RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (Four Year) Degree in Applied Sciences

Fourth Year - Semester I Examination – June/July 2018

PHY 4209 – PHYSICS OF ELECTRONIC DEVICES

Time: Two (02) hours

Answer all four questions

Use of a non - programmable calculator is permitted.
Unless otherwise specified, all the symbols have their usual meaning.

Some fundamental constants;

Electron rest mass $m_e = 9.1 \times 10^{-31}\ kg$
Elementary charge $e = 1.6 \times 10^{-19}\ C$
Electron volt $eV = 1.6 \times 10^{-19}\ J$
Boltzmann Constant $k = 1.38 \times 10^{-23}\ JK^{-1}$

Useful formulae;

$$E_F = \frac{E_C + E_V}{2} + kT \ln\left(\frac{N_V}{N_C}\right)^{1/2}$$

$$n(T) = N_C(T) e^{-(E_C - E_F)/kT}$$

$$p(T) = N_V(T) e^{-(E_F - E_V)/kT}$$

$$E_F = \frac{E_C + E_D}{2} + kT \ln\left(\frac{N_D}{2N_C}\right)^{1/2}$$

$$\sigma = ne(\mu_n + \mu_h)$$

$$D_n = \frac{kT}{e}\mu_n, \quad D_h = \frac{kT}{e}\mu_h$$

$$N_C = 2.5 \times 10^{19}\left(\frac{m_e^*}{m_e}\right)^{3/2}\left(\frac{T}{300}\right)^{3/2}$$

$$R = \rho\frac{l}{A}, \quad \rho = \frac{1}{\sigma}$$

$$f(E) = \frac{1}{e^{\frac{E - E_F}{KI}} + 1}$$

$$n_i = \sqrt{n_0 p_0}\, e^{\frac{-E_g}{2kT}}$$

Contd.

1. a) i. Derive an expression for the position of the Fermi level (E_F) relative to the center of the band gap as a function of temperature in an intrinsic semiconductor. (10 marks)

ii. Calculate the displacement of E_F from the center of the gap in Si at 300 K assuming $m_e^* = 1.1m_e$ and $m_h^* = 0.56m_e$. ($kT \sim 0.026$ eV at 300 K) (05 marks)

b) Suppose that the Fermi level of Si with a bandgap of 1.12 eV at 300 K located exactly at the middle of the bandgap. Calculate the probability that a state located at the bottom of the conduction band is filled. Mention the assumptions that you made in the calculation. (10 marks)

2. At 300 K, a very pure sample of Si, Ge, and GaAs have the properties given in the following table

Sample	n_i cm^{-3}	μ_n cm^2/V s	μ_p cm^2/V s
Si	1.00×10^{10}	1400	460
Ge	2.00×10^{13}	4000	2000
GaAs	2.25×10^{6}	8500	430

a) i. Calculate the resistivity of Si, Ge and GaAs. (12 marks)

ii. The conductivity varies with the resistivity values calculated above. Compare the conductivity among the samples and give reasons for the differences. (08 marks)

b) What is it meant by mobility of carriers in metals? (05 marks)

3. a) Intrinsic semiconductor material A has an energy gap of 0.36 eV, while material B has an energy gap of 0.72 eV. Compare the intrinsic densities of carriers in these two semiconductors at 300 K. Assume that the effective masses of all the electrons and holes are equal to the free electron mass. (15 marks)

b) CdTe is a semiconductor, with the same structure as InSb. In view of the positions of Cd and Te in the periodic table (all elements belong to the same row and Cd, Te, In, Sb are in the columns II, VI, III and V respectively) would you expect the band gap to be larger or smaller than in InSb? Explain. (10 marks)

4. Write short notes on the following.

(a) Law of mass action (08 marks)

(b) Optical properties of quantum wells (08 marks)

(c) Carrier freeze-out phenomenon in semiconductors. (09 marks)

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