46

RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
Third Year - Semester II Examination – April / May 2016

PHY 3309 – STRUCTURE AND PROPERTIES OF MATERIALS

Answer all questions **Time: Three (03) hours**

Symbols have their usual meaning.
Some fundamental constants and physical data;

Electron mass m_e = 9.1×10^{-31} kg
Electron charge e = -1.6×10^{-19} C
Planck's constant h = 6.626×10^{-34} J s

$$\vec{\nabla} = \hat{i}\frac{\partial}{\partial x} + \hat{j}\frac{\partial}{\partial y} + \hat{k}\frac{\partial}{\partial z}$$

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(01) (a) Define the term "unit cell" and draw unit cells for simple cubic, body-centered cubic and face-centered cubic lattices. [07 marks]

(b) Calculate the "packing fraction" for each of the above cubic lattices. [07 marks]

(c) Distinguish between "unit cell" and "primitive cell". [07 marks]

(d) Draw a primitive cell for a simple cubic lattice. [04 marks]

(02) (a) What are dislocations in metals?

(b) *"Plastic deformation of metals takes place most commonly by the slip process, involving the movement of dislocations"* Briefly explain the above statement. [08 marks]

(c) What are the **TWO** important factors that determine the most likely slip systems in metals? [07 marks]

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(d) The metal Polonium (Po) crystallizes in Simple cubic structure. How many slip systems are possible in Polonium? Comment on the ductility of the metal Polonium. [10 marks]

(03) (a) *"An electron in a solid has an effective mass m*"*. Briefly explain the above statement. [08 marks]

(b) (i) Show that the curvature of the energy band in which the particle (electron or hole) moves is inversely proportional to the effective mass of the particle. [07 marks]

(ii) The energy near the valence band edge of a crystal is given by $E = Ak^2$, where $A = 10^{-39}$ J m^2. An electron with wave vector $\mathbf{k} = 10^{10}\,\mathbf{k}_x$ m^{-1} is removed from an orbital in the completely filled valence band. Determine the effective mass, velocity, momentum and energy of the hole. [10 marks]

Hint: Consider effective mass and a wave vector of hole to be opposite to those of an electron.

(04) (a) State the assumptions made by Kronig and Penney in suggesting a simple model to obtain mathematical solution that confirms energy band formation in crystals. [10 marks]

(b) (i) Show that the permitted energies for the Delta-function potential with $P \to \infty$ in the Kronig-Penney model equal the energies of the electron in a box with impenetrable walls. Note: For the Delta-function potential, Kronig-Penney equation is $\frac{P\sin\alpha a}{\alpha a} + \cos\alpha a = \cos ka$, where $\alpha^2 = \frac{2m_e E}{\hbar^2}$. [10 marks]

(ii) What is " P " in the above Kronig-Penney equation? [05 marks]

(05) (a) Define the "reciprocal lattice" and briefly discuss the importance of the reciprocal lattice concept. [06 marks]

(b) Construct the reciprocal lattice of a Square lattice. [06 marks]

(c) Define the Wigner – Seitz cell. [06 marks]

(d) Construct the First Brillouin zone of a Square lattice. [07 marks]

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(06) Write short notes on the following:

(a) Point defect formation in a monatomic solid. [06 marks]

(b) Miller-Bravais indices in hexagonal crystal system. [06 marks]

(c) Burgers circuit and Burgers vector in an edge dislocation. [06 marks]

(d) Mohs hardness scale for minerals. [07 marks]

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