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# PES University, Bengaluru

(Established under Karnataka Act 16 of 2013) **UE18PH101**

## END SEMESTER ASSESSMENT (ESA) B TECH. I SEMESTER DEC 2018

## ENGINEERING PHYSICS

**Time: 3 hours** **Answer all questions** **Max marks: 100**

| **Useful constants:** | **h = 6.626 x $10^{-34}$ Js** | **$\varepsilon_o$ = 8.854 x $10^{-12}$ $Fm^{-1}$** | **$m_e$ = 9.1 x $10^{-31}$ kg** |
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| **$c$ = 3x$10^8$ $ms^{-1}$** | **$k_B$ = 1.38 x $10^{-23}$ $JK^{-1}$** | **$N_A$ = 6.02 x $10^{23}$ per mol** | |

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| **1 a)** | Using Maxwell's wave equations for electromagnetic waves in free space, estimate the energy carried by EM waves. | **6** |
| **b)** | Estimate the Compton shift for X rays scattered at **95°** with respect to the incident direction. If the momentum of the scattered X rays is **4.5x$10^{-24}$ kg m $s^{-1}$** estimate the wavelength of the incident X Rays. | **4** |
| **c)** | Elaborate the concept of matter waves and obtain the expression for the phase and group velocities associated with wave packets. | **5** |
| **d)** | What is the physical significance of normalization of a wave function? Normalize the wave function given **by** $\psi = A.\sin(\frac{\pi}{2}x)$ for $0 < x < 1$ and $\psi = 0$ for all other $x$. | **5** |
| **2 a)** | Starting from the Schrodinger's time dependent wave equation arrive at the Schrodinger's time independent wave equation. | **5** |
| **b)** | An electron of energy 3eV is incident on a **potential step** of height 2.75eV. Calculate the probability of transmission over the potential step. | **5** |
| **c)** | In radio activity **alpha particle emission** is explained as a case of **barrier tunneling**. Justify the explanation. | **5** |
| **d)** | Discuss the wave functions of a particle in a **finite potential** well and the method of estimating the energy of the particle in the first state. | **5** |
| **3 a)** | Discuss the concept of Fermi energy and Fermi factor for valence electrons in a metal. Estimate the Fermi factor of an energy state **0.01eV below** the Fermi level at 500K | **5** |
| **b)** | From the expression for the density of states for free electrons in a metal with **n** electrons per unit volume, obtain an expression for the Fermi energy of electrons at zero Kelvin. | **5** |
| **3c)** | Estimate the **molar specific heat of free electrons** at 500K as per the quantum free electron theory if the Fermi energy of the metal is 3.75 eV. | **5** |
| **3d)** | Draw the **E – k** graph for electrons in metal as per the band theory of solids and discuss the concept of the effective mass of electrons in the conduction band of the metal. | **5** |

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| 4 a) | From the concept of Einstein's interaction of radiation with matter find the ratios of<br>i) the rate of stimulated emission to the rate of induced absorption.<br>ii) the rate of spontaneous emission to the rate of induced absorption<br>Hence prove that $\frac{R_{spont\ emission}}{R_{induced\ absorption}} = \frac{N_1 - N_2}{N_1}$ | 5 |
| b) | Discuss the temporal and spatial coherence of a laser. Why is coherence an important property of the laser? | 5 |
| c) | Outline the principles behind the working of a semiconductor laser. Discuss the active medium, energy pump and cavity for the laser system. | 6 |
| d) | An emission system has two levels which gives rise to an emission wavelength of **546.1 nm**. If the population of the lower state is **$4x10^{22}$ at 600 K**, estimate the population of the higher energy state. | 4 |
| 5 a) | Elaborate on the Curie's law for paramagnetic materials. What are the arguments proposed by Weiss to modify the Curie's law? | 5 |
| b) | Elaborate on spin ordered magnetic materials and their classification. | 6 |
| c) | A solid dielectric has **$5 \times 10^{28}$** atoms per unit volume and a dielectric constant of **4**. Estimate the atomic polarisability. | 4 |
| d) | Discuss Ferroelectric materials with a suitable example and discuss the hysteresis in the polarization with varying electric field. | 5 |

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