Polarization

A light wave is an electromagnetic wave that travels through the vacuum of outer space.

Light waves are produced by vibrating electric charges.

electromagnetic wave is a transverse wave that has both an electric and a magnetic component.

The light wave that is vibrating in more than one plane is referred to as unpolarized light. Light emitted by the sun, by a lamp in the classroom, or by a candle flame is unpolarized light.

It is possible to transform unpolarized light into polarized light. Polarized light waves are light waves in which the vibrations occur in a single plane.

The process of transforming unpolarized light into polarized light is known as polarization.

There are a variety of methods of polarizing light. The four methods discussed on this page are:

1-Polarization by Transmission

2-Polarization by Reflection

3-Polarization by Refraction

4-Polarization by Scattering

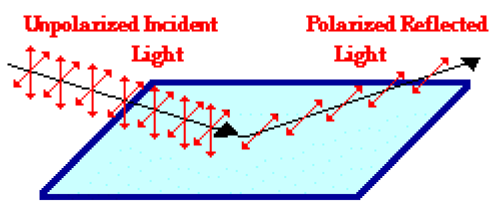
Polarization by Transmission

In this method, involves the use of filter materials that have special chemical composition. They are known as Polaroid filters. These polaroid filters can block one of the two planes of electromagnetic waves. When the unpolarized light is transmitted through these polaroid filters, it filters out one-half of the vibrations of the light in a single plane. This polarized light has one half of the intensity.

Polarization by Reflection

Unpolarized light can also undergo polarization by reflection off of nonmetallic surfaces. The extent to which polarization occurs is dependent upon the angle at which the light approaches the surface and upon the material that the surface is made of.

nonmetallic surfaces such as asphalt roadways, snowfields and water reflect light such that there is a large concentration of vibrations in a plane parallel to the reflecting surface.



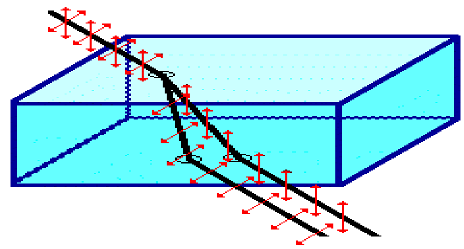
Reflection of light off of non-metallic surfaces results in some degree of polarization parallel to the surface.

Polarization by Refraction

Polarization can also occur by the refraction of light. Refraction occurs when a beam of light passes from one material into another material. At the surface of the two materials, the path of the beam changes its direction. The refracted beam acquires some degree of polarization.

The light is *split* into two beams upon entering the crystal. Subsequently, if an object is viewed by looking through an Iceland Spar crystal, two images will be seen.

The two images are the result of the double refraction of light. Both refracted light beams are polarized - one in a direction parallel to the surface and the other in a direction perpendicular to the surface.



The two refracted rays passing through the Iceland Spar crystal are polarized with perpendicular orientations.

Polarization by Scattering

Polarization also occurs when light is scattered while traveling through a medium. When light strikes the atoms of a material, it will often set the electrons of those atoms into vibration.

The vibrating electrons then produce their own electromagnetic wave that is radiated outward in all directions.

This newly generated wave strikes neighboring atoms, forcing their electrons into vibrations at the same original frequency.

These vibrating electrons produce another electromagnetic wave that is once more radiated outward in all directions.

This absorption and reemission of light waves causes the light to be scattered about the medium.

This scattered light is partially polarized.

Total Energy and Rest Energy

The first postulate of relativity states that the laws of physics are the same in all inertial frames. Einstein showed that the law of conservation of energy is valid relativistically, if we define energy to include a relativistic factor.

TOTAL ENERGY

Total energy E is defined to be $E = \gamma mc2$, where m is mass, c is the speed of light,

$$\gamma = \frac{1}{\sqrt{\frac{1}{1 - {v^2}/{c^2}}}}$$

v is the velocity of the mass relative to an observer.

Relativistic Energy

The famous Einstein relationship for energy

$$E = mc^2$$

includes both the kinetic energy and rest mass energy for a particle. The kinetic energy of a high speed particle can be calculated from

$$KE = mc^2 - m_0c^2$$

The relativistic energy of a particle can also be expressed in terms of its momentum in the expression

$$E = mc^2 = \sqrt{p^2c^2 + m_0^2c^4}$$

The relativistic energy expression is the tool used to calculate binding energies of nuclei and the energy yields of nuclear fission and fusion.

The mass of an object must depend on its speed! In fact, the mass must increase with speed

if an object at rest has a mass m, moving at a speed v it will have inertia corresponding to a "relativistic mass

$$m_{rel} = {m}/{\sqrt{1 - (v^2/c^2)}}$$

Note that this relativistic mass increase is an undetectably small effect at ordinary speeds, but as an object approaches the speed of light, the mass increases without limit!

Mass Really *Does* Increase with Speed

Particles are accelerated to speeds where their relativistic mass is thousands of times greater than their mass measured at rest, usually called the "rest mass

Binary property of particles

In 1905 AD, Einstein proposed the quantization of radiation itself and combined Huygens' wave theory with Newton's particle theory.

assuming that light is composed of photons accompanying a light wave, and each photon has an energy equal to $E = h\nu$

and momentum $P = \frac{h\nu}{c} = \hbar K$

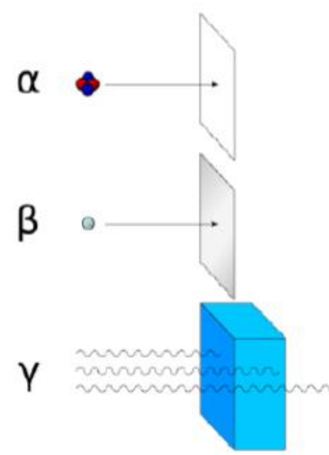
$$K = \frac{2\pi}{\lambda}$$

ν is The frequency (frequency) of light, h is Planck's constant, and K is the wave number These two relationships actually link the wave property of light represented by frequency Or wavelength With the particle property represented by energy E momentum p.

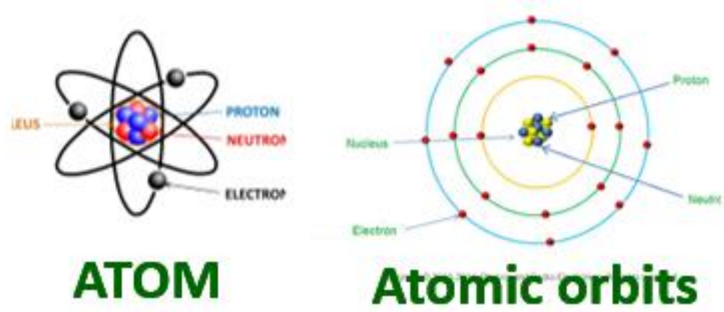
The radioactive decay of nuclei produces several types of ionizing radiation with several mega electron volts per particle. It was found that when these radiations pass through the body, they can cause biological hazardous such as cell damage, skin burns and cancer.

Ionizing radiation have the ability to penetrate matter.

- Alpha particles are stopped by a sheet of paper
- Beta particles can be stopped with a thin foil of Tin or aluminum .
- Gamma radiation is dampened when it penetrates matter. Gamma rays can be stopped from 4 meters of lead. Tungsten and tungsten alloys can stop Gamma radiation with much less mass than lead



Atomic Structure

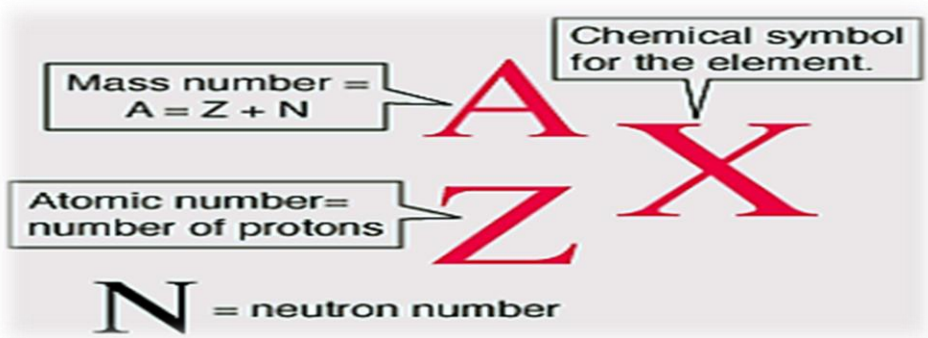


The nucleus consists of the elementary particles, protons and neutrons which are known as nucleons.

A proton has positive charge of the same magnitude as that of electron and its rest mass is about 1836 times the mass of an electron.

A neutron is electrically neutral, whose mass is almost equal to the mass of the proton.

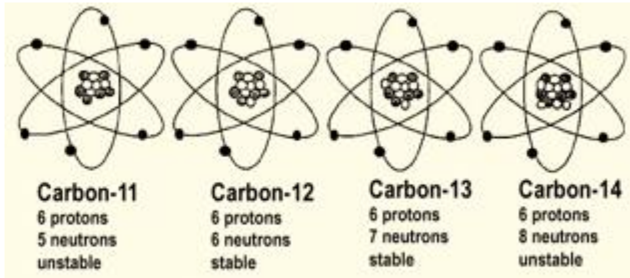
الكتلة			
ما يكافئها من طاقة	بوحدة الكتل الذرية	بالكيلوجرام	الجسيم
938.28	1.007276	1.67262×10^{-27}	البروتون
939.57	1.008665	1.67493×10^{-27}	النيوترون
0.510999	5.48579×10^{-4}	9.10939×10^{-31}	الإلكترون
938.783	1.007825	1.67353×10^{-27}	ذرة هيدروجين
3727.38	4.001506	6.64466×10^{-27}	نواة هليوم
11177.9	12	1.99265×10^{-26}	ذرة كربون



A nucleus of an element is represented as $_Z^AX$. X is the chemical symbol of the element. Z represents the atomic number which is equal to the number of protons and A, the mass number which is equal to the total number of protons and neutrons.

The number of neutrons is represented as N which is equal to A−Z. For example, the chlorine nucleus is represented as $_{17}Cl^{35}$. It contains 17 protons and 18 neutrons

- **Isotopes:** are atoms of the same element having the same atomic number Z but different mass number A. Ex: The nuclei $_1H^1$, $_1H^2$ and 1H3 are the isotopes of hydrogen.
- **Isobars** - Isobars are atoms of different elements having the same mass number A, but different atomic number Z. Ex: The nuclei $_8O^{16}$ and $_7N^{16}$ represent two isobars.
- **Isotones** - Isotones are atoms of different elements having the same number of neutrons. $_6C^{14}$ and $_8O^{16}$ are some examples of isotones.



normal radioactivity

Radioactiedecay (also known as nuclear decay, radioactivity, radioactive disintegration, or nuclear disintegration) is the process by which an unstable atomic nucleus loses energy by radiation. A material containing unstable nuclei is considered radioactive. Three of the most common types of decay are alpha, beta, and gamma decay. The weak force is the mechanism that is responsible for beta decay, while the other two are governed by the electromagnetism and nuclear force.

❖ α Decay

- A nucleus emitting an alpha particle loses two protons and two neutrons
  - The mass number, A, decreases by 4
  - The atomic number, Z, decreases by 2

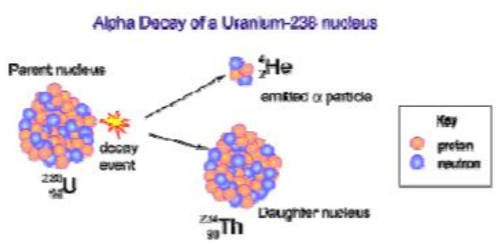
$$^{A}_{Z}X \rightarrow \, ^{A-4}_{Z-2}Y + \, ^{4}_{2}He$$

X – Parent Nucleus

Y – Daughter Nucleus

$$^{238}_{92}U \rightarrow \, ^{234}_{90}Th + \, ^{4}_{2}He$$

$$^{226}_{88}Ra \rightarrow \, ^{222}_{86}Rn + \, ^{4}_{2}He$$



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properties of Alpha particles

Alpha particles (a) are composite particles consisting of two protons and two neutrons tightly bound together. They are emitted from the nucleus of some radionuclides during a form of radioactive decay, called alpha-decay. An alpha-particle is identical to the nucleus of a normal (atomic mass four) helium atom i.e. a doubly ionised helium atom.

Alpha particles (also termed alpha radiation or alpha rays) was the first nuclear radiation to be discovered, beta particles and gamma rays were identified soon after.

Alpha particles are relatively slow and heavy compared with other forms of nuclear radiation. The particles travel at 5 to 7 % of the speed of light or 20,000,000 metres per second and has a mass approximately equivalent to 4 protons.

Alpha particles, because they are highly ionising, are unable to penetrate very far through matter and are brought to rest by a few centimetres of air or less than a tenth of a millimetre of biological tissue

❖ β Decay

- The basic process in beta decay converts a neutron into a proton and an electron:

$$^{1}_{0}n \longrightarrow {}^{1}_{1}p + e^{-}$$

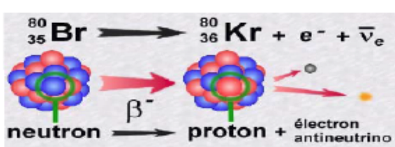
- Therefore, a nucleus that decays via beta decay loses a neutron and gains a proton.

$$^{A}_{Z}X \longrightarrow {}_{Z+1}^{\;\;A}Y + e^{-}$$

- If a nucleus emits a positron, a proton has become a neutron:

$$^{A}_{Z}X \longrightarrow {}_{Z}{}^{A}_{-1}Y + e^{+}$$

- Two typical processes are



$$^{14}_{6}C \rightarrow {}^{14}_{7}N + e^{-}$$

$$^{12}_{7}N \rightarrow {}^{12}_{6}C + e^{+}$$

properties of beta particles

Beta particles (β)are high energy, high speed electrons (β-) or positrons (β+) that are ejected from the nucleus by some radionuclides during a form of radioactive decay called beta-decay. Beta-decay normally occurs in nuclei that have too many neutrons to achieve stability.

Beta particles have a mass which is half of one thousandth of the mass of a proton and carry either a single negative (electron) or positive (positron) charge. As they have a small mass and can be released with high energy, they can reach relativistic speeds (close to the speed of light).

Their light mass means that they lose energy quickly through interaction with matter and have a haphazard path as they move through air or other materials.

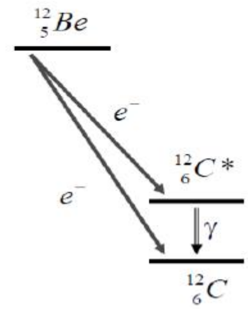
Beta particles are much less ionising than alpha particles and generally do less damage for a given amount of energy deposition. They typically have ranges of tens of centimetres in air (energy dependent) and a few millimetres in materials.

❖ γ Decay

- No Change in Atomic and Mass Number

$$^{12}_{6}C^{*} \rightarrow ^{12}_{6}C + ^{0}_{0}\gamma$$

- ➢ Carbon Nuclei in high energy state, it releases Gamma ray



<u>properties of gamma rays</u>

1. $\gamma - rays$ are electromagnetic waves of short wavelength and high frequency. The wavelength of $\gamma - rays$ range from 0.005 Angstrom to 0.5 Angstrom.
2. They travel with velocity of light and are not charged particles like alpha or beta rays.
3. They produce fluorescence effect on a photographic plate.
4. They ionize gas they travel through but the ionization produced is very small.
5. They are highly penetrating rays and they are even penetrative than alpha and beta particle. For instance, $\gamma - rays$ can even pass through 30cm thick iron.