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RV COLLEGE OF ENGINEERING®

(An Autonomous Institution affiliated to VTU)

II Semester B. E. Examinations October– 2023

COMMON TO AI, BT, CS, CY, CD, IS

QUANTUM 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 FIVE full questions from Part B. In Part B question number 2 & 11 are compulsory. Answer any one full question from 3 and 4, 5 and 6, 7 and 8, 9 and 10, and 11 lab components (compulsory).
3. Handbook of Physics is allowed.

PART A

1	1.1	According to Heisenberg's uncertainity principle, if an electron resides in a state with very high life-time as it de-excites to the ground state, the broadening in the wavelength of the photons emitted by the atom will _____.	01
	1.2	At $T > 0K$, for energy level $E = E_F$, the Fermi factor is _____.	01
	1.3	Define bit in classical computing.	01
	1.4	Write an expression for the rate of stimulated absorption in a Laser.	01
	1.5	The free electron density of aluminum is $18.1 \times 10^{28} m^{-3}$. Calculate the Fermi Energy at $0K$.	02
	1.6	Mention any two properties of wave function.	02
	1.7	An electron moves with a speed of 4.70×10^{6}m/s. What is its de Broglie wavelength?	02

PART B

2	a	For a particle in a one dimensional potential well of infinite depth, solve time independent Schrodinger wave equation and obtain an expression for the normalized wave function. Hence write the normalized wave function for the lowest 3 energy eigen states.	10
	b	The first excited state wave function of a particle in an infinite well is $\psi = Bsin(10^9 \pi x)$ Calculate B. An electron is confined to move between two rigid wall separated by $20A°$.Find the de Broglie wavelength and the corresponding energy eigen values for the first two allowed energy states.	04
3	a	Prove that Pauli matrices σ_x, $\sigma_y$and σ_z are unitary matrices.	06
	b	Elucidate the difference between classical and quantum computing. Consider $\|\Psi\rangle$ and $\|\phi\rangle$ are the two wavefunctions. Prove that $\langle\Psi\|\phi\rangle = \langle\phi\|\Psi\rangle^*$	08
		OR	
4	a	With a neat labeled diagram, prove that a single photon simultaneously travels through both the paths at the same time and does not choose any one of the paths in a random way.	10
	b	Discuss $CNOT$ gate and its operation on four different input states.	04

5	a	With a neat labeled block diagram, explain point to point communication system using optical fibers. Explain the role of repeater.	06
	b	Distinguish spontaneous and stimulated emission and identify which plays a role in the operation of laser. Two levels of an atomic system at thermal equilibrium has energy difference of $1.8eV$. If the system is at temperature $300K$ determine the ratio of population of these two energy levels.	08
		OR	
6	a	With energy band diagram, explain construction and working of semiconductor diode laser.	07
	b	Explain Graded index multimode fiber with a neat sketch of ray propagation and refractive index profile diagram. A laser operating at temperature of $300K$ and wavelength of 680nm is at thermal equilibrium. Determine the ratio of Einstein coefficients.	07
7	a	What is Fermi factor in metals? Discuss the temperature dependence of Fermi factor in metals at $T = 0K$ and $T > 0K$	04
	b	Draw energy band diagram for the n-type semiconductor, and explain the effect of doping concentration on the band gap. At what temperature, can we expect an 8% probability of occupancy by electrons in an energy level which is 2% above the Fermi level? Given $E_F = 7eV$.	10
		OR	
8	a	What is Hall Effect? With a neat diagram, explain the Hall effect setup and arrive at the expression for Hall coefficient of an n-type semiconductor.	06
	b	Elucidate the difference between classical and quantum free electron theory An intrinsic semiconductor has an energy gap of $0.4eV$. Calculate the ratio of probability of occupation of the lowest level in the conduction band at $300K$.	08
9	a	Explain DC and AC Josephson effect with relevant diagram. With graph, explain the dependence of resistivity on temperature of a superconductor with that of a normal conductor.	10
	b	The transition temperature for Pb is $7.2K$. However, at $5K$ it loses the superconducting property if subjected to magnetic field of 3.3×10^4A/m. Find the maximum value of H which will allow the metal to retain its superconductivity at $0\ K$.	04
		OR	
10	a	Classify superconductors based on the penetration of the magnetic field into the superconductor with the help of $M - H$ graphs.	06
	b	Discuss the principle and working of $DC\ SQUID$. Mention its applications. The critical magnetic field at $5K$ is $2x10^3$A/m in a superconductor ring of radius $0.02m$. Find the value of critical current.	08
11	a	Write the condition for diffraction of light to be observed. Write the experimental procedure to determine the tan θ and wavelength of given Laser beam using a diffraction grating. From the data given below determine the tan θ and wavelength of Laser beam.	

Diffraction order	1	2	3	4	5	6
Distance 2Xn (cm)	2	4.1	6.1	8	10.2	12.3

Distance between the grating & screen $d = 72\ cm$
Grating constant = $5.08 \times 10^{-5}\ m$

	b	With experimental circuit diagram and model graphs, explain the procedure to draw the input and output characteristics of an npn transistor in common emitter mode. Write the expression for current gain in CE mode.	10