NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHSYICS DEPARTMENT

SPH 4101 – SOLID STATE PHYSICS II

BSc HONOURS PART IV: JANUARY 2004 *DURATION: 3 HOURS*

ANSWER **ALL** PARTS OF QUESTION 1 IN SECTION A AND ANY **THREE** QUESTIONS FROM SECTION B. SECTION A CARRIES 40 MARKS AND SECTION B 60 MARKS

SECTION A

1 (a) (i) Define the volt equivalent of temperature [2]

(ii) What is its magnitude at room temperature? [3]

(b) Sketch the curves of;

(i) E versus f (E)

(ii) E versus N (E)

(iii) E versus p (E) for electronics and holes in a semiconductor.

Where f (E) is the Fermi- Dirac probability f unction, N (E) density of status, P (E) density of carriers [6]

(c) Determine the electrical conductivity of silicon when 0,0001 atoms % antimony is added as a dopant, how does it compare when 0,0001 atom % Indium is used? [5]

(d) Calculate the maximum magnetisation expected in nickel, which has 7 electrons in the $4f$ level. [5]

(e) At 400 ^{0} C, the fraction of aluminium sites vacant is 2.29 x 10 $^{-5}$, calculate the fraction of vacancies at (i) 20 ^{0} C (ii) 660 ^{0} C . Ev = 0,76eV,R= 8.317 J/(Kg.Mol) K^{-1} [5]

(f) What are octahedral and tetrahedral sites? [5]

(g) Briefly describe the five types of energies which determines the domain structure of a ferrom genetic material [5]

(h) What is the Burger's vector and what is its importance? [4]

SECTION B

2. (a) What does the Fermi – Dirac probability function signify? [4]

(b) Show that the Fermi level in an intrinstic semiconductor lies midway in the forbidden band [10]

(c) In an n – type semiconductor, the Fermi level lies 0,2eV below the conduction band at 300^0 K find the new position of the fermi level if temperature is increased to 350^0 K. [6]

3. (a) (i) A sample of germanin is doped with a single type impurity. Outline the measurements you would make to determine the sign and concentration of the carriers, their immobility and effective mass, [9]

(ii) A Hall effect experiment is performed on a heavily doped n-type semiconductor sample of length 2.65cm , a width of 1.70cm and a thickness of 0.0520 cm in a magnetic field of 0.500T The current in the sample along its length is 200. A. The potential difference across its width is 21.4mV and 195mV along its length. Determine the concentration of the charge carries and their mobility. [5]

(b) Explain, with the aid of examples why some metal oxides have semi conducting properties [6]

4. (a) Define the Bohr mageton and explain its usefulness in explaining the magnetic properties of materials. [4]

(b) Show that below the curie temperature, the spontaneous magnetization varies with temperature [8]

(c) Classify magnetic materials according to the magnitude of their susceptibility and temperature dependence. Give at least one example of each [8]

5. Write brief notes the following topics

(a) type I and type II superconductors [8]
(b) Meissner effect [5]
(c) normal and inverse spinnel [7]

6. (a) (i) Define the terms erientational , ionic and electronic polarisation [3]
(ii) Show that orientational polarisation per molecule in a polyatomic gas is given by

$\alpha = \frac{p^2}{3KT}$; where p is the permanent dipole moment per molecule in the absence of a electric field [8]

(b) (i) State the Curie – Weiss law for the absolute dielectric constant of a Ferro – electric material for temperatures above the curve temperatures [3]

(c) Describe the piezo - electric property in some dielectrics [6]

END OF EXAMINATION