**COURSE: BBS01T1002 SEMICONDUCTOR PHYSICS**

**Syllabus for B.Tech. Sem -II**

**ETE- (****Winter-2021-22)**

**Unit 1** **Quantum and Band Theory of electron:** Quantum free electron theory. Fermi Dirac distribution function and Fermi level, density of states, Energy band in solids, E-K diagram and Brillouin zone, effective mass, concept of holes.

**Unit 2 Semiconductor:** Types of semiconductor, Fermi level in semiconductor, effect of carrier concentration and temperature on fermi level, direct-indirect band gap semiconductors, compound semiconductors, Conductivity and mobility, recombination process, Hall effect and applications.

**Unit 3 Applications of Diodes :** Concept in optical transitions in bulk semiconductors- absorption process, recombination process, explanation for spontaneous emission-stimulated emission-transition rate, theory of p-n junction, p-n junction diode and its I-V characteristics, optoelectronics devices-LEDs, laser diode, Basics of Photovoltaics- photovoltaic effect, Determination of efficiency of PV cell.

**Unit- 4 Low Dimension Physics and Nano-materials:** Density of states in 0D, 1 D and 2D –Low dimensional systems: Quantum well, Quantum wire, Quantum dots, Nanomaterials and its properties, Classification of Nanomaterials, Carbon nanowires and nanotubes, Semiconductor nanomaterials, Graphene, Characterization techniques (basic ideas): Scanning Electron Microscopy and Transmission Scanning Electron microscopy

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| S.No. | **Unit 1 [Quantum and Band Theory of electron]:** Questions | Max Marks |
| 1 | Find the least energy of an electron moving in one dimensional infinitely high potential box of width 0.05 nm. [Given Planck’s Constant (h) =6.625x10-34 J.s. and mass of electron (m)= 9.1x10-31 kg. ] | 2 |
| 2 | Find the least energy of an electron moving in one dimensional infinitely high potential box of width 0.05 nm | 2 |
| 3 | An electron is bound in a one dimensional potential box which has a width 2.5x10-10 m. Assuming the height of the box to be infinite, calculate the lowest two permitted energy values of the electron.[Given Planck’s Constant ( h) =6.625x10-34 J.s. and mass of electron (m) = 9.1x10-31 kg.] | 2 |
| 4 | Find the minimum energy of an electron moving in one dimension in an infinitely high potential box of width 1Å. [Given Planck’s Constant (h) =6.625x10-34 J.s. and mass of electron (m) = 9.1x10-31 kg.] | 2 |
| 5 | The Fermi Energy for a given solid is 5.0 eV at T=0K. What is the average energy of the electron in the metal at 0 K? | 2 |
| 6 | The Fermi level for potassium is 2.0 eV. Calculate the velocity of the electrons at the Fermi level. | 2 |
| 7 | What is the value of Fermi-Dirac distribution function for T=0, when (i) energy is greater than Fermi Energy and (ii) when energy is less than Fermi Energy. | 2 |
| 8 | Define the Fermi Energy. If the Fermi energy is 10eV, calculate the mean energy of electron at 0 Kelvin. | 2 |
| 9 | Write Schrodinger’s time-independent equation for matter waves. Explain the physical significance of the wave function? | 5 |
| 10 | Explain the idea of wave function for a quantum particle. Write the basic characteristics of well-behaved wave function? | 5 |
| 11 | Draw the E-K diagram of a semiconductor based on band theory of solids. Explain the Brillouin zones in a solid. | 5 |
| 12 | What would be the band structure if the barrier strength is extremely high or negligible? Justify your answer with a suitable diagram. | 8 |
| 13 | Define the density of energy state in a solid. Find the expression for density of states. | 8 |
| 14 | An electron is in motion along a line between x=0 and x= L with zero potential energy. At points for which x ≤ 0 and x ≥ L, the potential energy is infinite. The wave function for the particle in the nth state is given by ψn=A Sin (nπx/L). Find the expression for the normalized wave function. | 8 |
| 15 | An electron is in motion along a line between x=0 and x=L with zero potential energy. At points for which x ≤ 0 and x ≥ L, the potential energy is infinite. Solving Schrodinger’s equation, obtain energy Eigen values | 8 |
| 16 | Explain the energy band in solids and classify the materials based on energy gap. | 8 |

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| S.No. | Unit- 2 [Semiconductor] : Questions | Max Marks |
| 1 | An electric field of 200 volt/m is applied to a sample of n type semiconductor whose Hall coefficient is -0.0145 m2/coulomb. Calculate the current density in the sample assuming mobility of electron equals to 0.36 V-1 S-1. | 2 |
| 2 | The carrier concentration in n-type semiconductor is 3.0 X1019/m3. Determine the value of Hall coefficient. Given that e =1.6× 10-19 C | 2 |
| 3 | What is the wavelength corresponding to the bandgap of GaAs (1.42eV) approximately? | 2 |
| 4 | Calculate energy band gap of semiconducting material if it emits light of wavelength 414 nm. | 2 |
| 5 | The carrier concentration in n-type semiconductor is 1019/m3. Determine the value of Hall coefficient. | 2 |
| 6 | Hall coefficient of a semiconductor is 3.22x10-4 m3/C. Its resistivity is 9x10-3ohm-meter. Calculate the mobility in the semiconductor. | 2 |
| 7 | The Hall coefficient (RH) of a semiconductor is 3.22× 10-4 m3/C.  Calculate the carrier concentration of the carriers. (Given that e =1.6× 10-19 C). | 2 |
| 8 | In a p-n junction diode, explain a). Minority charge carrier b). Majority charge carrier | 2 |
| 9 | Derive the expression of current density and Mobility of charge carriers for semiconductor | 5 |
| 10 | Distinguish between the direct and indirect band gap semiconductors using band diagram with one-one example. | 5 |
| 11 | Define current density and mobility of charge carriers for a semiconductor. Hall coefficient of a semiconductor is 3.22x10-4 m3/C. Its resistivity is 9x10-3ohm-meter. Calculate the mobility in the semiconductor. | 5 |
| 12 | Explain the Hall effect and derive the expression for Hall coefficient. | 5 |
| 13 | Define the drift velocity and mobility of an electron and find the expression of mobility in an intrinsic semiconductor. | 8 |
| 14 | Discuss the Hall effect phenomenon in a semiconductor with the suitable diagram | 8 |
| 15 | Discuss the Hall effect phenomenon in a semiconductor with the suitable diagram also derive the expression for Hall coefficient. Write two application of Hall effect . | 8 |
| 16 | Show that in an intrinsic semiconductor the conductivity of the material is given by the expression; σ= e n (µe +µp), where [ σ =conductivity, n carrier density µe = mobility of electron and µp= mobility of hole and e= electronic charge]. The intrinsic carrier density of Ge at 27oC is 2.4 x 10 17 m-3. Calculate its resistivity, if the electron and hole mobility are 0.35 m2 V-1 s-1 and 0.18 m2 V-1 s-1 respectively. | 8 |

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| S.No. | Unit -3 [Applications of Diodes] : Questions | Max Marks |
| 1 | Write down the diode equation. How this equation is modified during forward bias? | 2 |
| 2 | Explain avalanche breakdown and Zener breakdown in a p-n junction diode | 2 |
| 3 | Explain threshold voltage ( knee voltage)  and breakdown voltage in a p-n junction diode | 2 |
| 4 | Define built-in-potential (potential barrier). What will be direction of internal electric field developed due to potential barrier in a zero biased p-n junction diode? | 2 |
| 5 | Describe the Forward and reverse biased p-n Junction along with proper circuit diagram. | 5 |
| 6 | In a PN junction diode, explain: a). Minority charge carrier b). Majority charge carrier c). Break down voltage. | 5 |
| 7 | Describe the formation of depletion layer in p-n junction diode. Draw and explain the V-I characteristics of a p-n Junction diode. | 5 |
| 8 | Interpret the recombination and generation of electron-hole pairs in a semiconductor. Find the wavelength corresponding to the band gap of GaAs (1.42eV) approximately? | 5 |
| 9 | Discuss in detail that an ideal p-n junction diode act as short circuit in forward biased mode and open circuit in a reverse biased mode. | 8 |
| 10 | Describe the formation of depletion layer in p-n junction diode. Draw and explain the V-I characteristics of a p-n Junction diode. Is current flowing through the p-n junction diode due to majority charge carries? Justify your answer. | 8 |
| 11 | Discuss the different types of biasing of p-n junction diode and its applications | 5 |
| 12 | Explain the construction and working of photo diode. |  |
| 13 | Interpret the recombination and generation of electron hole pairs in a semiconductor. | 8 |
| 14 | Describe the working of light emitting diode (LED) with its energy band diagram. In a LED, the semiconductor material has band gap of 1.1 eV. Calculate the wavelength of light emitted by the LED | 8 |
| 15 | Discuss principle and working of solar cell also explain Voltage -current characteristic curve and fill factor of solar cell. | 8 |
| 16 | Differentiate between spontaneous and stimulated emission and write two -two properties of Coherent and incoherent waves. Also write two uses of coherent waves. | 8 |
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| S.No. | **Unit- 4 [Low Dimension Physics and Nano-materials]**: Questions | Max Marks |
| 1 | Draw the ray diagram of transmission scanning electron microscopy (TSEM) | 2 |
| 2 | Explain the difference between back scattered and secondary electrons, and their use in SEM. | 2 |
| 3 | Explain the 0D, 1D and 2D structure of Nano-materials with examples. | 2 |
| 4 | How melting point and colours are changing by reducing the size of materials at the Nano scale? | 2 |
| 5 | Compare graphically the density of states for quantum wire, Quantum dot and Quantum well. | 2 |
| 6 | Explain different electron sources used in Scanning electron Microscopy (SEM). | 2 |
| 7 | Write two different electron sources used in scanning electron microscopy (SEM) | 2 |
| 8 | Explain the structure and types of bonding of the graphene and write four applications. | 2 |
| 9 | Explain quantum well. quantum wire and quantum dots | 5 |
| 10 | Explain the single and multi-wall carbon nano tubes. | 5 |
| 11 | Describe the electronic, optical, and mechanical properties of graphene. | 5 |
| 12 | What are CNTs? Describe the single and multi-wall carbon nano tubes | 8 |
| 13 | Discuss the principle and working of Transmission Scanning Electron Microscope (TSEM). | 8 |
| 14 | Describe Carbon nanowires and nanotubes and explain their electronic and mechanical properties. | 8 |
| 15 | Describe the Chirality of Carbon nanotubes (CNTs). Write four application of a Carbon nanotubes. | 8 |
| 16 | Explain the basic principle of Scanning Electron Microscope (SEM). Describe the working of SEM using its basic diagram. | 8 |

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