THREE QUANTUM PROCES
(OR)
INTERACTION OF RADIATION (LIGHT) WITH MATTER

Introduction:

- In 1916, according to Einstein, when the radiation interacts with matter, results in the following 3-Quantum process:
    1. Stimulated Absorption / Induced Absorption
    2. Spontaneous Emission
    3. Stimulated Emission
- Emission or absorption takes place by the quantum of energy called photons.
- The energy of one photon is called quantum energy, i.e., $E = h\nu$

    where: $h \rightarrow$ Planck's constant & $h = 6.625 \times 10^{-34}$ Js

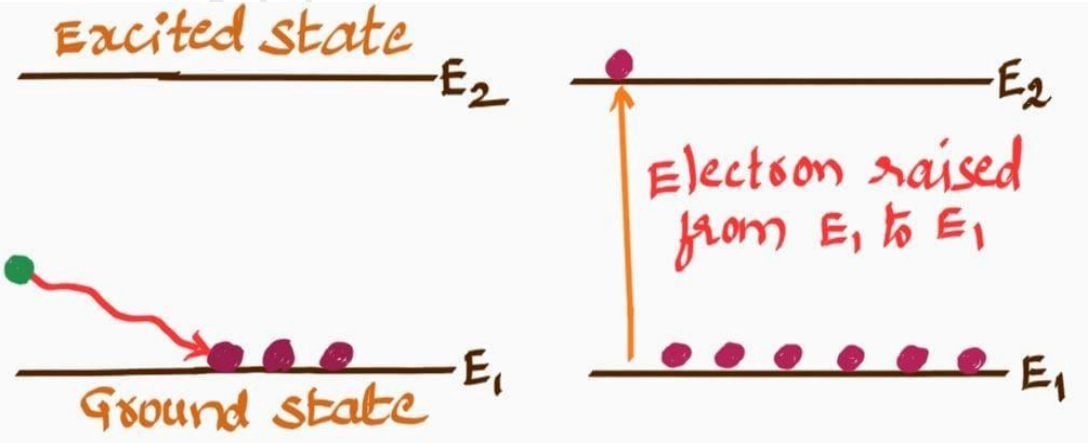
    $\nu \rightarrow$ Frequency of radiation

1. Stimulated Absorption or Induced Absorption

Definition: The process in which an electron is raised from a lower energy state to a higher energy state, due to absorption of an incident photon by an electron is called induced absorption or stimulated absorption.

Explanation:

- Let E_1 and E_2 be the energies of Ground state and excited states of an electron, such that $E_2 > E_1$
- When a photon of energy, $E_2 - E_1 = hv$ interacts with an electron present in the ground state, the electron gets excitation from ground state (E_1) to excited state (E_2). This process is called stimulated emission.
- **It is represented by:** photon + electron → electron*



- Rate of stimulated absorption depends upon the number of electrons available in the ground (lowest) energy state & energy density of photons.

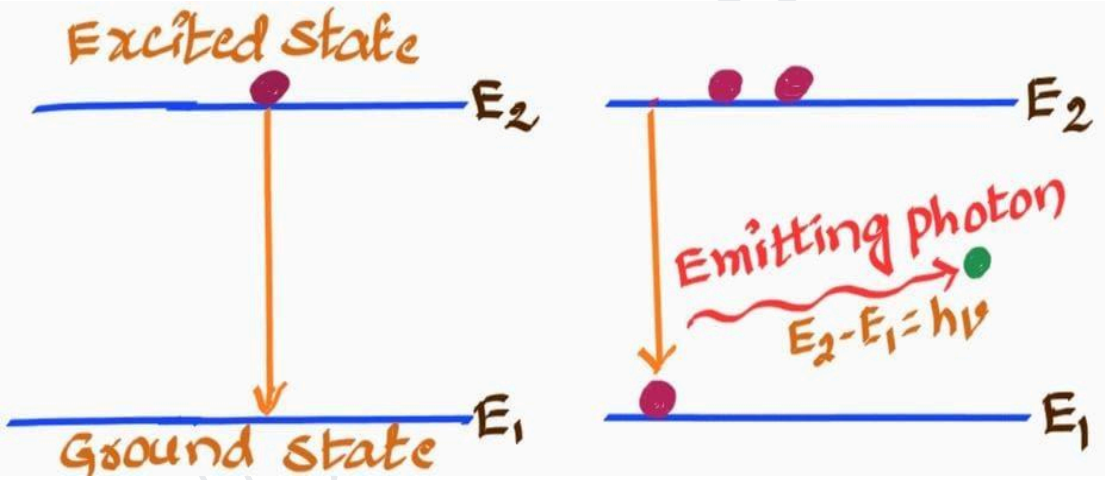
2. Spontaneous Emission:

Definition: The process in which an excited electron emits photons while it returns to the ground state from excited state is known as spontaneous emission.

- The electrons in the excited state do not stay for long time because of their low life time i.e., 10^{-8} seconds.

Explanation:

- Let E_1 and E_2 be the energies of ground and excited states of an electron.
- The electron in excited state does not stay for a long time, so gets de-excitation after its life (10^{-8} seconds) by emitting a photon of energy, i.e., $E_2 - E_1 = h\nu$. This process is known as spontaneous emission.
- **It is represented by:** electron* → electron + photon



- The rate of spontaneous emission depends on the number of electrons in the excited state.
- The electrons changing from one state to another state occurs naturally, so the photon emission also occurs naturally i.e.,spontaneously.
- The emitted photon does not flow exactly in the same direction of incident photons, they flow in the random direction.

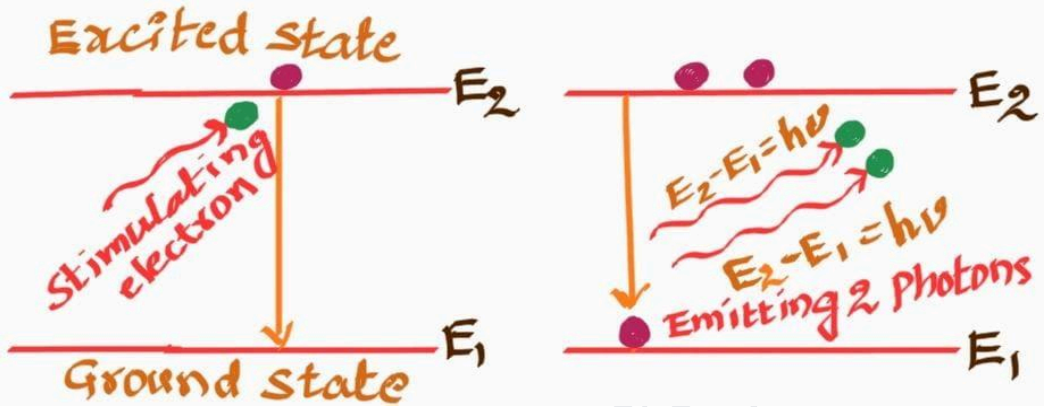
3. Stimulated Emission:

Definition: The process in which an excited electron is stimulated to emit photons while returning to the ground state is called stimulated emission.

- This stimulation occurs by applying an external energy or by inducement of photons in an excited state.

Explanation:

- Let E_1 and E_2 be the energies of ground and excited states of an electron and a photon of energy $E_2 - E_1 = h\nu$ interacts with the excited electron or metastable electron within their lifetime.
- The electron gets de-excitation to ground state by emitting additional photons of the same energy, same frequency, same phase and in the same direction, which follows coherence. This phenomenon is called stimulated emission.
- Therefore, in stimulated emission, each incident photon generates two new photons.



- This is only the method to produce coherent light.