

- (c) What are stokes and anti-stokes lines? 3
8. (a) Explain Franck-Condon principle? 7
- (b) Discuss rotational fine structure of electronic vibrational transitions. What is fortrat diagram? 7

UNIT - V

9. (a) Explain the following terms : 2x3=6  
 (i) Stimulated absorption  
 (ii) Spontaneous emission  
 (iii) Population inversion
- (b) Discuss the principle and working of He - Ne laser with the help of a diagram. 6
- (c) Name some properties, which make laser light different from ordinary light. 2
10. (a) Derive the relationship between various Einstein's co-efficients. What are the necessary conditions for the laser action to take place? 7
- (b) Differentiate between three level and four level lasers. 4
- (c) Why population inversion is not possible in 2 level system? 3

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**PG (NEP) EVEN SEMESTER EXAMINATION, 2023****PHYSICS**2<sup>nd</sup> Semester

Course No. : PHY - 553

**( Atomic, Molecular and Laser Physics )**

Full Marks : 70

Pass Marks : 28

Time : 3 hours

*The figures in the margin indicate full marks for the questions  
 (Answer five questions, taking one from each unit)*

UNIT - I

1. (a) Deduce the expression for relativistic correction in H-atom. Why was this correction necessary in Sommerfeld's elliptic atom model to explain the fine structure? 8+2=10
- (b) If the doublet splitting of the first excited state.,  $2^2P_{3/2} - 2^2P_{1/2}$  of He<sup>+</sup> is 5.84 cm<sup>-1</sup>, calculate the corresponding separation of H. 4
2. (a) What is L-S coupling? Deduce various interaction energy terms for L-S coupling. 3+5=8

( Turn Over )

(2)

- (b) The quantum numbers of two electrons in a two valence electron atoms are

$$n_1 = 6, l_1 = 3, s_1 = 1/2$$

$$n_2 = 5, l_2 = 1, s_2 = 1/2$$

- (i) Assuming L-S coupling, find the possible values of L and hence of J.

- (ii) Assuming J-J coupling, find the possible values of J. 3+3=6

### UNIT - II

3. What is Lande g-factor? Derive an expression for Lande's splitting g-factor and explain with its help the Zeeman effect of the sodium doublet components  $D_1$  and  $D_2$ . 2+7+5=14

4. (a) What is Stark effect? Discuss the weak-field Stark effect in hydrogen? 2+6=8

- (b) What is meant by hyperfine structure of spectral lines? How could it be explained on the basis of nuclear spin? 2+4=6

### UNIT - III

5. (a) Considering the molecule as a rigid rotator, discuss the rotational spectra of a diatomic molecule. 9

(3)

- (b) Calculate the rotational energy of  $^{14}_N^{16}O$  corresponding to  $J = 1$  level in joule and  $cm^{-1}$  assuming to be a rigid rotator. The atomic masses of  $^{14}N$  and  $^{16}O$  are 14.004 amu and 15.9994 amu respectively and the band length is 115  $\mu m$ . 5

6. (a) What is Born-Oppenheimer approximation? 4

- (b) Discuss how the study of vibrational spectrum of a diatomic molecule enables us to determine anharmonicity and equilibrium frequency of vibration. 7

- (c) The force constant of CO is  $1840 Nm^{-1}$ . Calculate oscillation frequency and wave number in  $cm^{-1}$ . (Atomic mass of C is 12 amu and O is 15.994 amu). 3

### UNIT - IV

7. (a) Consider  $H_2$ ,  $N_2$ , HCl and OH molecules. State giving reasons, which one of these will show infra-red spectrum and which one will give Raman spectrum. 4

- (b) Discuss origin of Raman effect. Obtain expression for frequency shift of rotational Raman lines. 7

( Turn Over )