[567] SEAT No._____ No. of Printed Pages : 03

SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

M. Sc. (Physics) 1st Semester Examination

Monday, 10th April, 2017

Time: 10:00 am to 01:00 pm

Subject: PS01CPHY01 [Mathematical Physics & Computer Programming]

Total Marks: 70

Note: (1) Figures to the right indicate marks.
(2) Symbols have their traditional meaning.

Q:1 **Attempt all of the following Multiple choice type questions. [01 mark each]** [08]

(1) Two vectors $\vec{a}_1$ and $\vec{a}_2$ are defined as linearly dependent if two numbers x_1 and x_2 can be found such that

(a) $x_1 \neq 0 \;\; x_2 \neq 0$ (c) $x_1 = 0 \;\; x_2 \neq 0$

(b) $x_1 = 0 \;\; x_2 = 0$ (d) $x_1 \neq 0 \;\; x_2 = 0$

(2) Eigen values of a Hermitian operator are

(a) complex (c) real

(b) zero (d) imaginary

(3) In the Laurent expansion of $f(z)$ about z_0 $f(z) = \sum_{n=-\infty}^{\infty} a_n (z - z_0)^n$, if the summation continues to $n = -\infty$, then z_0 is called a

(a) essential singularity (c) pole of order infinity

(b) simple pole (d) isolated singularity

(4) The sum of a complex number and its conjugate is

(a) complex (c) real

(b) zero (d) imaginary

(5) If the correspondence between elements of two groups preserves group multiplication then the two group are

(a) commutative (c) isomorphic

(b) abelian (d) homomorphic

(6) $\{\delta(t)\} = 1$ is also called

(a) impulse function. (c) eigen function.

(b) Laplacian function. (d) Heaviside function

(7) Which of the following is not a valid real constant

(a) 1.0 (c) -0.00187

(b) 43,20.33 (d) 39.00

(8) Which is the correct precedence of arithmetic operators

(a) Unary - ; ** ; *,/ ; +,-
(b) Unary - ; ** ; +,- ; *,/
(c) Unary - ; *,/ ; +,- ; **
(d) ** ; *,/ ; +,- ; Unary -

Q:2 **Answer any 7 of the following 9 questions briefly. [02 marks each]** [14]

1 Define (i) eigen value (ii) projection operator
2 Explain outer product and contraction of tensors.
3 Define complex number and give its geometrical representation.
4 Define an analytic function. Is z^2 analytic?
5 Write Cauchy-Riemann conditions.
6 What are linearly independent vectors and unitary operators?
7 Draw figure and write the expression which explains RLC analogy.
8 Explain FORMAT specifications.
9 Explain input output statements.

Q:3 (a) (i) Define symmetric and anti-symmetric tensors. [6]
(ii) State and prove Quotient law.

(b) Define Hermitian operator and prove that its Eigen values are real quantities. Explain projection operator. [6]

OR

(b) Prove that $\begin{pmatrix} -xy & x^2 \\ y^2 & xy \end{pmatrix}$ is a tensor. [6]

Q:4 (a) Explain mapping using suitable examples. [6]

(b) Show that $\int_0^{2\pi} \frac{d\theta}{(a+b\cdot\sin\theta)} = \frac{2\pi}{(a^2-b^2)^{1/2}}$; a>b . [6]

OR

(b) Obtain Green's function for $\frac{d^2y}{dx^2} + \omega^2 y = 0$, where $f(x)$ is known function and $y(0) = 0$ and $y(L) = 0$. [6]

Q:5 (a) Discuss how Fourier transform can be used to resolve a finite pulse into sinusoidal waves. [6]

(b) Discuss how a damped harmonic oscillator can be studied with the help of Laplace transform. [6]

OR

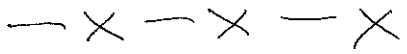
(b) Write a note on Group, its representation and character. Giving an illustration discuss the group multiplication table. [6]

Q:6 (a) Write a short note on DO loops in FORTRAN 77. Write a program to compute the sum of integers 0 to 20 making use of DO loops. [6]

(b) With the help of a suitable example explain the IF-ELSEIF construct. [6]

OR

(b) Write a detailed note on subroutines. [6]



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[411]

SARDAR PATEL UNIVERSITY

M. Sc. (Physics) I[st] Semester Examination

Day and Date: Saturday, 15[th] April, 2017

Time: 10.00 am to 1.00 pm

Subject: Atomic, Molecular and Laser Physics

Paper No: PS01CPHY03

Total Marks: 70

Note: All questions are compulsory.

Q.1 Multiple choice Questions. (8)

(1) The ratio of Einstein coefficients A and B for laser is proportional to _____.
(a) υ (b) υ^2 (c) υ^3 (d) υ^4

(2) A three level system of atoms has N_1 atoms in level E_1, N_2 in level E_2 and N_3 in level E_3, ($N_2 > N_1 > N_3$ and $E_1 < E_2 < E_3$). The laser emission is possible between levels _____.
(a) $E_3 \rightarrow E_1$ (b) $E_2 \rightarrow E_1$ (c) $E_3 \rightarrow E_2$ (d) $E_2 \rightarrow E_3$

(3) In He:Ne laser, the most favorable ratio of helium to neon for laser action is _____.
(a) 1:5 (b) 5:1 (c) 10:1 (d) 1:10

(4) Raman effect is due to collision of _____.
(a) photon – electron (b) photon – molecule
(c) electron – atom (d) Electron – photon

(5) The energy difference between various vibrational levels corresponds to the _____ region of the electromagnetic spectrum.
(a) infrared (b) visible (c) ultraviolet (d) far infrared

(6) With usual notation, for two electron system, $S_z\chi_1(1,2)$ = _____.
(a) $\chi_1(1,2)$ (b) $\chi_2(1,2)$ (c) $\chi_+(1,2)$ (d) $\chi_-(1,2)$

(7) Life time for cavity photon in a given lasing system depends on _____.
(a) internal absorption (b) leakage through window (mirror-2)
(c) scattering (d) all of the above

(8) For three level laser system, _____gives necessary mathematical condition for population inversion between level 1 and 2.
(a) $T_{32} = T_{21}$ (b) $T_{32} > T_{21}$ (c) $T_{32} < T_{21}$ (d) $T_{32} > T_{31}$

Q.2 Short questions (Attempt any seven) (14)

(1) Explain "The two level system is not suitable for optical pumping".
(2) Why is it difficult to make X-ray laser?
(3) Explain three fundamental modes of vibration in CO_2.
(4) Explain coherent antistokes Raman scattering with diagram.
(5) Draw and explain the graph for effective potential for hydrogenic-atom.

(6) What is the reason for *fine structure* of energy levels of H-atom?

(7) Prove that the function $\chi_+(1,2) = \frac{1}{\sqrt{2}}[\chi_2(1,2) + \chi_3(1,2)]$ of two-electron system is symmetric under the exchange of electrons 1 and 2.

(8) Write two limitations of Thomas-Fermi model for many-electron atom.

(9) Give a difference between stokes lines and antistokes lines in Raman scattering.

Q.3 (a) What is Lamb shift? Discuss in detail the Lamb shift experiment. (6)

(b) Starting with $\left[\frac{d^2}{d\rho^2} - \frac{l(l+1)}{\rho^2} + \frac{\lambda}{\rho} - \frac{1}{4}\right] u_{E,l}(\rho) = 0$, derive expression for discrete energy eigen values (E_n)for bound state ($E < 0$) of H-atom. Here $\rho = \left(-\frac{8\mu E}{\hbar^2}\right)^{-\frac{1}{2}} r$ and $\lambda = \frac{Ze^2}{4\pi\epsilon_0\hbar}\left(-\frac{\mu}{2E}\right)^{-\frac{1}{2}}$. (6)

OR

(b) Name different contributions to total Hamiltonian. Give expression for total or corrected energy. Draw and discuss in detail *fine structure* energy level diagram for H-atom. (6)

Q.4 (a) What is Born-Oppenheimer approximation? Based on this approximation, derive an expression for total energy for diatomic molecule. What is the advantage of using Morse potential? Draw its schematic diagram. (6)

(b) Give detailed note on LCAO method considering an example of H_2^+ ion. (6)

OR

(b) Write assumptions involved in Thomas–Fermi theory for many-electron atoms, and derive $\frac{d^2\chi(x)}{dx^2(x)} - \frac{1}{\sqrt{x}}[\chi(x)]^{\frac{3}{2}} = 0$. (6)

Q.5 (a) Explain the Einstein's coefficient for two level system. Derive ratio of Einstein's coefficients. (6)

(b) Obtain rate equation for three level system. (6)

OR

(b) Discuss variation of laser power around threshold condition. (6)

Q.6 (a) What is laser? Discuss in detail the semiconductor laser. (6)

(b) Write acronym of MASER. Describe NH_3 maser in detail. (6)

OR

(b) Define hyper Raman effect and derive its second order induced electric dipole moment using classical treatment. (6)

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