PYL 102: PRINCIPLES OF ELECTRONIC MATERIALS

TOTAL MARKS: 20 **MINOR-II (11.10.2015)** **DURATION: 60 Minutes**

Q.1. (a) Consider the conductivity of a semiconductor, $\sigma = en\mu_e + ep\mu_h$. Will doping always increase the conductivity? Justify your answer.

(b) Show that the minimum conductivity for Si is obtained when it is *p*-type doped such that the hole concentration is $p_m = n_i \cdot \sqrt{\frac{\mu_e}{\mu_h}}$ and the corresponding minimum conductivity (maximum resistivity) is $\sigma_{min} = 2en_i\sqrt{\mu_e\mu_h}$. [2+4]

Q.2. In a one-dimensional model of an intrinsic semiconductor the energy measured from the bottom of the valence band is

$$E = \frac{\hbar^2 k_1^2}{3m_0} + \frac{\hbar^2 (k - k_1)^2}{m_0}$$

This is an approximate formula accurate only in the vicinity of the minimum of the conduction band, which occurs when $k = k_1 = \pi/a$, where 'a' the lattice spacing is 0.314 nm. The Fermi energy is at 2.17 eV.

Calculate:(i) the energy gap between the valence and conduction bands, and **(ii)** the effective mass of electrons at the bottom of the conduction band. Assume that the Fermi level is halfway between the valence and conduction bands.(Given: $h = 2\pi\hbar = 6.626\times10^{-34}$ Joule-sec., $m_0 = 9.1\times 10^{-31}$ kg., 1eV$=1.6\times 10^{-19}$ Joule). [4]

Q.3. A sample of GaAs was doped with excess arsenic to a level calculated to produce a resistivity of 0.05 Ωm. Owing to the presence of an unknown acceptor impurity the actual resistivity was 0.06 Ωm, the sample remaining n-type. What were the concentrations of donors and acceptors present? (Given: $\mu_e = 0.85$ m^2/Vs and assume that all impurity atoms are ionized). [3]

Q.4. (a) Draw a properly labelled energy level band diagram of a Schottky junction between a metal and an n-type semiconductor. Draw necessary diagrams to show its usage as a solar cell and a photodiode. You are not required to write any text and therefore show all the required information on the diagrams.

(b) Consider a case when the energy of the incident light is less than the band gap of the n-type semiconductor. Will the Schottky junction still respond as a solar cell? Give brief explanation.

(c) Consider a Schottky junction and a ohmic contact between a metal and an n-type semiconductor. (i) Is the Peltier effect observed in both contacts? Give brief justification. (ii) Which junction would you choose for a thermoelectric cooler? Give reasons. [4+1+2]