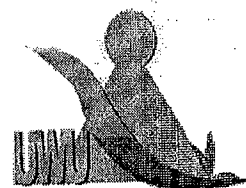


Uva Wellassa University, Sri Lanka
End Semester Examination – February 2012
SCT 351-3
Materials Physics
(Repeat)



Time: Three (03) hours

Total 06 Questions
Answer ALL questions
Each question contains 25 marks

Boltzmann constant - $1.38 \times 10^{-23} \text{ JK}^{-1}$
Avogadro number - $6.022 \times 10^{23} \text{ mol}^{-1}$
Plank's constant (h) - $6.626 \times 10^{-34} \text{ Js}$
Electron charge (e) - $1.602 \times 10^{-19} \text{ C}$
Electron mass (m) = $9.109 \times 10^{-31} \text{ kg}$

- 01) (a) Obtain the wave function and the probability density function of a particle of mass m confined to move in one dimensional box of length l .
- (b) Explain the comparison between classical and quantum ideas of the above results.
- (c) What is the minimum energy possible for the particle?
- 02) (a) i. Describe three concepts including Compton scattering that leads for the development of Quantum Mechanics.
- ii. A 100 keV photon collides with an electron at rest. It is scattered through 90° . What is its energy after the collision? What is the kinetic energy in eV of the electron and what is the direction of its recoil?
- (b) i. What is normalization of a wave function? Normalize the one dimensional wave function given by:
- $$\Psi(x) = A \sin\left(\frac{\pi x}{a}\right) \quad 0 < x < a$$
- $$\Psi(x) = 0 \quad \text{outside}$$
- ii. Show that the eigenkets of any hermitian operator are orthogonal to each other if the eigenvalues are different.



- 03) (a) Explain the free nature of the valence electrons in the free electron gas model.
 (b) Define density of states and Fermi-energy. Explain the variation of density of electronic states $D(E)$ with energy, for a one-dimensional metallic crystal.
 (c) Show that at the Fermi level, $D(E)$ may be expressed as

$$D(E) = \frac{3}{2} \frac{N}{E_F}$$

E_F = Fermi energy

N = Total number of free (valence) electrons

- 04) (a) Describe Band theory of solids.
 (b) Show that the solutions of the wave equation in a periodic lattice are in the Bloch form.
 (c) Explain metals, semiconductors and insulators on the basis of the Band theories.
- 5) (a) What is statistical ensemble?
 (b) Write down three types of ensembles. Compare and contrast them.
 (c) Explain the distinguishing features of Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics.
 (d) What are the number of ways to arrange two particles x and y in three energy states according to Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics? Write in tabular form and explain.
 (e) State which statistics (classical Maxwell-Boltzmann; Fermi-Dirac; or Bose-Einstein) would be obeyed by the followings and explain why.
 - i. Free electrons in metals
 - ii. Photons
 - iii. Molecules of N_2 gas at N.T.P.
- 6) Consider a gas of N_0 non-interacting molecules enclosed in a container of volume V_0 . Consider any subvolume V of this container and let N be the number of molecules located within V . Each molecule is equally like to be located anywhere within the container and hence the probability that a given molecule is located within V is simply equal to V/V_0 .
 - (a) What is the mean number \bar{N} of molecules located within V ?
 - (b) Find the relative dispersion $\overline{(N - \bar{N})^2} / (\bar{N})^2$ in the number of molecules located within V . Express your answer in terms of \bar{N} , V_0 and V .
 - (c) What does the above answer become when $V \ll V_0$?