**QUESTIONS BANK**

**BBS01T1002 SEMICONDUCTOR PHYSICS**

**Unit 1: Quantum and Band Theory of electron**

(CO1): Identify the energy band in solids and electron occupation probability

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| Questions | S.No. |
| 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? | 1 |
| The Fermi level for potassium is 2.0 eV. Calculate the velocity of the electrons at the Fermi level. | 2 |
| Find the value of Fermi function F(E) if E-EF = 0.01 eV at T= 200 K for any material | 3 |
| The Fermi energy in the solid is proportional to the density of electron(n) as n ^(2a/2a+1). Find the value of 'a'. | 4 |
| If the value of Fermi function for a certain energy level is 0.7. What is the percentage of probability that this energy level is unoccupied by the electron? | 5 |
| 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. | 6 |
| Draw the curve showing variation of:  Velocity of electrons with momentum vector  Effective mass of electrons with momentum vector | 7 |
| Find the least energy of an electron moving in one dimensional infinitely high potential box of width 0.05 nm | 8 |
| For a particle inside a box of length L unit, and for n=2, find out the positions where the probability of occupancy is zero. | 9 |
| Define the Fermi Energy. If the Fermi energy is 10eV, calculate the mean energy of electron at 0K. | 10 |
| Write the expression of eigen value and wave function for a free particle moving one dimensionally (1-D) in a potential well. | 11 |
| Explain the energy band in solids and classify the materials based on energy gap. | 12 |
| Draw the E-K diagram of a semiconductor material | 13 |
| Explain the Brillouin zones in a solid | 14 |
| What would be the band structure if the barrier strength is extremely negligible? Justify your answer with a suitable diagram. | 15 |
| What would be the band structure if the barrier strength is extremely high? Justify your answer with a diagram. | 16 |
| Based on band theory of solids, distinguish between conductors, semiconductors, and insulators. | 17 |
| Explain the idea of wave function for a quantum particle. What are the basic characteristics of well-behaved wave function? | 18 |
| Define the density of energy state in a solid. Find the expression for density of states. | 19 |
| Define the Fermi energy and Fermi distribution function. Plot the Fermi distribution function at different temperatures. | 20 |
| Define the effective mass of an electron and obtain its expression. Also plot the curve for effective mass and interpret the curve. | 21 |

**Unit 2: Semiconductor**

(CO2): Understand the physics of semiconductor and develop the ability to choose the appropriate semiconductor for engineering applications

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| Questions | S.No. |  |
| 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. | 1 |  |
| What is the wavelength corresponding to the bandgap of GaAs (1.42eV) approximately? | 2 |  |
| The carrier concentration in n-type semiconductor is 1019/m3. Determine the value of Hall coefficient. | 3 |  |
| Hall coefficient of a semiconductor is 3.22x10-4 m3/C. Its resistivity is 9x10-3ohm-meter. Calculate the mobility in the semiconductor. | 4 |  |
| 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). | 5 |  |
| Outline the nature of charge on an intrinsic semiconductor on addition of neutral pentavalent or trivalent atoms. | 6 |  |
| The intrinsic carrier density of Ge at 27oC is 2.4 x 10 17 m-2. 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. | 7 |  |
| Discuss the variation of fermi level position with temperature and doping concentration. | 8 |  |
| Distinguish between elemental and compound semiconductors with examples. | 9 |  |
| Draw and interpret the graph for the Fermi Energy variation with temperature for P and N type semiconductors. | 10 |  |
| Define the relaxation time and Drift velocity of an electron in a semiconductor | 11 |  |
| Explain the extrinsic semiconductor. Using suitable diagram, discuss how the Fermi level changes with change of temperature in extrinsic semiconductors. | 12 |  |
| Distinguish between the direct and indirect band gap semiconductors with examples. | 13 |  |
| Describe the significance of negative effective mass and explain the concept of hole. | 14 |  |
| Describe the P and N type semiconductors and indicate the Fermi level and energy level of impurity atoms in band diagram | 15 |  |
| Hall coefficient of a semiconductor is 3.22x10^-4 m3/C. Its resistivity is 9x10^-3ohm-meter. Calculate the mobility and carrier concentration in the semiconductor. | 16 |  |
| What are the charge carriers responsible for current conduction in pure semiconductor? Find the expression for conductivity of such semiconductor. | 17 |  |
| Derive the expression of current density and Mobility of charge carriers for semiconductor | 18 |  |
| Define the Hall effect phenomenon in a semiconductor with the suitable diagram | 19 |  |
| Explain the Hall effect and derive the expression for Hall coefficient. | 20 |  |
| Define the drift velocity and mobility of an electron and find the expression of mobility in an intrinsic semiconductor. | 21 |  |

**Unit 3: Applications of Diodes**

(CO3): Apply the knowledge of diode to the development of new and novel optoelectronic devices

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| Questions | S.No. |  |
| Write down the diode equation. How does this equation is modified during forward bias? | 1 |  |
| Classify the optical transitions in bulk semiconductors | 2 |  |
| The open circuit voltage and short circuit current of a solar cell illuminated uniformly with solar light of power 100 mW/cm2 are 0.5 V and 180 mA respectively. The solar cell has an area of 3 cm2 and a fill factor of 0.7. Estimate the maximum efficiency (in %) of the device. | 3 |  |
| Illustrate drift and diffusion phenomena in semiconductors | 4 |  |
| What is solar cell? Draw the V-I characteristic curve of solar cell. | 5 |  |
| Differentiate between spontaneous and stimulated emission. Which one is used for laser action? | 6 |  |
| In a LED, the semiconductor material has band gap of 1.1 eV. What will be the wavelength of light emitted by this LED? | 7 |  |
| Interpret the recombination and generation of electron hole pairs in a semiconductor. | 8 |  |
| In a LED , the material has band gap of 2 eV. What will be the colour of emitting light | 9 |  |
| Explain the formation of depletion layer in a semiconductor with diagram. | 10 |  |
| Find energy band gap of semiconducting material if it emits light of wavelength 414 nm. | 11 |  |
| Describe the working of LED with its energy band diagram | 12 |  |
| Describe the reverse and forward biased PN Junction along with its circuit diagram. | 13 |  |
| In a PN junction diode, explain : a). Minority charge carrier b). Majority charge carrier c). Break down voltage. | 14 |  |
| Draw the I-V characteristics of a PN Junction diode and explain the knee voltage. | 15 |  |
| Explain the construction and working of photo diode. | 16 |  |
| Describe the formation of depletion layer in p-n junction diode. Draw and explain the V-I characteristics of a p-n Junction diode. | 17 |  |
| Describe the construction and working of light emitting diodes (LEDs) with suitable diagram. | 18 |  |

**Unit- 4 Low Dimension Physics and Nanomaterials**

(CO4): Utilize the knowledge of the low dimensional/ nano materials for engineering applications and understand the basic characterization techniques

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| Questions | S.No. |  |
| Describe the ray diagram of a TEM, with sample and image position. | 1 |  |
| Explain the difference between back scattered and secondary electrons, and their use in SEM. | 2 |  |
| Compare graphically the density of states for quantum wire, Quantum dot and Quantum well. | 3 |  |
| Explain different electron sources used in Scanning electron Microscopy (SEM). | 4 |  |
| Describe the four applications of graphene | 5 |  |
| Write four application of a Carbon nanotubes | 6 |  |
| What are zero-, one-, two- and three - dimensional nanomaterials | 7 |  |
| Explain blue shift by decreasing size of materials in nano scale | 8 |  |
|  | 9 |  |
| Explain quantum well. quantum wire and quantum dots. | 10 |  |
| Explain the single and multi-wall carbon nano tubes. | 11 |  |
| Describe the electronic, optical, and mechanical properties of graphene. | 12 |  |
| What is the graphene? Draw the structure of graphene | 13 |  |
| Explain the basic principle of Scanning Electron Microscope (SEM). Describe the working of SEM using its basic diagram. | 14 |  |
| Explain the 0D, 1D and 2D structure of Nanomaterials with examples. | 15 |  |
| Discuss the principle and working of Transmission Scanning Electron Microscope (TSEM). | 16 |  |
| Describe Carbon nanowires and nanotubes and explain their electronic and mechanical properties. | 17 |  |
| Describe the Chirality of Carbon nanotubes (CNTs) | 18 |  |

**SYLLABUS**

**ETE- (FALL-2021-22)**

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| **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. |
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| **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. |
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| **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 |
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| **Unit- 4 Low Dimension Physics and Nanomaterials** |
| 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 |