b) Show that the character of a matrix remains invariant under similarity transformation.

2+(2+2)+2 **(CO5)**

Or

10. a) In which point group symmetry a water molecule belongs? Establish its character table from the consequences of the "Great Orthogonality Theorem".

b) For H_2O molecule, how the transformation properties for the translational vector (**x**), rotational vector ($\mathbf{R_y}$) and the quadratic component $\mathbf{z^2}$ change with respect to all its symmetry elements?

2+3+3 **(CO5)**

M. Sc. Physics Examination, 2023

(2nd Year, 2nd Semester)

Atomic, Molecular and Optical Physics (II)

Paper – 408

Time : 2 hours   Full Marks : 40

Answer *all* questions.

1. a) How the Franck-Condon principle helps us in explaining the intensity of vibrational electronic spectral lines?

b) Deduce the expression for the difference of *Band head and Band origin* in connection with Fortrat parabolae.

c) What useful information do we get by studying the Fortrat diagram?   4+3+1 **(CO1)**

Or

2. a) How the molecular orbitals differ from atomic orbitals? What is LCAO approximation?

b) Using molecular orbital theory, obtain the expression of energies of the bonding and the antibonding orbitals of H_2^+ molecule in terms of Coulomb, Exchange and Overlap integrals.

2+1+5 **(CO1)**

3. a) Discuss briefly the selection rules governing the electronic transitions.

[Turn over

b) How a Deslandres table is constructed? Why is it so useful to us?

c) Discuss the v' progression with necessary diagram. What is sequence?　　　　　2+3+3 **(CO2)**

Or

4. a) What are the important features of the potential function that represents an electronic state?

b) In the rotational fine structure of electronic vibration spectra, in certain molecules the band head appears at the violet side of the spectrum and in some molecules it appears at the red side – Explain.

c) Discuss the selection rules for the rotational fine structure of electronic transitions.　2+4+2 **(CO2)**

5. a) What is a hologram?

b) Discuss with necessary ray diagram how we record a hologram.

c) Why holography did not become popular before the advent of laser?　　　　　1+5+2 **(CO3)**

Or

6. a) Discuss the *gain*-guided and *index*-guided laser heterostructures with necessary diagrams.

b) Explain how lasing action takes place in neodymium lasers with the help of appropriate energy level diagram.　　　　　4+4 **(CO3)**

7. a) What is "Raman effect"? Explain the quantum theory behind "Raman effect". Why Stokes lines are more intense than anti-Stokes lines in the Raman spectrum?

b) The exciting line in an experiment is 5460 Å and the Stokes line is at 5520 Å. Find the wavelength of the anti-Stokes line.　　　　　2+3+1+2 **(CO4)**

Or

8. a) Explain in brief how the rotational motion of a molecule can give rise to Raman spectrum. Hence establish the selection rule for rotational Raman spectrum $\Delta J = 0, \pm 2$. (Here J represents rotational energy level)

b) Why rotational fine structures are only seen in the vibrational Raman spectrum of light diatomic molecules? Explain the occurrences of "O" and "S" branches in such Raman spectrum.

　　　　　2+3+1+2 **(CO4)**

9. a) What are reducible and irreducible representations in context of molecular group theory? Hence prove the following through logical reasonings: (i) Number of irreducible representations is equal to the number of classes in a group (ii) The sum of the squares of the dimensions (l^2) of the irreducible representation is equal to the order (h) of the group.