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RV COLLEGE OF ENGINEERING®

(An Autonomous Institution affiliated to VTU)

I / II Semester B. E. Regular / Supplementary Examinations Feb-2024

Common to EC /EE / EI / ET

CONDENSED MATTER PHYSICS FOR ENGINEERS

Time: 03 Hours ***Maximum Marks: 100***

Instructions to candidates:

1. Answer all questions from Part A. Part A questions should be answered in first three pages of the answer book only.
2. Answer SIX full questions from Part B. In Part B question number 2 and 11 are compulsory. Answer any one full question from 3 and 4, 5 and 6, 7 and 8 & 9 and 10.
3. Handbook of Physics is allowed.

PART-A

1	1.1	What is the role of repeaters in point to point communication system using optical fibers?	01
	1.2	Calculate the probability of finding the particle at the wall of an infinite well in the $16th$ excited state.	01
	1.3	Name the interaction of radiation with matter which results in the emission of incoherent light.	01
	1.4	What is the form of output energy of a strain gauge?	01
	1.5	Mention the types of dieletric breakdown that happen in a dielectric material due to i) High electric field and ii) Surface defects.	02
	1.6	Fermi energy of Copper is $7.0eV$. Find the free electron density of copper at Zero Kelvin.	02
	1.7	In a laser cavity of length $1m$, the standing wave pattern consists of 3.16×10^6 complete loops. Find the wavelength of the laser light.	02

PART-B

2	a	Solve the time-independent Schrodinger's equation of a quantum particle in a one-dimensional infinite potential well of width 'a' and obtain the Eigen wave function and Eigen energy states.	08
	b	With a graphical plot, find the points of maximum and minimum probability density for the second and third excited state of a particle in a one-dimensional box of width 'a'. Verify the following wave function $\psi = A \sin kx$ is an eigen function of the momentum operator $P = -ih\frac{\partial}{\partial x}$. If its an eigen function, what is the eigen value?	06
3	a	Derive the relation between Fermi energy and energy band gap for an intrinsic semiconductor.	06
	b	The energy gap for semiconductor at $300K$ is $1.14eV$. i) Find the lowest frequency photon that will promote an electron from the valence band to the conduction band of silicon. ii) What is the wavelength of this photon?	

		What is Fermi energy at zero Kelvin for metals? Discuss the probability of occupation of various energy state by electrons at $T = 0K$ and $T > 0K$	08
		OR	
4	a	Derive the expression for electron concentration in the conduction band of an intrinsic semi-conductors?	08
	b	The carrier density of a Hall sample is $1.708 \times 10^{22}/m^3$. Calculate Hall coefficient of a sample. Identify the nature of Hall sample. State law of mass action. Obtain an equation for the conductivity of an intrinsic semiconductor in terms of mobility.	06
5	a	What are the fundamental ways in which light (photons) interacts with matter (atms)? Explain each way with energy level diagram. Calculate the ratio of stimulated to spontaneous emission at a temperature $300K$, if wavelength of light is $600mm$.	08
	b	With a neat sketch, explain multi mode step index and graded index multi mode optical fiber.	06
		OR	
6	a	Derive an expression for energy density of radiation in terms of Einstein coefficients. Arrive at the general expression after comparing with Plank's equation. The probability of spontaneous transition is given as $0.08m$ in a laser action which results with the radiation of $632.8nm$ wavelength. Calculate the probability of simulated emission.	10
	b	Explain absorption and scattering losses occurring in optical fibers.	04
7	a	With energy diagram, explain the effect of forward and reverse biasing on the width of the depletion region of a diode.	06
	b	Find I_c and I_E for an npn transistor. Given that $\alpha = 0.96$ and $I_B = 110\mu A$. Also calculate the β of the transistor. What is reverse breakdown? Explain the Avalanche breakdown mechanism.	08
		OR	
8	a	With the help of a circuit diagram, explain the input, output and transfer characteristics of an npn transistor in common emitter mode. With a circuit diagram, explain the construction and working of a bridge rectifier. Sketch its input and output waveforms.	10
	b	A silicon pn junction diode is formed from $p - material$ doped with 10^{22} acceptors $/m^3$ and n-material doped with 1.2×10^{21} donors $/m^3$. Find the thermal and barrier voltage at 25^0C. Given: $n_i = 1.5 \times 10^{16}/m^3$.	04
9	a	Define polarization and polarizability of a dielectric material. Arrive at an expression that gives the relationship between the dielectric constant and the polarizability for a three dimensional cubic solid. A solid elemental dielectric having density $3 \times 10^{28}\ atoms/m^3$ shows an electronic polarizability of $10^{-40}Fm^2$. Assuming the internal field to be a Lorentz field, find the dielectric constant of the material.	09
	b	Draw the stress-strain graph of an elastic body and explain the different regions of the graph.	05

OR

10 a For a dielectric material in an a.c field, describe the conditions under which the polarization is halted with the help of graphical plot.
If the relative susceptibility of a material is 4.94 and the number of dipoles per unit volume is $10^{28}/m^3$, calculate the polarizability of the material. 10

b Elucidate the difference between active and passive transducer. 04

LAB COMPONENT

11 a What is Band Gap of thermistor? Determine band gap of a thermistor by plotting the graph of logarithmic variation of resistance with inverse of temperature.
Following is the data of resistance and temperature

$R(\Omega)$	5.6	6.6	7.3	8	8.5	9.1	9.6	10.2	10.9
$T(K)$	356	354	352	350	348	346	344	342	340

10

b Write the principle and procedure to determine the numerical aperture and acceptance angle of an optical fiber. Calculate the numerical aperture and acceptance angle of an optical fiber using the data given below.

Distance between optical fiber and screen $L(mm)$	8	10	12	14	16
Width of the spot $W(mm)$	14	16	18	19	21

10