Interaction of Radiation and Matter

If matter is exposed to electromagnetic radiation, the radiation can be reflected, absorbed, transmitted, scattered or photoluminescence.

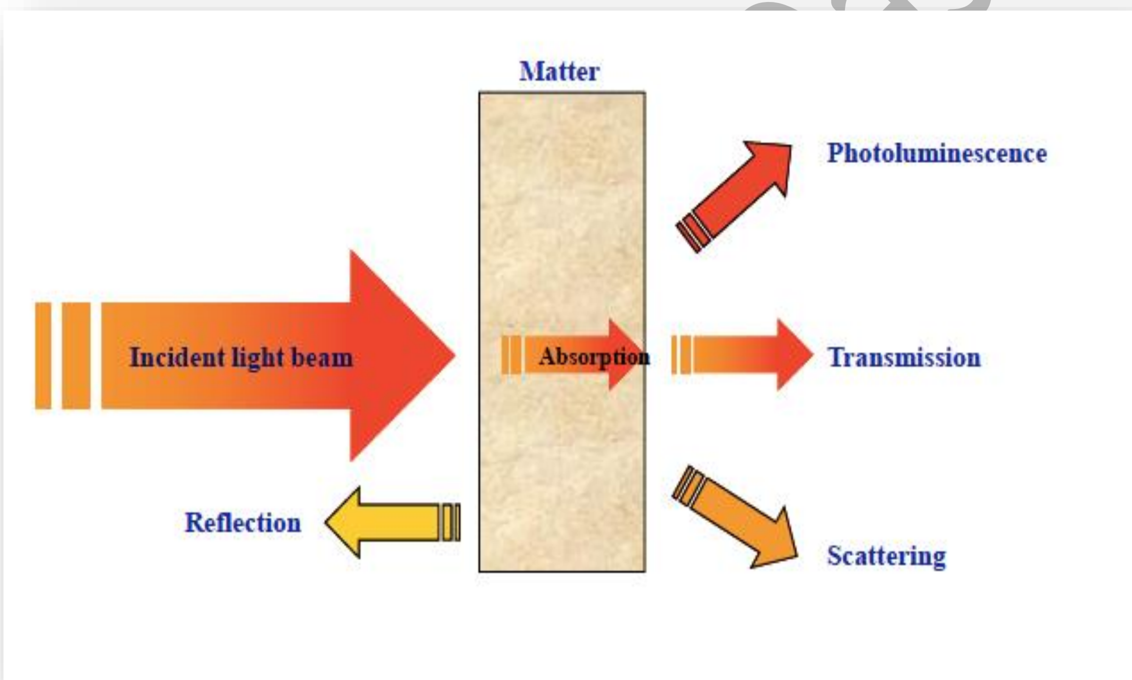

Fig. (9): A schematic explaining the interaction of Radiation and Matter

Photoluminescence:

Is a term used to refer to a number of effects that occur as a result of the emission of light from any form of matter after the absorption of photons (electromagnetic radiation).

It is one of the many forms of fluorescence (emission of light) and is initiated by photoexcitation (i.e. photons exciting electrons to a higher energy level in the atom) and after excitation various processes usually occur in which the photons are re-radiated, **including fluorescence, phosphorescence**, etc.

Fluorescence:

Fluorescence is a type of luminescence which is associated with... absorption of visible and ultraviolet rays when a beam of electromagnetic rays is directed on the molecules of a substance in the solution, these molecules absorb part of the energy and become excited and move electrons from the lowest electronic energy level to the highest excited electronic energy level, and the molecule moves to the ground level by losing a photon whose energy is proportional to the difference the energy between the ground and excited levels, so we obtain this electron by moving from $\boldsymbol{S}_1$ to $\boldsymbol{S}_0$ this is called fluorescence.

There is no change in the direction of the electron's spin.

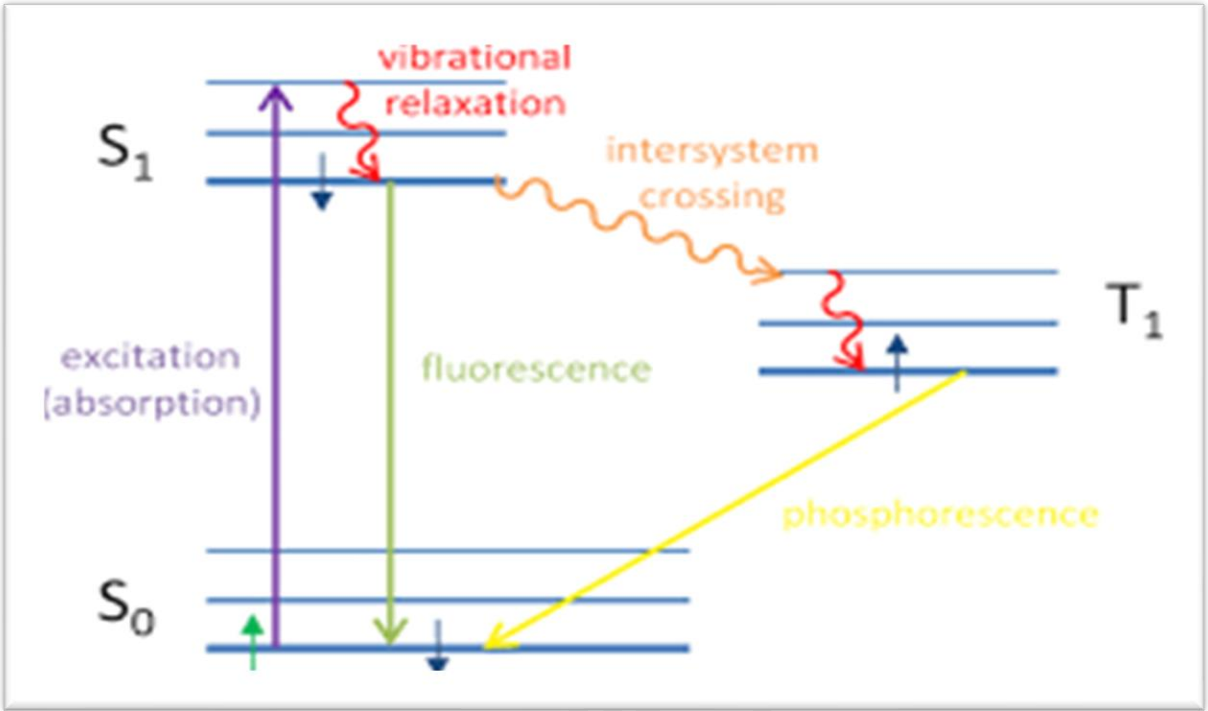

Fig. (10): A schematic explaining the Fluorescence and Phosphorescence

Phosphorescence:

The molecule absorbs suitable energy causing the electrons to move to a higher energy state and then an internal transformation occurs.

Transition from T_1 to S_0 by emission of photon, this process occur in 10^{-3} sec is called phosphorescence it takes more time compared to fluorescence.

The transition to the lower energy state occurs more slowly and the direction of the electron's spin may change.

- phosphorescence occurs slowly while fluorescence occurs very quickly.

- Phosphorescent materials glow in the dark while fluorescent materials if you turn off the light, the material stops glowing.

Transitions:

Is a term used to refer transitions between the ground state and excited electronic states of atoms and molecules can be occurred if the visible or ultraviolet light is absorbed.

Absorption: it's the transition is from lower to higher energy level.

Emission: it's the transition is from higher to lower energy level.

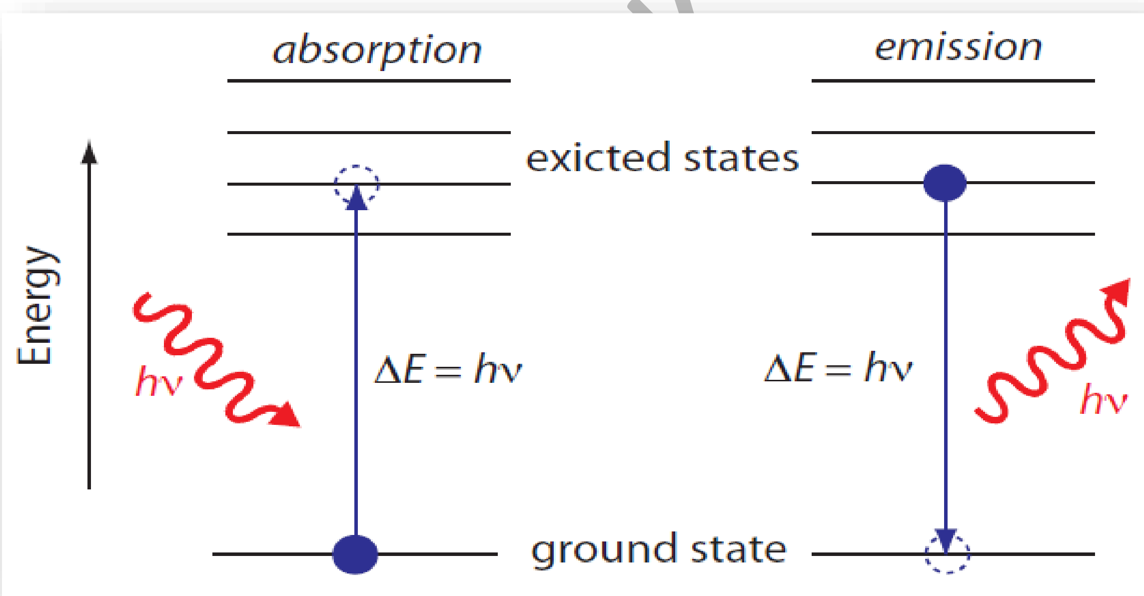

Fig. (11): A schematic explaining the absorption and emission.

Beer–Lambert law

The **transmittance**(T)of the sample at specific frequency is the ratio of the intensity of transmitted light (I) to the intensity of incident light (I_0) at that frequency.

$$T = \frac{I}{I_0}$$

The transmitted light intensity depends on: the length(b) of the sample and the molar concentration of solution(c) of the absorbing material.
The amount of absorbed energy depends on: the concentration of the substance.

As the concentration of the substance to be analyzed increases, the amount of absorbed energy increases, and vice versa, according to this equation:

$$A = £ . b . c$$

whereas:

A = absorbance

£ = molar absorption coefficient and its units ($cm^{-1}.L.mol^{-1}$)

C = concentration of the solution and its units (mol/L)

b = cell thickness and its units (cm)

Absorption can also be measured using the following relationship:

$$A = \log \frac{Io}{I}$$

whereas:

I_o = the intensity of incident light

I = the intensity of transmitted light

Where the ratio (I_o / I) is called the permeability

The absorbance (A) is related logarithmically to the transmittance (T) according to the relationship below:

A= - Log T

The absorbance values can be converted to the percentage of transmittance (percent transmittance T%) to the relationship below:

A= 2- Log T%

Example (1)

A colored aqueous solution with a molar absorption coefficient equal to (3200) l/mol. cm at a wavelength of (525 nm), Calculate the absorbance (A) and the percentage transmittance for a (3.4 x 10^{-4} M) solution using a (1 cm) thick cell.

Solution

A = £. b. c

A = 3200 x 3.4 x 10^{-4} x 1

= 1.09

A= 2- Log T%

1.09 = 2- logT%

logT% = 2 - 1.09

logT% = 0.91

T% = 10 $X^{0.91}$

T% = 8.13

Example (2)

Potassium chromate (K_2CrO_4) in a basic environment shows the highest absorbance at (372 nm), A basic solution containing ($3*10^{-5}$ molar) of potassium chromate gives a percentage transmittance (T%= 71.6) when placed in a cell measuring (1 cm) thick. Calculate:

1- Absorbance value of this solution**.**

2- Molar absorption coefficient of potassium chromate at 372 nm

Solution

-1

A= 2- Log T%

A= 2- Log 71.6

A= 2- 1.855

A= 0.145

-2

A = £. b. c

£ = A / b c

£ = $0.145 / 1 * 3*10^{-5}$

£ = 4833 L/ mole .cm

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Example (3)

A colored aqueous solution with a molar absorption coefficient equal to ($1.1*10^4$ L /mol.cm) giving an absorbance of (0.10312) at a wavelength of (525 nm), Calculate the percentage transmittance(T%) for a(3×10^{-4} M) solution Using a measuring cell with a thickness of (1 cm) .

Solution

A= 2- Log T%

0.10312= 2- Log T%

Log T %= 2- 0.10312

Log T %=1.8969

T %= anti log 1.8969 (10^x) **or** 10 (x^y)

T %= 78.87