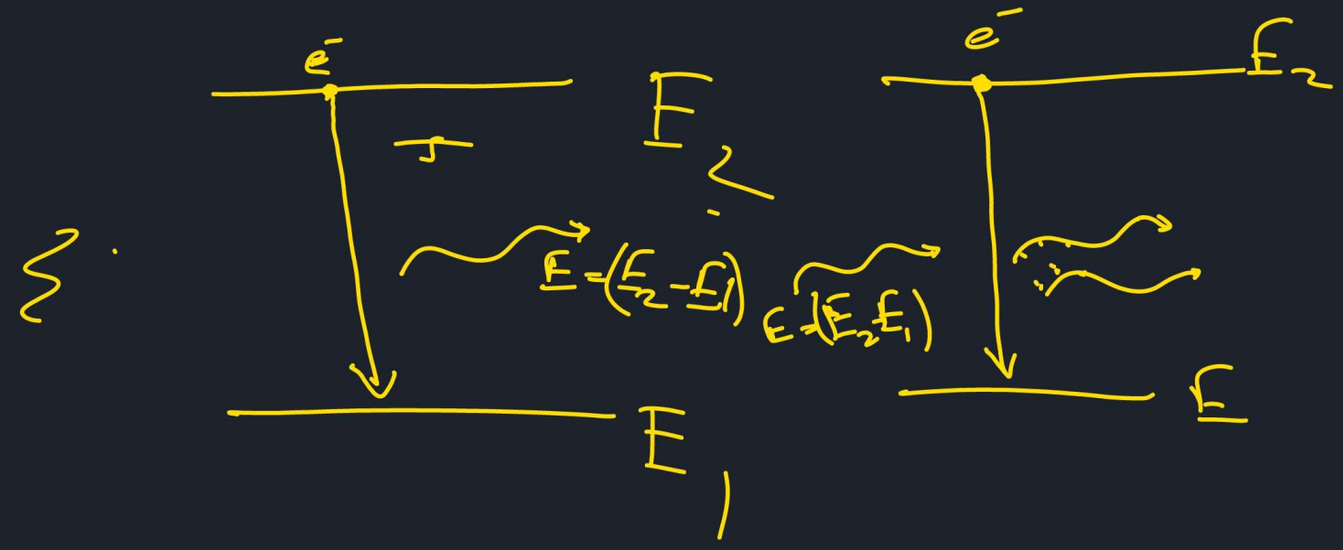
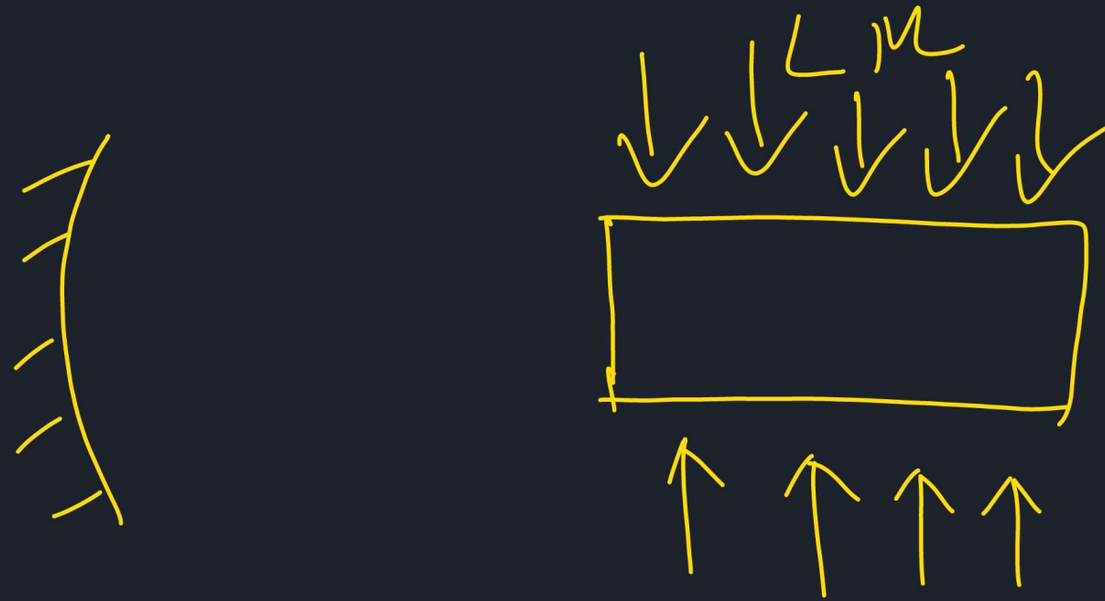
1) Absorption ✓

2) Stimulated emission
   ↙ coherent

3) Spontaneous emission
   ↙
   incoherent


e⁻
E₂
E = (E₂ − E₁)
E₁
e⁻
E₂
E
E = (E₂ E₁)



Mirror 1

Mirror 2

Lasing action

"Population inversion"

partially transmissive

Q)

Population E_1
N_1

Laser medium

atomic energy levels

Planck's law

$$\hbar = \frac{h}{2\pi}$$

$$h = 6.626 \times 10^{-34}\ J\,s$$

$$\omega_{21} = \frac{E_2 - E_1}{\hbar}$$

Energy

$1\ eV = 1.6 \times 10^{-19}\ J$

H.W. λ ?

$E_{ph} = 1.24\ eV$

Dual nature of light

① particle $\Rightarrow$ E_{ph} , $\vec{p}$

② Wave $\Rightarrow$ λ , $\vec{k}$

$|\vec{k}| = \frac{2\pi}{\lambda}$

wave vector

1138

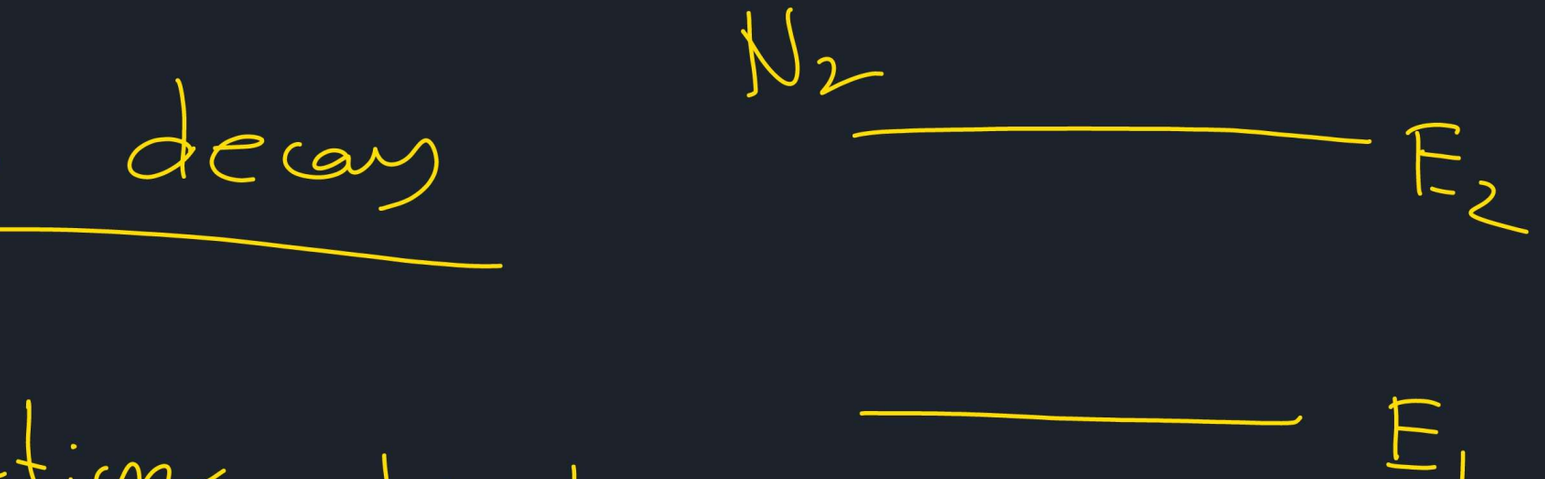
$$E_{ph} = \hbar\omega = h\frac{c}{\lambda}$$

$$\omega = 2\pi\frac{c}{\lambda}$$

$$\vec{p} = \vec{k}\hbar$$

$$|\vec{p}| = \frac{2\pi}{\lambda}\frac{h}{2\pi} = \frac{h}{\lambda}$$

Spontaneous decay



Rate equation

$$\left.\frac{dN_2}{dt}\right|_{Spon} = -\Gamma_2 N_2 \equiv -\frac{N_2}{\tau_2}$$

$$\tau_2 = \frac{1}{\Gamma_2}$$

$t=0 \quad N_{20}$

$N_2(t) =$

$$N_2(t) = N_{20}\, e^{-\frac{t}{\tau_2}}$$

$$\gamma_{tot} = \sum_i \gamma_i$$