- Calculate the wavelength of laser emitted from an extrinsic semiconductor laser, if the band gap is 0.02eV. To which region of EM spectrum does it belong?

**Given Data:**

$\Delta E$ = 0.02eV

$\lambda$ = ?

Sol: w k t $\lambda = \frac{h\,c}{\Delta E}$

$$\lambda = \frac{(6.625X10^{-34})\ X\ (3X10^{8})}{0.02}$$

$$\lambda = (6.21X10^{-5})\ \text{m}$$

$$\lambda = (0.621X10^{-6})\ \text{m} \quad \text{or}\ \lambda = 0.621\mu\text{m}$$

The wavelength of light emitted from this semiconductor laser is lies in the FARINFRARED region of EM spectrum.

- A pulsed laser emits photons of wavelength 780nm with 20mW average power /pulse. Calculate the number of photons contained in each pulse if the pulse duration is 10ns.

**Given Data:**

**Wavelength of light $\lambda$ = 780X10$^{-9}$ m**

**Power of each pulse P = 20 X 10$^{-3}$ J/s**

**Duration of each pulse t = 10 X 10$^{-9}$ s**

***No. of photons in each pulse* N = ?**

Sol: w k t $\Delta E = \frac{hc}{\lambda}$

$$\Delta E = \frac{(6.625X10^{-34})\ X\ (3X10^{8})}{780\ X\ 10^{-9}}$$

$$\Delta E = 2.548\ X\ 10^{-19}\ \text{J}$$

**Now , we have energy of each pulse,**

**E = Power X Duration of each pulse**

**E = P X t = 20 X 10$^{-3}$ X 10 X 10$^{-9}$**

**E = 2 X 10$^{-10}$ J**

**If N is the number of photons (each of energy $\Delta E$ ) in the pulse ,**

**Then,** E = N X $\Delta E$

$$N = \frac{E}{\Delta E} = \frac{2\ X\ 10^{-10}}{2.548\ X\ 10^{-19}} = 7.849\ X\ 10^{8}$$

**No. of photons in each pulse is 7.849 X 10$^{8}$**

- A laser operating at 632.8nm emits 3.182 x $10^{16}$ photons per second. Calculate the output power of the laser if the input power is 100 watt. Also find the percentage power converted into coherent light energy.

**Given Data:**

**Wavelength of light $\lambda$ = $632.8X10^{-9}$ m**

**No. of photons emitted n = $3.182X10^{16}$**

**I/P power $P_{in}$ = 100 W**

**% of power efficiency $P_E$ = ?**
**(Laser light energy)**

Sol: Energy of each photon

$$E = \frac{h\,c}{\lambda}$$

$$E = \frac{(6.625X10^{-34})\,X\,(3X10^{8})}{632.8X10^{-9}}$$

$$E = 3.140X10^{-19}\ \text{J}$$

**O/P Power = Energy emitted per second**

**O/P Power = [No. of photons emitted per second] X Energy of each photon**

**= n E = $3.182X10^{16}$ X $3.140X10^{-19}$**

**O/P Power = 0.009 W**

$$\text{\% of power efficiency } P_E = \frac{\textit{Output power in laser}}{\textit{Input power}} \text{ X } 100$$

$$= \frac{0.009}{100} \text{ X } 100$$

$$= 0.009$$

**% of power converted into light energy = 0.009**

- The average output power of laser source emitting a laser beam of wavelength 632.8 nm is 5mW. Find the number of photons emitted per second by the laser source .

- A lase beam with power per pulse is 1mW lasts 10ns, if the number of photons emitted per pulse is $3.941 X 10^{7}$, calculate the wavelength of laser.

**Sol**: Energy of each pulse,

$E = P X t = 1 X 10^{-3} X 10 X 10^{-9}$

$E = 10^{-11}$ J

Energy of each photon

$$\Delta E = \frac{h c}{\lambda} = \frac{(6.625 X 10^{-34}) X (3 X 10^{8})}{\lambda}$$

$$\Delta E = \frac{19.875 X 10^{-26}}{\lambda}$$

Let N be the no. of photons in the pulse,

Then $E = N X \Delta E \Rightarrow N = \frac{E}{\Delta E} = \frac{10^{-11}}{\frac{19.875 X 10^{-26}}{\lambda}} \Rightarrow \frac{10^{-11} X \lambda}{19.875 X 10^{-26}}$

$\lambda = 19.875 X 10^{-26} X 3.941 X 10^{7} X 10^{11}$

$\lambda$ = 783.2 nm

Given Data:

Power of each pulse $P = 1 X 10^{-3}$ W

Duration of each pulse $t = 10 X 10^{-9}$ s

*No. of photons in each pulse* $N = 3.941 X 10^{7}$

Wavelength of light $\lambda$ = ?

- Find the number of modes of the standing waves and their frequency of separation in a resonant cavity of length 1m of He-Ne laser operating at a wavelength 632.8nm.

<u>Sol</u>: For laser cavity

**Given Data:**

**Length of cavity L = 1 m**

**Wavelength of light $\lambda$ = $632.8 \text{ X } 10^{-9}$ m**

***No. of modes*** **N = ?**

**Frequency separation $\nu_n$ - $\nu_{n-1}$ = ?**

$$\lambda = \frac{2L}{n}$$

$$n = \frac{2L}{\lambda} = \frac{2 \text{ X } 1}{632.8 \text{ X } 10^{-9}}$$

$$n = 3.160 \text{ X } 10^{6}$$

Wkt $\lambda = \frac{C}{\nu} \Rightarrow \frac{C}{\nu} = \frac{2L}{n}$

$$\nu = \frac{nC}{2L} \Rightarrow \qquad \nu_n = \frac{nC}{2L} \qquad \nu_{n-1} = \frac{(n-1)C}{2L} \Rightarrow$$

$$\nu_n - \nu_{n-1} = \frac{C}{2L} = \frac{3 \text{.X } 10^{8}}{2 \text{ X } 1} = 1.5 \text{ X } 10^{8} \text{ Hz}$$