RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B. Sc. (General) Degree in Applied Sciences
Third Year - Semester II Examination – October / November 2017

PHY 3309 – STRUCTURE AND PROPERTIES OF MATERIALS

Answer SIX questions only **Time: 3 hours**

The use of a non-programmable calculator is permitted.
Symbols have their usual meaning.

01. (a) Define the "reciprocal lattice" and briefly discuss the importance of the reciprocal lattice concept. [07 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. [06 marks]

02. (a) (i) Show that the curvature of the energy band in which the particle moves is inversely proportional to the mass of the particle. [06 marks]

(ii) How can the effective mass of a carrier be different in different directions? [03 marks]

(b) Prove that the group velocity is twice the phase velocity for any state of an ideal free electron gas. [06 marks]

(c) (i) The electron energies in a system can be fitted to the expression $E(k) = ak^2 - bk^4$, where a and b are constants for that system. Find the group and phase velocities in the system. [06 marks]

(ii) What are the values of k in terms of a and b at which the two types of velocities are equal? [04 marks]

Contd..

03. (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 lattice. [06 marks]

(c) Distinguish between "unit cell" and "primitive cell". [06 marks]

(d) Draw a primitive cell for a simple cubic lattice. [06 marks]

04. (a) What are dislocations in metals? [04 marks]

(b) Explain why the actual shear strength of metals is very much less than the theoretical shear strength? [05 marks]

(c) Define the "dislocation line $\underline{t}$" and the "Burgers vector $\underline{b}$" of an edge dislocation. [06 marks]

(d) Use the Finish to Start Right Hand Screw Convection (FS/RHS Convention) and show that the Burgers vector $\underline{b}$ is perpendicular to the dislocation line $\underline{t}$ in an edge dislocation. [10 marks]

05 (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. [08 marks]

(b) (i) Show that the energy of the lowest band at $k = 0$ for the Delta-function potential with $P << 1$ in the Kronig-Penney model is given by $E = \frac{\hbar^2 P}{ma^2}$. For the Delta-function potential, Kronig-Penney equation is

$$\frac{P \sin \alpha a}{\alpha a} + \cos \alpha a = \cos ka \text{, where } \alpha^2 = \frac{2m_e E}{\hbar^2}.$$

Hint: You may use $\sin x \approx x$ and $\cos x \approx 1 - x^2/2$ for small values of x [12 marks]

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

Contd.

06. (a) Mark [111] direction in simple cubic lattice. [03 marks]

(b) Write down all the members equivalent to the direction given in (a) above. [08 marks]

(c) Mark (001) plane in simple cubic lattice [03 marks]

(d) Write down all the members equivalent to the plane given in (c) above. [06 marks]

(e) Explain why the Miller- Bravais indexing for planes and directions is better over the Miller indexing as far as the hexagonal lattice is concerned. [05 marks]

07. Write short notes on the following.

(i) Glass vs. crystalline materials. [07 marks]

(ii) Frankel defect formation in MgO. [06 marks]

(iii) London dispersion force. [06 marks]

(iv) Talc vs. diamond. [06 marks]

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