

M.Sc. PHYSICS  
SECOND SEMESTER  
ATOMIC, MOLECULAR & LASER PHYSICS  
MSP – 204 [REPEAT] [OLD COURSE]  
[USE OMR FOR OBJECTIVE PART]

2023/06

SET  
**A**

Duration : 3 hrs.

Full Marks : 70

Time : 30 min.

Marks : 20

[Objective]

$$1 \times 20 = 20$$

Choose the correct answer from the following:

1. During amplification of beam, .....  
a. stimulated emission must predominate over spontaneous emission.  
b. spontaneous emission must predominate over stimulated emission.  
c. stimulated emission does not occur.  
d. spontaneous emission does not occur.
2. The concentration of energy in a laser beam, both spatially and ----- accounts for great intensity of lasers.  
a. temporally  
b. distinctly  
c. spectrally  
d. directly
3. The difference between the adjacent frequencies in a resonator is always  
a. constant  
b. variable  
c. 1  
d.  $2\pi\lambda$
4. The major drawback of conventional holographic process is the requirement of coherent ----- in the image reconstruction.  
a. absorption  
b. distribution  
c. variation  
d. illumination
5. For a typical laser, the beam divergence is ----- 0.01 milliradian.  
a. equal to  
b. more than  
c. less than  
d. none of these
6. The real image obtained in holography is called ----- image.  
a. pseudoscopic  
b. inverted  
c. lateral  
d. all of the above
7. Power Density (PD), or light concentration is measured in -----  
a.  $\text{W/cm}$   
b.  $\text{W/cm}^2$   
c.  $\text{W/cm}^3$   
d. mW
8. Laser means Light Amplification by Stimulated Emission of Radiation and was first theorized by  
a. Maiman  
b. Ali Javan  
c. Hertz  
d. Einstein

9. The Stoke's rotational Raman lines in oxygen molecule ( $O_2$ ) are separated by a distance of -----.
- a. 8B
  - b. 12B
  - c. 6B
  - d. 4B
10. Band head occurs in the R branch of the rotational spectral line if-----.
- a.  $B' < B''$
  - b.  $B' > B''$
  - c.  $B' = B''$
  - d.  $B' > B''$
11. The intensity distribution of vibrational bands in electronic transition of oxygen molecule ( $O_2$ ) is in accordance with -----.
- a.  $r'_e = r''_e$
  - b.  $r'_e > r''_e$
  - c.  $r'_e < r''_e$
  - d.  $r'_e \ll r''_e$
12. The selection rule for P & R branches of rotational spectral lines are respectively
- a.  $\Delta J = +1 \& -1$
  - b.  $\Delta J = -1 \& +1$
  - c.  $\Delta J = 0 \& -1$
  - d.  $\Delta J = 0 \& +1$
13. The vibrational Raman spectrum of homo nuclear diatomic molecule under harmonic approximation obey the selection rule
- a.  $\Delta v = \pm 2 \text{ only}$
  - b.  $\Delta v = \pm 1 \text{ only}$
  - c.  $\Delta v = 0, \pm 1$
  - d.  $\Delta v = \pm 1 \& \pm 2$
14. Assuming that L-S coupling is valid, the number of permitted transition from  $2_{P_{1/2}}$  to  $2_{S_{1/2}}$  state in a weak magnetic field is
- a. 6
  - b. 4
  - c. 3
  - d. 2
15. According to Bohr's atom model the ionization potential of  $Li^{2+}$  ion is
- a. 13.6 eV
  - b. 40.8 eV
  - c. 122.4 eV
  - d. 27.2 eV
16. The diatomic molecule AB has the energy of rotational transition from  $J = 0$  to  $J = 1$  is  $3.9 \text{ cm}^{-1}$ . The energy of transition from  $J = 3$  to  $J = 4$  is
- a.  $3.9 \text{ cm}^{-1}$
  - b.  $7.8 \text{ cm}^{-1}$
  - c.  $15.6 \text{ cm}^{-1}$
  - d.  $11.7 \text{ cm}^{-1}$
17. The ground state of Helium atom is
- a.  $3_{P_2}$
  - b.  $1_{P_1}$
  - c.  $3_{S_1}$
  - d.  $1_{S_0}$
18. The energy level which lie deepest is
- a.  $3_{P_1}$
  - b.  $3_{P_2}$
  - c.  $1_{P_1}$
  - d.  $3_{P_0}$

19. The ratio of the frequencies of first spectral line of Lyman series and that of Balmer series of Hydrogen atom is

a.	$\frac{4}{27}$	b.	$\frac{8}{27}$
c.	$\frac{27}{27}$	d.	$\frac{27}{5}$
	$\frac{8}{8}$		

20. The selection rules applicable to the transition in Helium atom is

a. $\Delta L = \pm 1, \Delta S = 0, \Delta J = \pm 1$	b. $\Delta J = \pm 1$
c. $\Delta L = \pm 1$	d. $\Delta S = 0$

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( descriptive )

Time: 2 hrs. 30 min.

Marks: 50

[Answer question no.1 & any four (4) from the rest]

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|--|--------------|
| 1. a. Derive the relationship between various Einstein's coefficients. Discuss the significance of Einstein's coefficients in context of Laser operations. | 5+5=10       |
| b. Draw the energy level diagram of Helium Neon laser. Explain the operation principle of He-Ne laser.   |              |
| 2. a. What is Holography? Differentiate between holography and photography.  | 4+6=10       |
| b. Give qualitative idea of formation and reconstruction of a hologram.  |              |
| 3. a. What is diffraction loss? How can it be minimized in an optical resonator?   | 3+7=10       |
| b. Explain the concept of population inversion. Show that population inversion is necessary condition of amplification.                                    |              |
| 4. a. What are different types of intensity distribution of vibrational bands in electronic transitions? Give example of each type.                        | 3+2+5<br>=10 |
| b. State and explain Franck-Condon principle to explain various intensity distributions of vibrational bands.  |              |

5. a. Write down the expression of interaction energy of an electron in a weak magnetic field. State the selection rule for transition in Zeeman levels. Show the Zeeman splitting of Sodium D<sub>1</sub> line. 2+2+3+  
3=10
- b. Calculate the Zeeman shift of a spectral line of wavelength 500 nm in a magnetic field of one (01) Tesla.
6. Give the Quantum theory of Raman effect. Why classical theory is not accepted for Raman spectroscopy? 3+1+4+  
2 =10
- b. Discuss the rotational Raman spectrum of oxygen molecule. Calculate the wavenumber of first Stokes line of 14<sub>N<sub>2</sub></sub> if the wavenumber of incident radiation is 20487 cm<sup>-1</sup>. (Rotational constant of 14<sub>N<sub>2</sub></sub> is 2 cm<sup>-1</sup>)
7. a. What do you mean by Orthohelium and Parahelium? Discuss important features of emission spectra of helium atom. 2+3+  
3+2=10
- b. Calculate the interaction energies in L-S coupling for a system of two electrons in sp configuration. Show the energy splitting in different states.
8. a. Write the expression of rotational energy os a non-rigid rotator. Calculate the value of rotational quantum number at which intensity of rotational spectral line is maximum. 2+3+1+  
3+1 =10
- b. Write the expression for the energy of a rotating vibrator. Calculate the frequencies of fundamental, first overtone and second overtone transition. What do you mean by hot band?

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