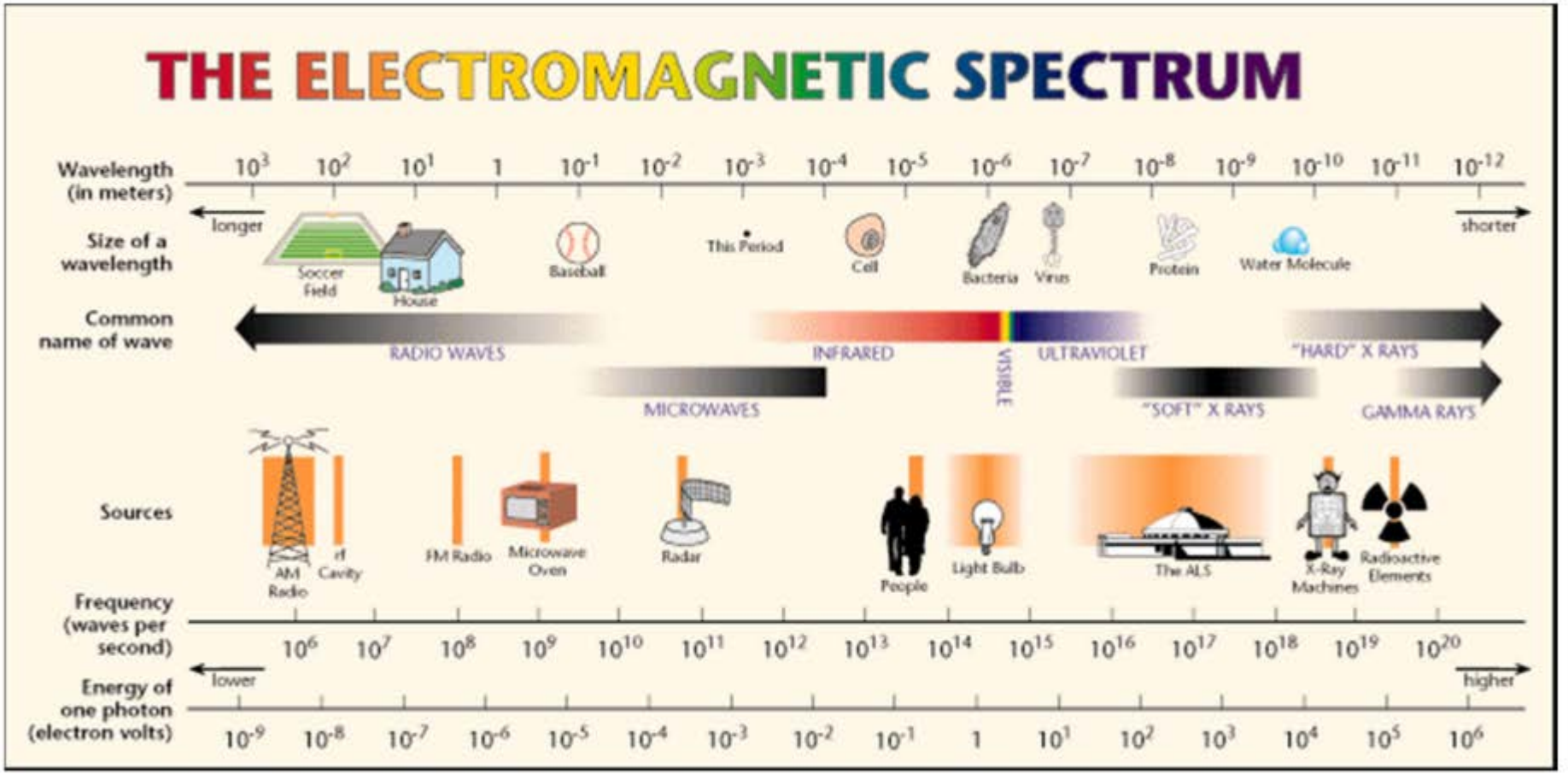
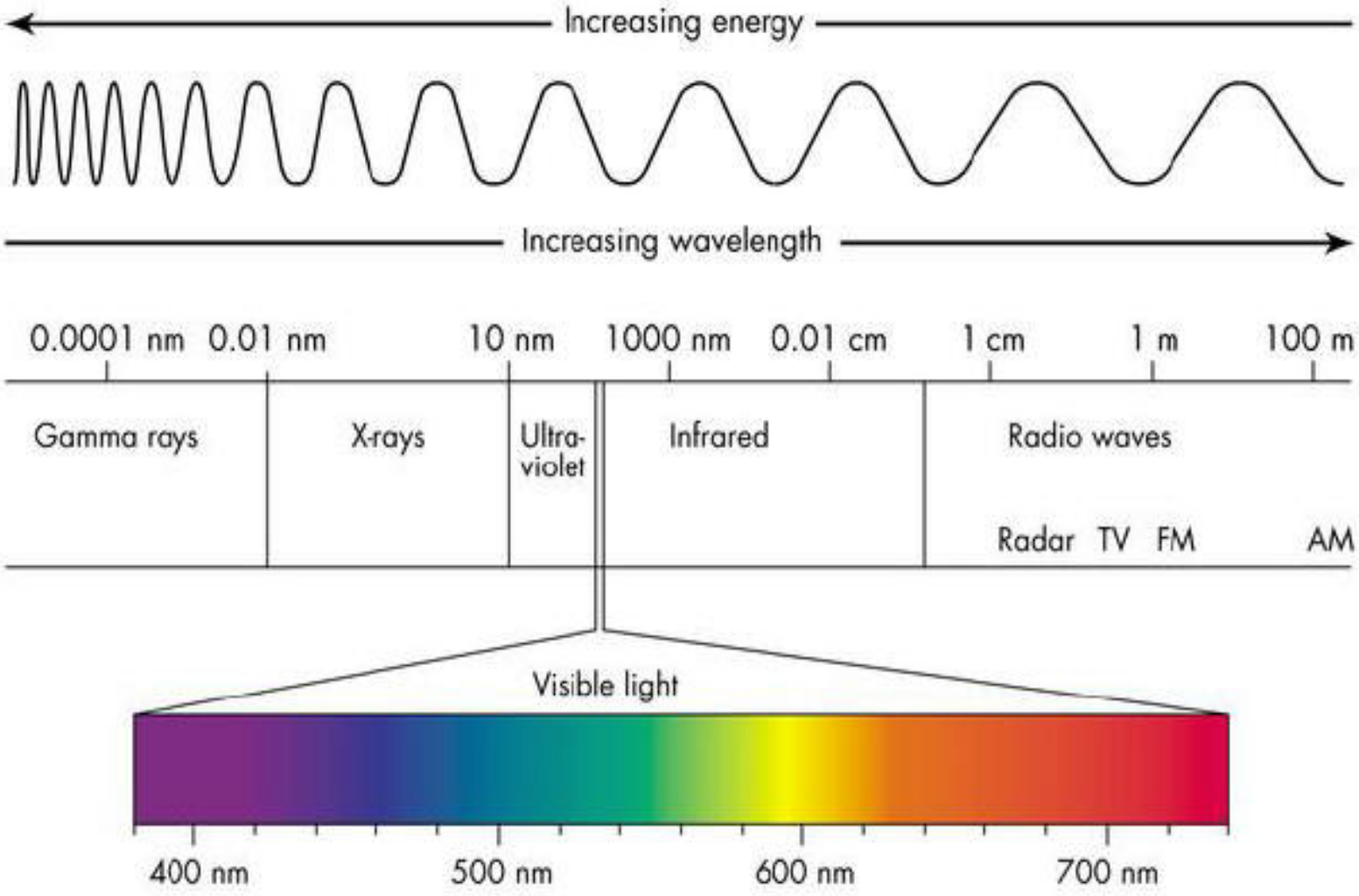
Spectroscopy is the study of interaction of electromagnetic radiation with matter (atoms and molecules)

Spectroscopy is the study of interaction of electromagnetic radiation with matter as a function of frequency

Spectroscopy is the study of the exchange of energy between electromagnetic radiation and matter


THE ELECTROMAGNETIC SPECTRUM
Wavelength (in meters)
10^{3} 10^{2} 10^{1} 1 10^{-1} 10^{-2} 10^{-3} 10^{-4} 10^{-5} 10^{-6} 10^{-7} 10^{-8} 10^{-9} 10^{-10} 10^{-11} 10^{-12}
longer
shorter
Size of a wavelength
Soccer Field
House
Baseball
This Period
Cell
Bacteria
Virus
Protein
Water Molecule
Common name of wave
RADIO WAVES
INFRARED
VISIBLE
ULTRAVIOLET
"HARD" X RAYS
MICROWAVES
"SOFT" X RAYS
GAMMA RAYS
Sources
AM Radio
rf Cavity
FM Radio
Microwave Oven
Radar
People
Light Bulb
The ALS
X-Ray Machines
Radioactive Elements
Frequency (waves per second)
10^{6} 10^{7} 10^{8} 10^{9} 10^{10} 10^{11} 10^{12} 10^{13} 10^{14} 10^{15} 10^{16} 10^{17} 10^{18} 10^{19} 10^{20}
Energy of one photon (electron volts)
lower
higher
10^{-9} 10^{-8} 10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 1 10^{1} 10^{2} 10^{3} 10^{4} 10^{5} 10^{6}

Spectra of light

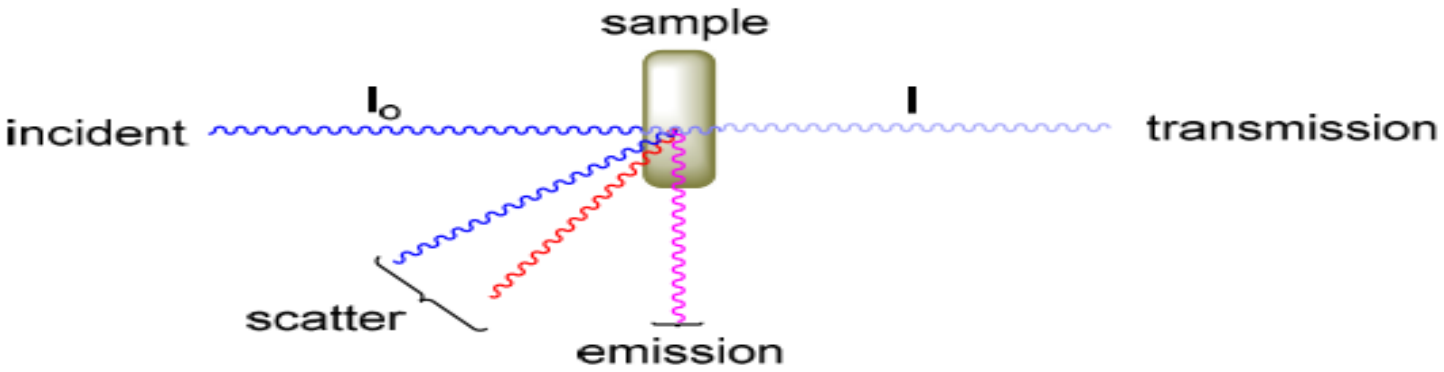


Spectroscopy is the study of interaction of electromagnetic radiation with matter (atoms and molecules)

Depending on the region of the electromagnetic spectrum used for the excitation, different processes occur in atoms and molecules leading to different spectroscopic techniques

Region of electromagnetic radiation (energy per photon)	Process that occur and the corresponding Spectroscopic technique
Gamma rays $10^5 - 10^6$ eV/photon	Nuclear transitions, change of nuclear configuration **Mössbauer spectroscopy**
X-rays $10^2 - 10^4$ eV/photon	Inner shell electronic transitions **Electron spectroscopy, XPS, Aüger**
Ultraviolet and visible rays $1 - 10^2$ eV/photon	Valence shell electronic transitions in molecules **Electronic spectroscopy** also known as **UV-Vis spectroscopy**
Infrared rays $10^{-2} - 1$ eV/photon	Transition among vibrational levels of molecules **Vibrational spectroscopy** also known as **Infrared Spectroscopy**
Microwave rays $10^{-5} - 10^{-3}$ eV/photon	Transitions among rotational levels of molecules **Rotational spectroscopy**
Radiowave rays $10^{-9} - 10^{-6}$ eV/photon	Change of electron and nuclear spins in the presence of a magentic field. **Nuclear Magnetic Resonance (NMR) and Electron Spin Resonance (ESR) spectroscopy**

Reflection and Scattering Losses



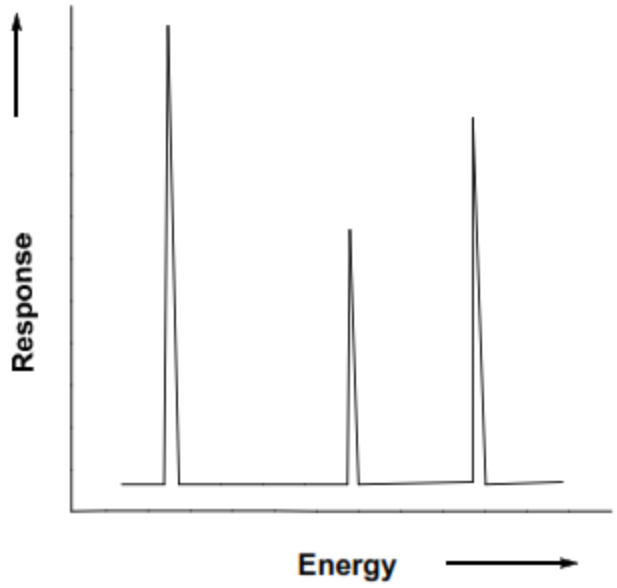
I_o is incident intensity of the radiation and I is transmitted intensity

The ratio I/I_o is known as transmittance (T)

log (I_o/I) is known as absorbance (A)

Types of spectroscopic techniques:
Absorption spectroscopy (e.g. IR)
Emission spectroscopy (e.g. fluorescence)
Scattering spectroscopy (e.g. Raman)

What is a spectrum?

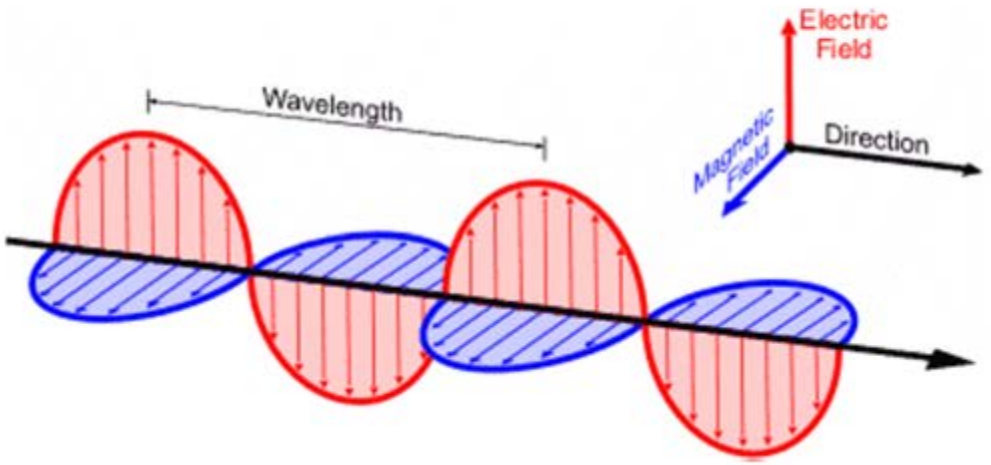


Beer Lambert law – a quantitative correlation

Absorbance = $\log(I_0/I) = \varepsilon c l$

ε = extinction coefficient / molar absorptivity
c = concentration of substance in mol L^{-1}
l = path length in cm

Wave nature of light (electromagnetic radiation)



Spectroscopy

It is a branch of science which deals with interaction of electromagnetic radiations with matter.

Applications:It provide us a scope to know more about structure of molecule or atom.

It is a tool in chemical analysis of wide range of samples.

This interaction of electromagnetic radiations with matter induces a variety of transitions in them.

1)In atom electrons get excited from lower to higher energy state and emit absorbed energy when come back to lower electronic level.

2)The energy absorbed or emit is quantized and having fixed wavelength.

3)A plot of intensity of wavelength of radiations emitted or absorbed against corresponding wavelength or frequency is called spectrum.

4)The atomic spectra are simpler because they have electronic transitions only.

5)Molecular spectra are complicated because they involve electronic , vibrational , rotational and transitional transitions depending upon the nature of radiations absorbed.

Molecular Energies

1. Translational Energy
2. Rotational Energy
3. Vibrational Energy
4. Electronic Energy

Translational Energy

Kinetic energy posses by molecule due to its motion in space is Translational Energy.

Average Transitional Energy is =3/2kT

Where k =Boltzman constant

Translational

Rotational Energy

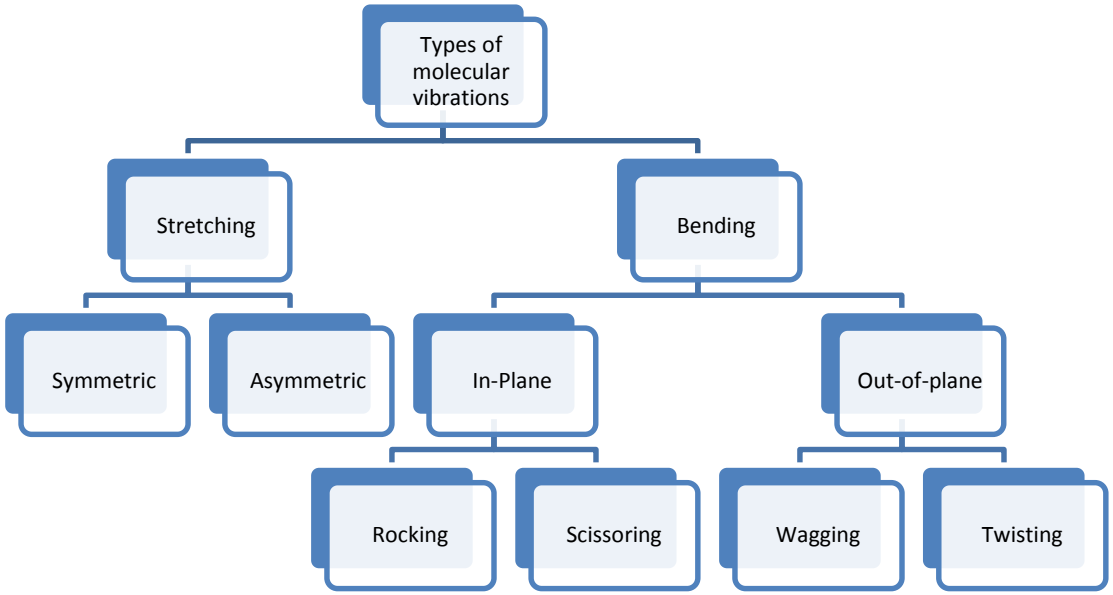
The energy involved in rotation of molecule or its part ,about the centre of gravity is Rotational Energy.Its value for

Linear molecule=Two Rotational degrees of freedom.

Non linear molecule=Three Rotational degrees of freedom.

Vibrational Energy :The energy involned in causing the vibrations in molecule is Vibrational Energy.

Modes OF MOLECULAR VIBRATIONS(AX_2)



A linear molecule with n atoms having (3n-5)vibrational degrees of freedom.

A non linear molecule with n atoms having (3n-6)vibrational degrees of freedom.

Calculate vibrational degrees of freedom for the following molecules.

CH_4,NH_3,CO_2,H_2O,C_2H_2,etc

Electronic Energy

The energy involved in excitation of electron to higher energy level or due to change in distribution of electron by cleavage of bond is electronic Energy.

At room temperature translational energies are closely spaced and continuous.

E(total)=E(e)+E(v)+E(r)

The relative magnitude of these energies are as folloes-

a)The energy difference between two electronic level is much larger as compared to vibrational level belongs to same electronic level.

b)The two rotational levels are still closer and have less energy difference.