VIGNAN'S

FOUNDATION FOR SCIENCE, TECHNOLOGY & RESEARCH

(Deemed to be University) - Estd. u/s 3 of UGC Act 1956

Module Bank

Module 2

Academic Year 2025-26

Staff Name: Dr. Sreekar Guddeti

Program Name: B. Tech
Branch: AI/ML
Year: 1
Semester: 1
Course: EP
Code: 25PY101

Section number: 28, 34

Instructions:

1. Answer all questions.
2. BT stands for Blooms Taxonomy.

PART-B

1. Solar cell **[10 M]**

a) Write the equations for $I-V$ characteristics and $P-V$ characteristics of pn junction solar cell. [BT 1][2 M]

b) Derive the equation to determine the operating voltage for maximum power generation V_m in terms of the photocurrent I_L and reverse saturation current I_s. [BT 3][4 M]

c) The reverse saturation current density for a solar cell pn junction is $3.6 \cdot 10^{-11} A/cm^2$. What is the photocurrent density required to generate open circuit voltage of 0.60 V. [BT 4][4 M]

2. $n_0 p_0$ product in extrinsic semiconductor **[10 M]**

a) Design a new semiconductor material. It has to be p type and doped with $N_a = 5 \cdot 10^{15} cm^{-3}$ acceptor atoms. Assume complete ionization and assume $N_d = 0$. The effective density of states functions are $N_c = 1.2 \cdot 10^{19} cm^{-3}$ and $N_v = 1.8 \cdot 10^{19} cm^{-3}$ at $T = 300K$. The requirement is that the hole concentration must not exceed $5.08 \cdot 10^{15} cm^{-3}$ at $T = 350K$. What is the minimum bandgap energy required in this material? You can assume the $n_0 p_0$ product rule is valid for extrinsic semiconductor also. [Hint: Apply the $n_0 p_0$ product rule on the charge neutrality condition $n_0 + N_a^- = p_0 + N_d^+$.] [BT 6][10 M]

3. Blackbody radiation and optical absorption **[10 M]**

a) The Planck's blackbody radiation law is given by

$$I(\nu) = \frac{2h\nu^3}{c^2} \frac{1}{\exp\left(\frac{h\nu}{k_B T}\right) - 1}$$

where $I(\nu)$ is the irradiance at a given frequency ν and temperature T. Find the expression for wavelength λ_m corresponding to maximum irradiance in terms of temperature T. [BT 3][4 M]

b) An alien ship crash landed onto Earth's surface. From the debris, the solar panel used for power generation is found to have a band gap of 5 eV. Estimate the temperature of the alien Sun. [BT 5][4 M]

c) Is the solar panel useful for applications on Earth? Why or why not? [BT 2][2 M]

End of module bank