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FOURTH SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, APRIL 2023

(CBCSS)

Physics

PHY 4E 22—PHYSICS OF SEMICONDUCTORS

(2019 Admission onwards)

Time : Three Hours

Maximum : 30 Weightage

Section A

8 *Short questions, each answerable within* 7.5 *minutes.*
Answer **all** *questions, Each question carries weightage* 1.

1. Explain Burstein Moss effect.
2. Why does the energy band gap decrease in semiconductors as temperature is increased ?
3. What are the different types of capacitance exhibited by a *p-n* junction diode ?
4. Distinguish between quantum dot and a quantum well structures.
5. Distinguish between drift and diffusion current in semiconductors.
6. How does a Light emitting diode work ?
7. Enlist the characteristics of an ideal diode.
8. Explain an application of thermoelectric electromotive force.

(8 × 1 = 8 weightage)

Section B

4 *Essay questions, each answerable within* 30 *minutes*
Answer any **two** *questions, Each question carries weightage* 5.

9. With neat diagram explain the quantum mechanical tunnelling in a tunnel diode.
10. Explain the concept of Fermi level in semiconductors and its variation with doping density. With proper mathematical steps show the Fermi level in an intrinsic semiconductor is located in the middle of the forbidden gap.

Turn over

11. Write explanatory notes on any *two* methods of preparation of low dimensional semiconductor structure like quantum wells and quantum dots.

12. Explain the theory of Hall Effect. Using the two band model of Hall Effect derive an expression for the total Hall co-efficient.

(2 × 5 = 10 weightage)

Section C

7 Problems answerable within 15 *minutes.*

Answer any **four** *questions, Each question carries weightage* 3.

1. A potential well has a height of 0.05 eV. What should be the width of the well so that the binding energy of the electron ($m^* = 0.063\ m_e$) would be equal to 0.025 eV.
2. The following data are given for intrinsic germanium at 300 K $n_i = 2.4 \times 10^{19}\ m^{-3}$, $\mu_e = 0.39\ m^2/V\text{-}s$; $\mu_h = 0.19\ m^2/V\text{-}s$. Calculate the resistivity of the sample.
3. Consider a silicon crystal at room temperature, doped with both donor and acceptor atoms so that $N_D = 2 \times 10^{15}\ cm^{-3}$ and $N_A = 1 \times 10^{15}\ cm^{-3}$. What type of material would this yield ? What will the hole concentration be in this material ? Intrinsic carrier concentration for Si is $1.45 \times 10^{10}\ cm^{-3}$.
4. The Hall co-efficient (R_H) of a semiconductor is $3.22 \times 10^{-4}\ m^3\ C^{-1}$. Its resistivity is $8.50 \times 10^{-3}\ \Omega\text{-m}$. Calculate the mobility and carrier concentration of the carriers.
5. Calculate the space charge width at zero bias for a Schottky contact with the following parameters: capacitance permittivity $\varepsilon_s = 11.7$, built in potential barrier $V_{bi} = 0.334$ V, doping density $N_d = 10^{16}\ cm^{-3}$.
6. Find the relaxation time of conduction electrons in a metal of resistivity $1.54 \times 10^{-8}\ \Omega\text{-m}$, if the metal has 5.8×10^{28} conduction electrons/m^3.
7. Calculate the mobility of the electrons in copper obeying classical laws. Given that the density of copper = $8.92 \times 10^3\ kg/m^3$, Resistivity of copper = 1.73×10^{-8} ohm-m, atomic weight of copper = 63.5 and Avogadro's number = 6.02×10^{26} per k-mol.

(4 × 3 = 12 weightage)