2014

Interdisciplinary Graduate School of Medicine and Engineering, Doctoral Course, University of Yamanashi

Entrance Examination

Course or Program	Special Doctoral Program for Green Energy Conversion Science and Technology	Subject	Solid State Physics

Question 1

Draw and explain the schematic temperature dependences of the carrier concentration, $1/T$ vs $\log N$, of (1) intrinsic, (2) shallow-doped, and (3) degenerate semiconductors. (T : temperature, N : carrier density)

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Question 2

Answer the following questions for ZnS

(1) There are two types of crystal structure for ZnS, zincblende and wurtzite. Write each crystal system and z value (number of ZnS in one unit cell).

	Crystal system	z value
zincblende		
wurtzite		

(2) Calculate density of the ZnS (d_{ZnS}) using Zn–S bond length (l), atomic weights of Zn (M_{Zn}), S (M_S) and Avogadro's number (N_A). Please note that ZnS has ideal crystal structure without distortion.

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Question 3

The bond between two carbon atoms in diamond has a cohesive energy of 7.3 eV with respect to separated neutral atoms. Single bond for H-H, Si-Si, O-O, and Cl-Cl has also strong bond energy of 4.5, 1.8, 1.4 and 2.5 eV, respectively.

(1) What type of binding force is dominant for this strong bond?

(2) Explain the origin of the bond.

(3) Explain the details of this strong binding force in terms of molecular orbitals and exchange interaction for one of the examples described above.

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Question 4

Answer the following questions.

(1) Draw the relationship between electric polarization (***P***) and electric field (***E***) for the following dielectrics; (a) paraelectrics, (b) ferroelectrics, and (c) antiferroelectrics.

(2) Crystal structure of ferroelectric barium titanate ($BaTiO_3$) is tetragonal symmetry with tetragonality (c/a ratio) of 1.01, and its electric polarization is 26 μC/cm^2. Thus, this material has two kinds of ferroelectric domain structure; i.e., (d) pure electric domain and (e) electric & elastic domain structure. Firstly, describe what angle between neighbored domains for (d) and (e)-type domain structure. Then, draw (d) and (e)-type domain structure.