 marks)

Unit cell	n	CN	APF	a/R
SC				
BCC				
FCC				

3.

- a. Show the following planes in cubic unit cells: (210) , $(\bar{1}10)$, and $(10\bar{2})$. (6 marks)
- b. Show the following directions in cubic unit cells: $[111]$, $[\bar{1}\bar{2}1]$, and $[0\bar{1}2]$. (6 marks)
- c. A metal has FCC structure at 300 K and its atomic radius is 0.1431 nm. Calculate the planar packing fraction of the (110) plane and the linear packing density (atoms/cm) of the $[100]$ direction. (4 marks)
- d. Cesium chloride (CsCl) crystal has cubic structure in which Cs^+ ions occupy the center position of a unit cell and its corner positions are occupied by Cl^- ions. The density of CsCl is $3.97 \times 10^6 \text{ g/m}^3$. If the ionic radii of Cs^+ and Cl^- are 0.169 nm and 0.181 nm respectively, compute the lattice parameter and compare it with the value estimated from density. (4 marks)

4.

- a. Why X-rays are so important for crystal structure determination? (3 marks)
- b. What are the methods or sources used for X-ray generation? Briefly describe one of them. (5 marks)
- c. What acceleration potential (V) must be applied to electrons to cause electron diffraction on $\{220\}$ planes of gold (Au) at Bragg angle (θ) 5° when value of atomic volume (V_{mol}) is $10.2 \text{ cm}^3/\text{mol}$ and lattice parameter (a) is 4.08 \AA ?

NOTE: Value of atomic volume (V_{mol}) is given as $V_{\text{mol}} = \frac{N_A}{4} a^3$ where N_A is Avogadro constant and a is lattice parameter. (6 marks)

d. X-rays of an unknown wavelength are diffracted by an Aluminum (Al) sample (FCC crystal structure). The 2θ angle was 78.26° for (311) planes. What is the wavelength of the X-rays used in this experiment? (Assume this happened for the 1st order diffraction and the lattice constant of Al is 0.4048 nm).

(6 marks)

5.

a. Explain briefly Schottky and Frenkel types of defects in ionic solids using appropriate diagrams.

(6 marks)

b. Suppose that Li_2O is added as an impurity to CaO . If the Li^+ ion substitutes for Ca^{2+} ion, what kind of vacancies would you expect? How many of these vacancies are created for every Li^+ ion added?

(4 marks)

c. Distinguish between substitutional solid solutions and interstitial solid solutions.

(6 marks)

d. Explain Hume Rothery rules for the formation of substitutional solid solutions.

(4 marks)

e. Briefly describe strengthening mechanisms of metals.

(10 marks)

