

M.Sc. PHYSICS  
THIRD SEMESTER  
LASER & NONLINEAR OPTICS-I  
MSP – 304D  
[USE OMR SHEET FOR OBJECTIVE PART]

SET  
A

Duration : 3 hrs.

Full Marks : 70

Time: 30 min.

( **Objective** )

Marks: 20

*Choose the correct answer from the following:*

1X20=20

- The photon output of lasers ranges over -----.  
a.  $10^{16}$  to  $10^{28}$     b.  $10^{20}$  to  $10^{28}$   
c.  $10^{22}$  to  $10^{28}$     d.  $10^{25}$  to  $10^{28}$
- In the original semiconductor lasers, the junction was formed by ----- of p-type impurity into a crystal of n-type.  
a. gaseous diffusion    b. ion diffusion  
c. both options (a)&(b)    d. none of these
- The laser action in  $Xe_2^+$  excimer laser is obtained in their transition to the ground state at  $\lambda$  nearly  
a. 178 nm    b. 175 nm  
c. 172 nm    d. none of these
- The excess energy of He is transformed to the kinetic energy of the ejected electron in a He-Cd laser, such an ionization is known as  
a. Electro spray ionization    b. Electron impact ionization  
c. Penning ionization    d. Matrix-assisted laser desorption ionization
- The probability of spontaneous transition is  $1/\tau_{sp}$  where,  $\tau_{sp}$  is the -----.  
a. Spontaneous absorption decay time    b. Spontaneous emission decay time  
c. Spontaneous absorption de- excitation time    d. Spontaneous emission de- excitation time
- has the arrangement of two distributed Bragg reflectors.  
a. A Semiconductor injection laser    b. An Excimer laser  
c. A Vertical- cavity surface-emitting laser    d. An Argon-ion laser
- The wavelength corresponding to 488.1 nm and 514.5 nm in an Argon-ion laser has the following characteristics.  
a. shortest wavelength CW output    b. longest wavelength CW output  
c. most intense    d. all of these
- The pulse width in case of Q-switching is about -----.  
a. 6  $\mu$ m    b. 6 ns  
c. 6 ps    d. 6 nm

9. There are possible ways by which the  $4p$  level in an  $\text{Ar}^+$  laser can be populated. Among the following options, choose the correct options.
- |   |   |
|---|---|
| a. Collision with ions in metastable states                   | b. Radiative cascade from higher states |
| c. Electron collision with $\text{Ar}^+$ ions in ground state | d. all of the above                     |
10. Which of the following lasers is referred to as *Superradiant lasers*?
- |   |                        |
|---|------------------------|
| a. Copper-vapour laser                    | b. $\text{CO}_2$ laser |
| c. Vertical-cavity surface-emitting laser | d. Excimer laser       |
11. The electric field strength of conventional light sources can go up to
- |                                  |                                  |
|----------------------------------|----------------------------------|
| a. $E \sim 10^3 \text{ V/cm}$    | b. $E \sim 10^7 \text{ V/cm}$    |
| c. $E \sim 10^{11} \text{ V/cm}$ | d. $E \sim 10^{15} \text{ V/cm}$ |
12. Linear refractive index of a medium relates to its linear susceptibility via
- |                          |                            |
|--------------------------|----------------------------|
| a. $n = 1 + \chi$        | b. $n^2 = 1 - \chi$        |
| c. $n = \sqrt{1 + \chi}$ | d. $n^2 = \sqrt{1 - \chi}$ |
13. In the first experiment on nonlinear optics, \_\_\_\_\_ was produced by the application of a Ruby laser.
- |                |                    |
|----------------|--------------------|
| a. an UV light | b. an X-ray        |
| c. an IR light | d. a $\gamma$ -ray |
14. In optical rectification (OR) process, a \_\_\_\_\_ produces across the nonlinear media. (Choose the correct option).
- |                           |                           |
|---------------------------|---------------------------|
| a. varying magnetic field | b. varying electric field |
| c. static magnetic field  | d. static electric field  |
15. In parametric generation process light energy is
- |              |                  |
|--------------|------------------|
| a. scattered | b. amplified     |
| c. reduced   | d. none of these |
16. Multi-photon photoelectric effect depends on
- |  |                            |
|--|----------------------------|
| a. Frequency of light only               | b. Intensity of light only |
| c. Both frequency and intensity of light | d. Phase of the waves      |
17. For efficient frequency doubling, the necessary phase matching condition is
- |                     |                     |
|---------------------|---------------------|
| a. $\Delta k_1 = 0$ | b. $\Delta k_2 = 0$ |
| c. $k_2 - 2k_1 = 0$ | d. $k_1 - 2k_2 = 0$ |
18. \_\_\_\_\_ process is analogous to second harmonic generation
- |                             |                                   |
|-----------------------------|-----------------------------------|
| a. Sum frequency generation | b. Different frequency generation |
| c. Optical rectification    | d. Third harmonic generation      |

19. Kerr-type nonlinear effect can be expressed by the following relation.

a.  $n = \frac{n_2}{n_0} I$

b.  $n = n_0 n_2 I$

c.  $n = (n_0 + n_2) I$

d.  $n = n_0 + n_2 I$

20. Stokes lines in Raman spectra are found at \_\_\_\_\_ frequencies than the pump frequency.

a. lower

b. higher

c. same

d. all of these

-----

( Descriptive )

Time : 2 hrs. 30mins.

Marks : 50

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

1. a. Discuss second-harmonic generation with energy level diagram. 3+2+5  
=10  
b. Give an application of the second-harmonic generation process.  
c. Explain briefly why second-harmonic generation do not occur in isotropic nonlinear media.
  
2. Discuss the sum frequency generation (SFG) and different frequency generation (DFG) processes. Give applications of the SFG and DFG process. 5+5=10
  
3. Explain self-focusing of light and derive the relation how nonlinear refractive index of a medium is related to intensity of light. 2+8=10
  
4. a. What do you understand by multi-photon process? Show that under multi-photon photoelectric effect, the threshold frequency lowers by a factor of number of photons. 1+4+2+3  
=10  
b. Discuss briefly the three-photon process. Establish the 'wave synchronism' condition in terms of refractive indices  $n$ , for efficient transfer of light in second harmonic generation (SHG).
  
5. a. What is the difference between Q-switching pulsed generation of lasers and mode locking? 6+4=10  
b. Deduce the relation of variation of photon number ' $n$ ' and population inversion  $\Delta N$  in the cavity as a function of time.
  
6. a. What are the four basic modes of a laser resonator? 2+6+2=  
10  
b. With the help of energy-level diagram of an Argon-ion Laser, explain its working principle and operation.  
c. What is the application of Argon-ion Laser?

7. Write short notes on the following.

10

- a. *Penning ionization*
- b. *Vertical-cavity surface-emitting laser*
- c. *Excimer laser*
- d. *Self-terminating laser pulse*

8. a. Write the rate-equations of a four-level laser system.

5+5=10

b. Write about the working principle of Nd:YAG laser. Draw its energy-level diagram.

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