4.15 Various Levels of Laser Systems

Q.25 Explain different levels of laser systems.

Ans. : a) Three level laser system : In these systems three energy levels are involved in the laser action. The atoms are pumped from the ground state E_1 to E_3. Out of the two transitions from E_3 to E_2 and from E_2 to E_1, one is a non-radiative spontaneous transition and the other is the lasing transition as shown in Fig. Q.24.1 (a) and (b). The Ruby laser is an example of three level laser system.

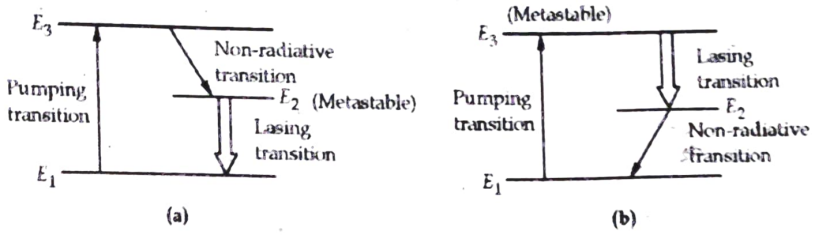

Fig. Q.24.1

b) Four level laser systems : Pumping transition takes the atoms from E_1 to E_4 from where there is a spontaneous transition to E_3. The lasing transition is from E_3 to E_2 which is then followed by another spontaneous transition to E_1 as shown in Fig. Q.24.2. Nd-YAG laser is an example of the four level laser system.

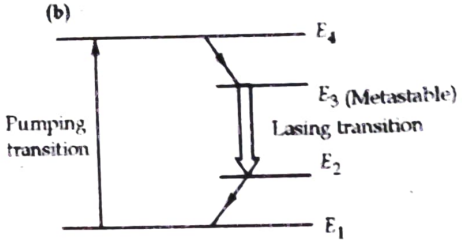

Fig. Q.24.2

4.16 CO_2 Laser (Carbon Dioxide Laser)

Q.26 What is laser? Give the construction and working of carbon dioxide laser device. **[VTU : Jan-15, Marks 10]**

Ans. : • The carbon dioxide laser makes use of transitions in the molecular vibrational and rotational energy levels. In addition to the electronic energy levels in atoms, the molecules possess vibrational and rotational energies which are quantized. The CO_2 molecule has three modes of vibration as shown in Fig. Q.26.1 (a) and a number of modes of rotation for each mode of vibration as shown in Fig. Q.26.1 (b).

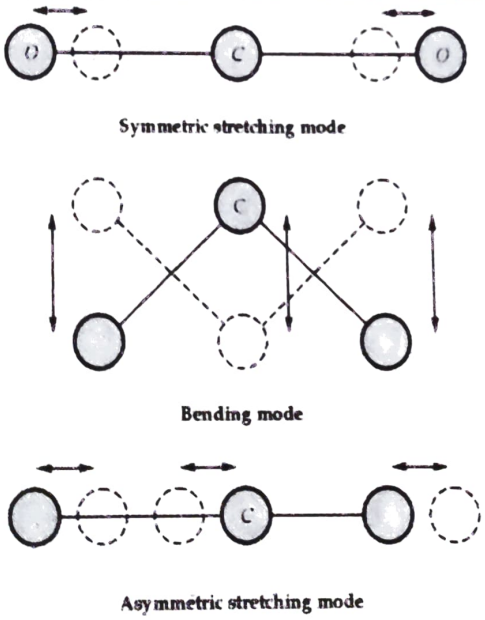

Fig. Q.26.1

- In symmetric stretching mode, the two oxygen atoms either simultaneously move towards or away from the carbon atom. In asymmetric stretching mode one of the oxygen atom moves towards and the other away from the carbon atom. In the bending mode, the three atoms vibrate perpendicular to the axis of the molecule in such a way that the carbon atom moves in opposite direction to the oxygen atom which move in same direction at any instant of time.
- The difference in energies between these molecular levels is small compared to the atomic energy levels. Hence radition emitted by transition in molecular energy levels lies in far infra red region of the spectrum.
- **Construction :** A mixture of CO_2, He and N_2 is circulated in a glass tube which has two electrodes connected to a power supply as shown in Fig. Q.26.2. One end of the tube has a partially silvered mirror and the other end has a Brewster's window. A completely silvered mirror is kept beyond the Brewster's window.

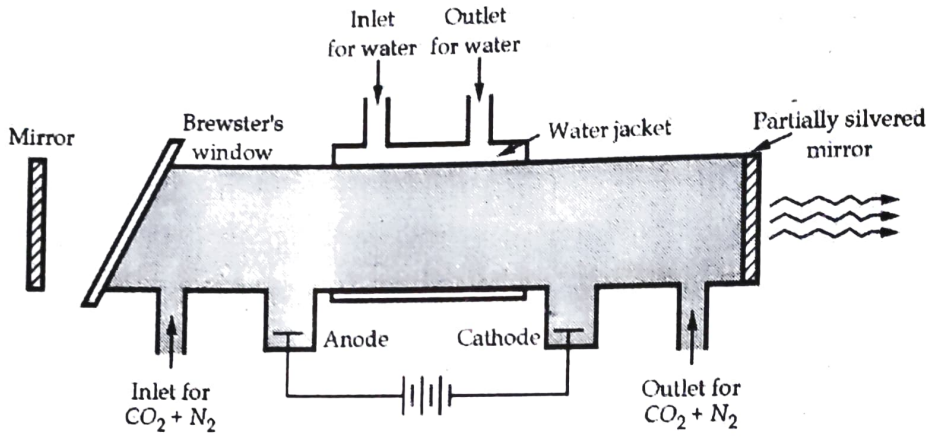

Fig. Q.26.2

- **Working :** The high voltage across the electrodes excites the gas molecules. The nitrogen molecules in the gas are excited to higher levels and transfer energy to CO_2 molecules by collisions as shown in Fig. Q.26.3. The CO_2 molecules are excited to the metastable state E_5 where population inversion takes place with respect to the two lower lasing levels E_3 and E_4. Transition from E_5 to E_4 gives rise to 10.6 μm wavelength laser and the transition from E_5 to E_3 gives rise to 9.6 μm wavelength which are both in the far infra red region. Helium depopulates the lower energy levels in CO_2 which facilitates population inversion.

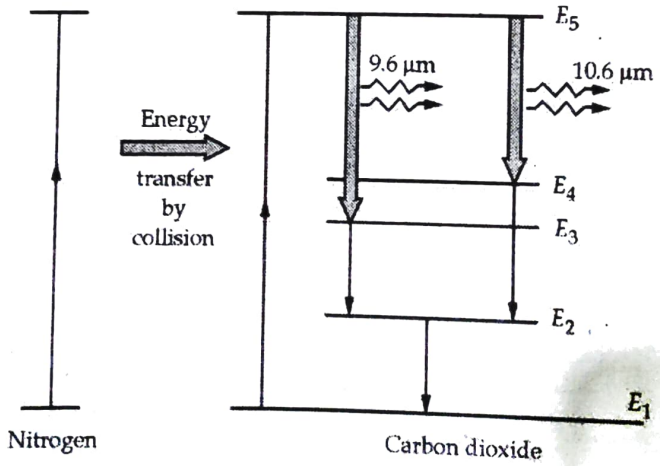

Fig. Q.26.3

- The carbon dioxide laser is a high power laser producing power as high as 10 kW. It also has very high efficiency of the order of about 40 %.