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WK 13 • 084-281

NAME : Rahul Sharma
BATCH : F6
ENO : 9919103173

PHYSICS - 02
(ASSINGNMENT - 03)

1. i) Spontaneous emission : It is the process in which a quantum mechanical system transits from an excited state to lower energy state & emits quantized amount of energy in the form of photon.

ii) Stimulated emission : It is the process by which an incoming photon of a specific ν can interact with an excited atomic e, causing it to drop to a lower energy level.

iii) Metastable state : It's a particular excited state of an atom, nucleus or other system that has a longer life time than the ordinary excited state & that generally has a shorter lifetime than the lowest often stable energy state, called ground state.

iv) Population inversion: It is the redistribution of atomic energy levels that take place in a system so that laser action can occur. Normally, a system of atoms is in temp. equilibrium & there are always more atoms in low energy states than in higher ones.

v) Optical pumping: It is the process in which light is used to raise $\bar{e}_s$ from lower energy level in atom or molecule to higher one.

2. Energy of each photon:

$$E = nh\nu$$
$$\Rightarrow n = \frac{E}{h\nu} = \frac{E\lambda}{hc}$$

Putting the values, we get,

$$n = \frac{1 \times 699 \times 10^{-9}\ m}{6.62 \times 10^{-34} \times 3 \times 10^{8}} = 3.5 \times 10^{18} \text{ ions.}$$

Energy of the laser = Total no. of ions (n) × Energy of each photon

$$E = nh\nu = \frac{nhc}{\lambda} = 2.8 \times 10^{19} \times \frac{6.62 \times 10^{-34} \times 3 \times 10^{8}}{7 \times 10^{-7}}$$

$$\boxed{E = 7.99\ J}$$

3. Ratio of population

$$\frac{N_2}{N_1} = e^{-(E_2-E_1)/KT}, \quad E_2 - E_1 = \frac{hc}{\lambda} = 1.96\ eV$$

So, $\frac{N_2}{N_1} = e^{-1.96/8.61\times10^{-5}\times300}$

$= e^{-75.85} = 1.1\times10^{-33}$

4. Ratio of spontaneous to stimulated emission:

$$R = \left[e^{h\nu/KT} - 1\right] = \left[e^{hc/\lambda KT} - 1\right]$$

at given conditions $T = 50K$, $\lambda = 10^{-5}\ m$

$R = e^{28.78} - 1$

$R = 3.16\times10^{12}$

5. Efficiency of laser $= 1\% = 0.01$

$$n = \frac{P_{out}}{P_{in}}$$

So, $P_{in} = \frac{P_{out}}{n_{efficiency}} = 1\ W = 1\ J/sec.$

No. of atoms excited in 1 sec. $= \frac{1J}{20eV} = \frac{1J}{20\times1.6\times10^{-14}J} = 3.12\times10^{17}\ Am$

6. i) $\lambda = 5890\,\text{Å}$

So, $\nu = \frac{c}{\lambda} = 5.09 \times 10^{19}$ Hz

ii) No. of oscillations $n = \frac{l_c}{\lambda} = \frac{2.945 \times 10^{-2}}{5.89 \times 10^{-7}} = 5 \times 10^4$

iii) Conesive time $t_c = \frac{l_c}{c} = \frac{2.945 \times 10^{-2}}{3 \times 10^8} = 9.82 \times 10^{-11}$ sec. Am

7. Relative population : $\frac{N_2}{N_1} = e^{-(E_2 - E_1)/KT}$

$$E_2 - E_1 = \frac{hc}{\lambda} = 1.77\,eV$$

At 27°C, i.e, 300 K,

$$\left(\frac{N_2}{N_1}\right)_{300K} = e^{-68.5}$$

At 227°C, i.e, 500 K,

$$\left(\frac{N_2}{N_1}\right)_{500K} = e^{-41.1}$$

SO_2 ratio $= \frac{(N_2/N_1)_{300K}}{(N_2/N_1)_{500K}} = 1.25 \times 10^{-12}$ Am

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