NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

SPH 4101 – SOLID STATE PHYSICS II

BSc HONOURS PART IV : JANUARY 2003 *DURATION : 3 HOURS*

ANSWER **ALL** QUESTIONS IN SECTION A AND ANY **THREE** QUESTIONS FROM SECTION B. SECTION A CARRIES 40 MARKS AND SECTION B CARRIES 60 MARKS. DRAW NEAT DIAGRAMS WHEREVER NECESSARY.

Constants

Mass of an electron,	m_e	=	9.11×10^{-31} kg
Mass of neutron,	m_n	=	1.68×10^{-27} kg
Electron chaarge,	e	=	1.60×10^{-19}C
Plank's constant,	n	=	6.63×10^{-34} J.S
Boltsman constant,	k	=	1.38×10^{-23} JK^{-1}
Speed light,	c	=	3.00×10^{8} ms^{-1}
Universal gas constant,	R	=	$8.31 Jmol^{-1} K^{-1}$
Eelectron volt,	leV	=	1.60×10^{-19} J

SECTION A

1 (a) In a n-type semiconductor, the Fermi level lies 0.3 eV below the conduction band at 300K. If the temperature is increased to 330K, find the new position of the Fermi level. [5]

(b) A paramagnetic material is subjected to a homogeneous field of 10^6 amp / meter at a room temperature of 37 ^{O}C. Determine the average magnetic moment along the field direction per spin in Bohr magnetons. [4]

(c) Construct crystal planes in a simple cubic unit cell with the following Miller indices:
(i) (111),
(ii) (112),
(iii) (201). [6]

(d) Describe in brief the following:
(i) Meissner effect,
(ii) Cooper pair ,
(iii) Cohorence length. [6]

(e) Show schematically by drawing the conduction and valence bands, where the Fermi energy lies in the following solids:
(i) intrinsic semiconductor,
(ii) p-type semiconductor,
(iii) n-type semiconductor,
(iv) p-n junction diode. [8]

(f) Define an ohmic contact. [3]

(g) (i) What are F- centres? [2]
(ii) Why do the presence of the F centre impart colour to an otherwise colourless crystal such as sodium chloride? [2]

(h) Determine the Lande g factor and the total magnetic moment of an ion in the ${}^{8}S_{\frac{7}{2}}$ state. [3]

(i) Define the ferromagnetic Curie temperature. [2]

SECTION B

2. (a) Give concise definitions of the following terms :
(i) Fermi energy,
(ii) Fermi level. [4]

(b) A sample of Germanium has the following values of resistance at the given temperatures:

T (K)	310	321	339	360	383	405	434
R (Ω)	13.5	9.10	4.95	2.41	1.22	0.74	0.37

Sketch a graph and use it to determine the energy gap of the given semiconductor. [8]

(c) Show that for an intrinsic semiconductor, the Fermi Level is given by

$$E_F = \frac{E_C + E_V}{2} + \frac{3}{4} K_B T_1 \left(\frac{m_h^*}{m_e^*} \right)$$ [8]

3 (a) For Silicon and Tin at 25°C, and using the table below, compare;

	Silicon	*Tin*
Lattice parameter, a_o	$0.54x10^{-9}m$	$0.649x10^{-9}m$
δ	$5x10^{-4}\ \Omega^{-1}m^{-1}$	$9x10^{6}\Omega^{-1}m^{-1}$
μ_e	$0.19m^2Vs^{-1}$	$0.25m^2V.s^{-1}$
μ_n	$0.05m^2Vs^{-1}$	0.24m2V.s-1
E_g	1.107 Ev	$8.63x10^{-5}$Ev

(i) the number of charge carries per cubic millimeter, [2]

(ii) the fraction of the total electrons in the valency band excited into the conduction band, [4]

(iii) the constant n_o for silicon and tin [2]

(iv) Estimate the electrical conductivity of silicon doped with 0.0001 atom % Asernic above the exhaustion plateau at $600^{O}C$. [4]

(b) Define the following terms used in semiconductor physics
(i) a hole,
(ii) exhaustion region,
(iii) effective mass,
(iv) indirect transition. [8]

4 (a) Classify in brief the magnetic materials. [14]

(b) Show that at high temperatures, the Weiss's hypothesis is consistant with the Curie-Weiss law. [6]

5 (a) *"All solids are inherently defective"*. Comment on this statement, giving equations and examples where appropriate. [10]

(b) Define,
(i) a dislocation,
(ii) an edge dislocation,
(iii) a screw dislocation. [6]

(c) Determine the interplanar spacing and the Burger vector on the (110) [111] slip system. [4]

6 Write brief notes on the following:
(a) super exchange interaction, [4]
(b) the London Equation, [4]
(c) oxide Semiconductors, [6]
(d) ferro electrics [6]

-END OF EXAMINATION PAPER -