SNS COLLEGE OF ALLIED HEALTH SCIENCES- COIMBATORE 35

DEPARTMENT : RADIOGRAPHY AND IMAGNG TECHNOLOGY

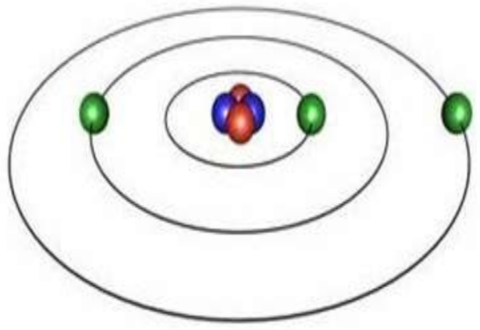
SUBJECT : GENERAL PHYSICS, RADIATION PHYSICS AND PHYSICS OF DIAGNOSTIC RADIOLOGY

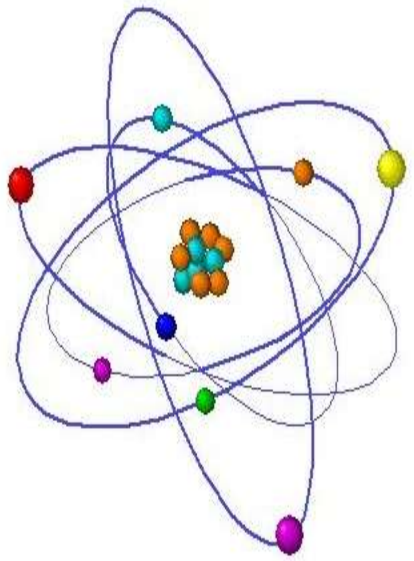
PAPER : PAPER II (UNIT 4 – INTERACTIONS OF RADIATION WITH MATTER)

TOPIC : 3. INTRACTIONS OF RADIATION WITH MATTER

INTRACTIONS OF RADIATION WITH MATTER

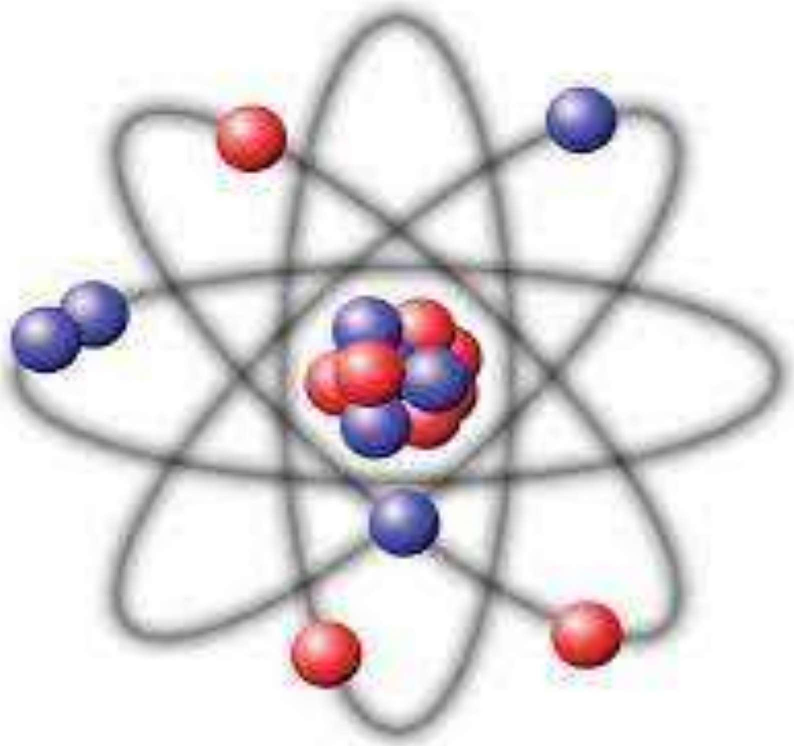
- When X or y radiation passes through a medium, it interacts with an atom and produces moving electrons. These electrons travel in the medium, interact with other atoms and produce ionization and excitation.
- As a result, energy is deposited on the cells, which are either damaged partially or completely.
- In addition, sufficient amount of heat is also produced. In summary, the x or y photon transfer energy to the electrons, which in turn transfer the energy to the cell system and produce the biological effect. That is why they are called as indirectly ionizing radiations.
- The above interaction is said to have wavelike and particle like properties. X and gamma rays interacts with structures that are similar in size to their wavelength.





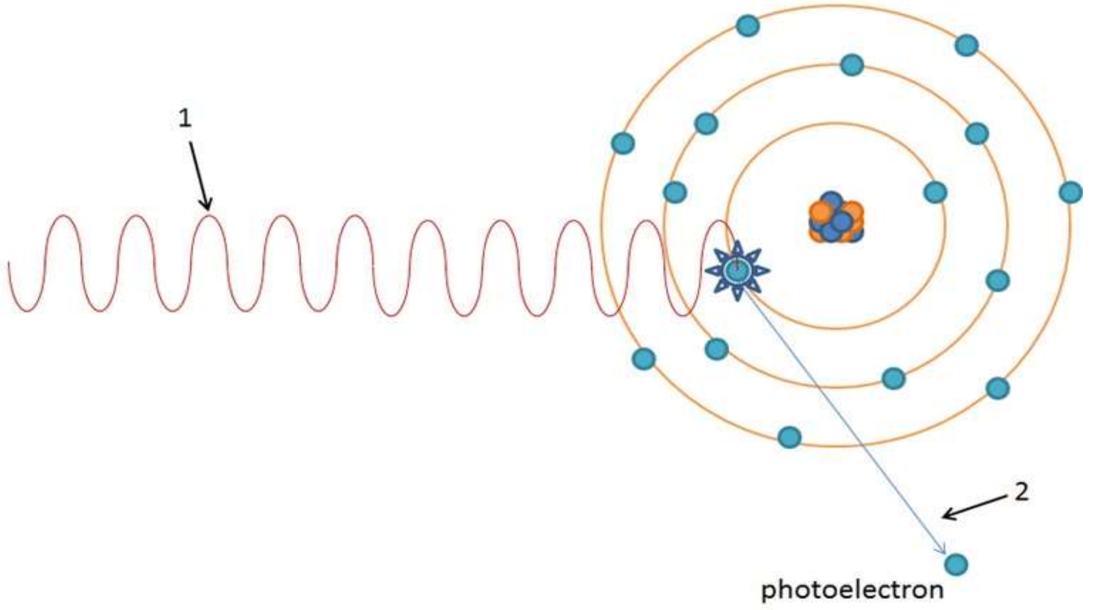
INTRACTIONS OF RADIATION WITH MATTER

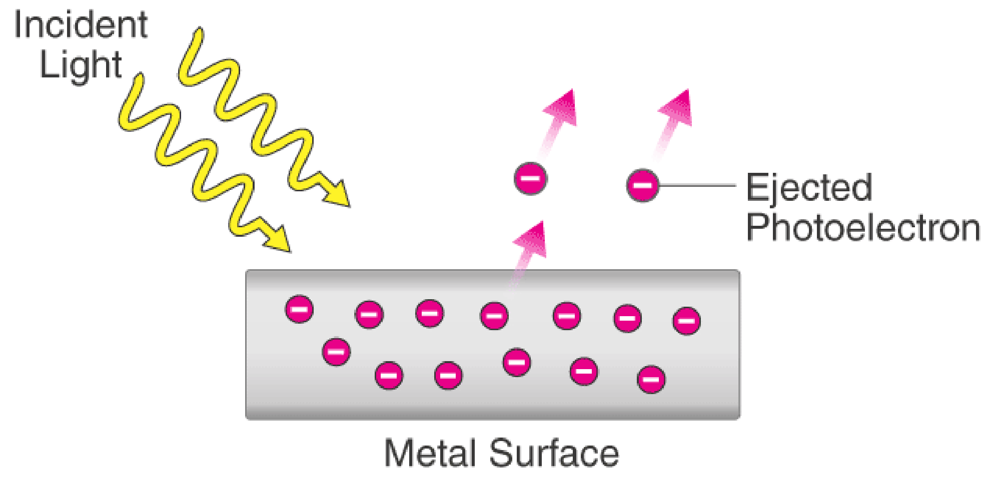
- Low energy photons tend to interact with atoms, medium energy to that of electrons and high energy photons with that of nuclei.
- The above structural level interactions may be performed by five mechanisms, namely
- (i) Photoelectric absorption,
- (ii) Compton scattering,
- (ii) Coherent scattering,
- (iii) Pair production, Annihilation
- (v) Photodisintegration.
- The compton scattering and photo electric absorption are the two most important interactions in diagnostic radiology.



PHOTOELECTRIC EFFECT

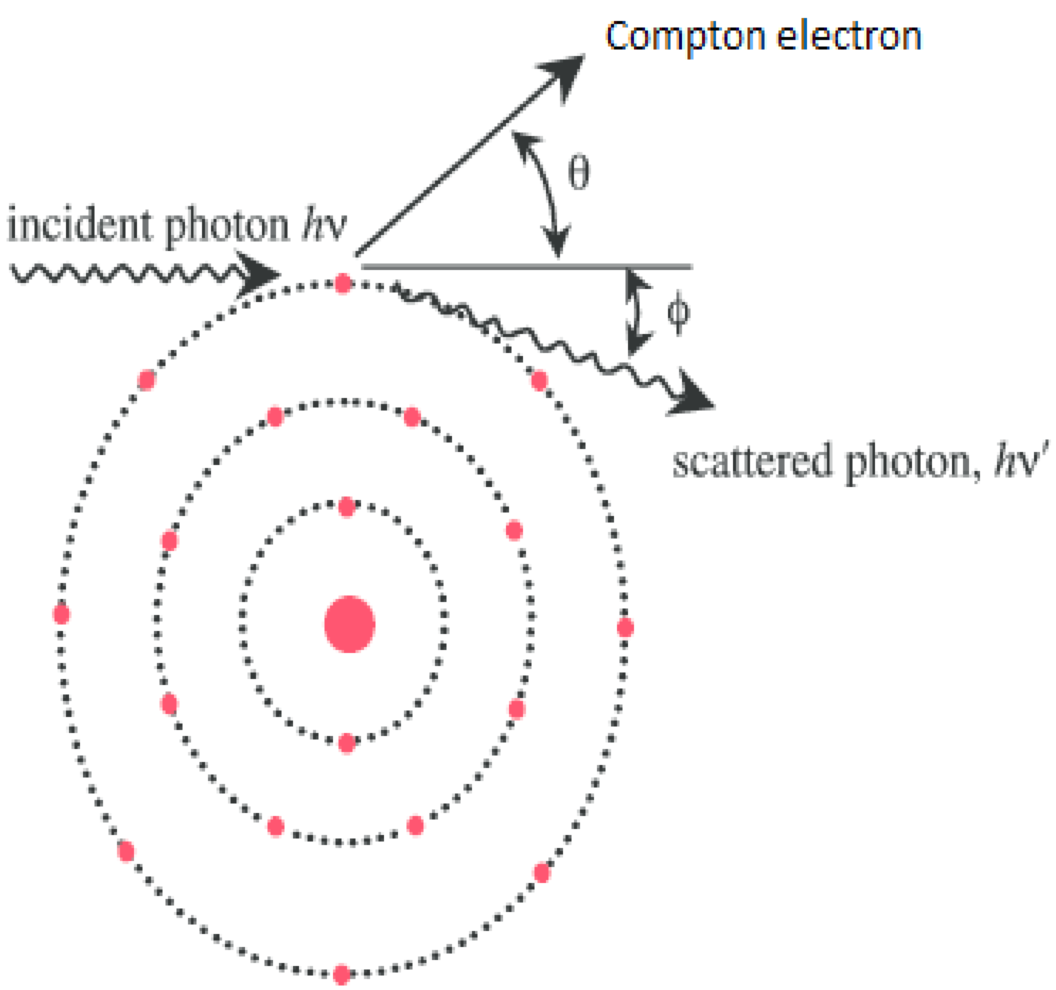
- The photoelectric effect interaction occurs when the energy of an incident photon has slightly greater energy than the binding energy of the electrons.
- When the incident x-ray photon interacts with an inner-shell electron, the total energy is absorbed by the electron resulting in the ejection of electrons from the atom. After the ejection of an electron, the atom is ionized.
- This state of the atom is highly unstable, so the inner shell vacancy is immediately filled by an electron from an outer orbit to achieve a stable state.
- When the electron drops into the inner shell vacancy, the energy is released in the form of a characteristic X-ray.
- Most Photoelectric interactions occur in the K shell. The Photoelectric Effect Does not produce scatter radiation.





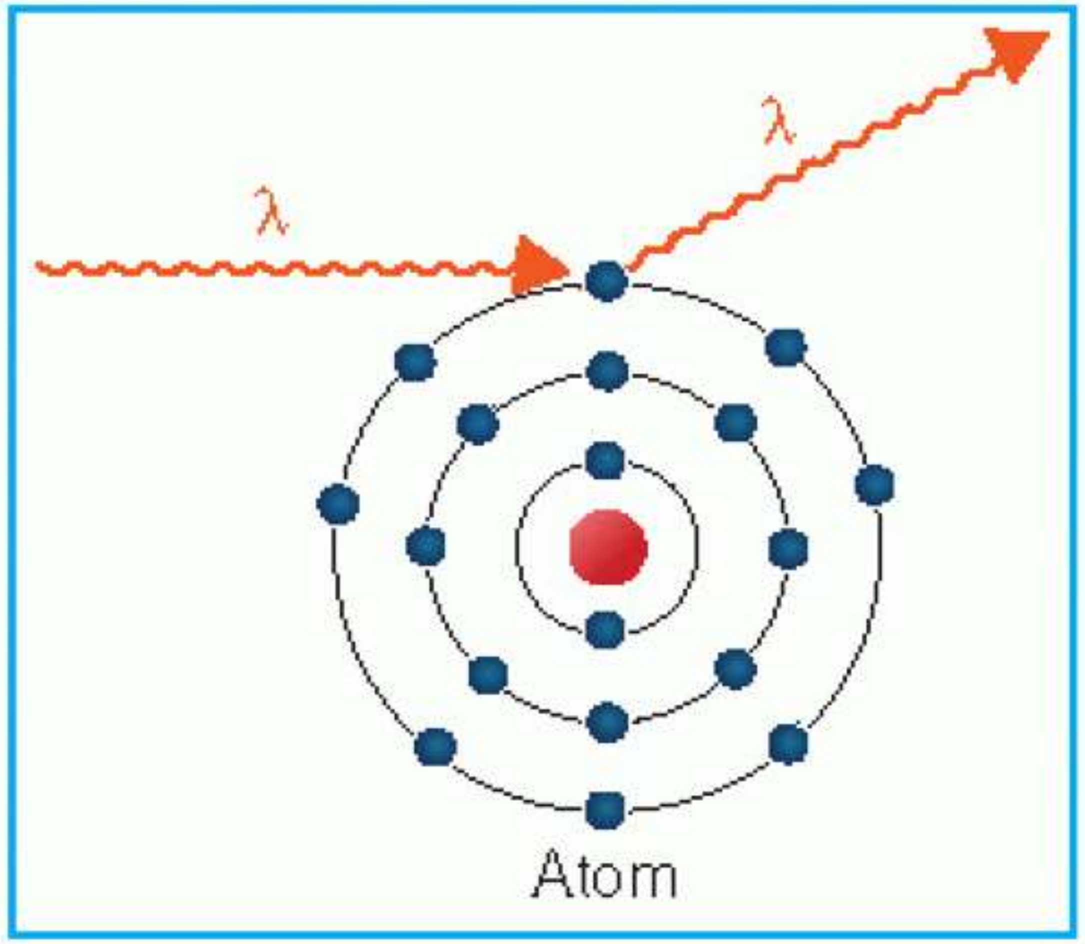
COMPTON EFFECT

- Interaction occurs between photons and Free electrons.
- Outer shell electron has negligible binding energy.
- The electron is ejected from the atom, and the photon is scattered with some reduction in energy.
- If the photon makes a direct hit on the electron, the electron will travel straight forward (φ = 0) and the scattered photon will be scattered back with ϴ = 180 degree.
- Scatter X-rays are called Compton scatter, and ejected electron is referred to as recoil electron.
- 97% of scatter x rays originate from Compton interaction.
- Compton scattering is the main interaction of x-ray with soft tissue.



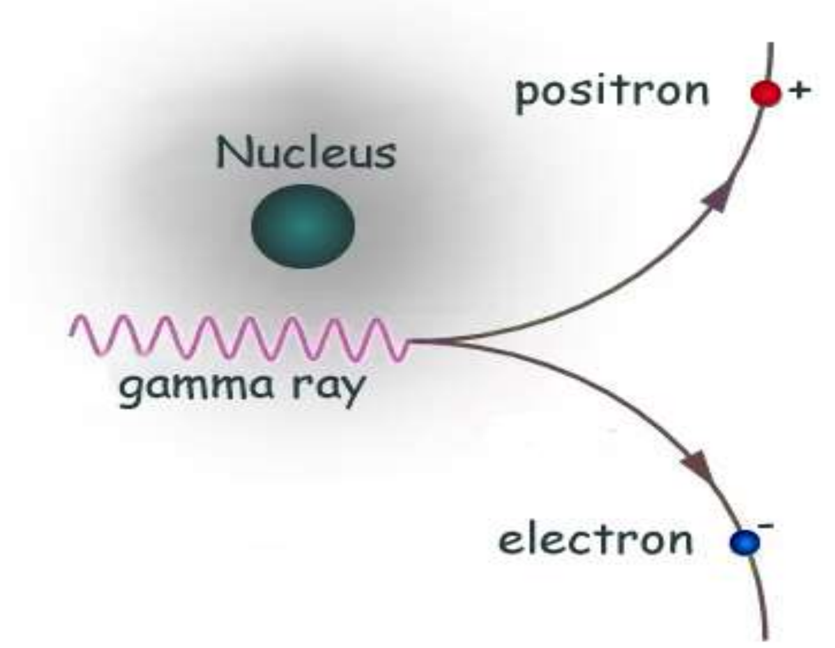
COHERENT EFFECT

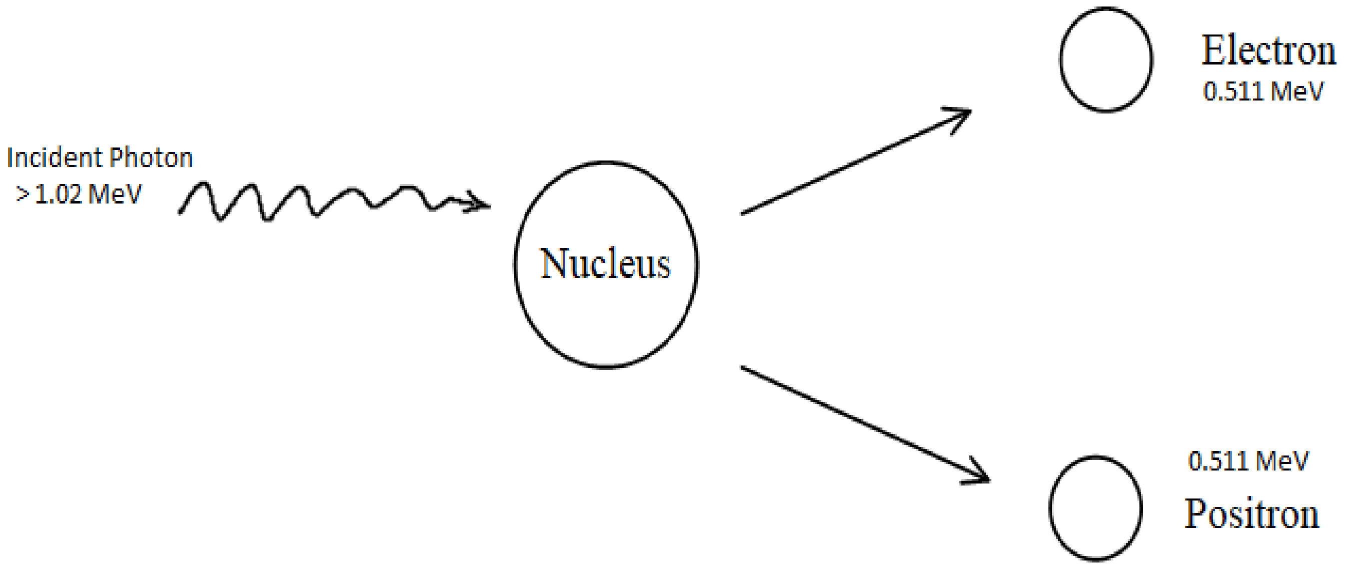
- The coherent scattering, also known as classical scattering or Rayleigh scattering, The process can be visualized by considering the wave nature of electromagnetic radiation.
- This interaction consists of an electromagnetic wave passing near the electron and setting it into oscillation.
- The oscillating electron reradiates the energy at the same frequency as the incident electromagnetic wave.
- These scattered x-rays have the same wavelength as the incident beam.
- Thus, no energy is changed into electronic motion and no energy is absorbed in the medium.
- **The only effect is the scattering of the photon at small angles.**
- The coherent scattering is probable in high-atomic-number materials and with photons of low energy.
- The process is only of academic interest in radiation therapy.



PAIR PRODUCTION

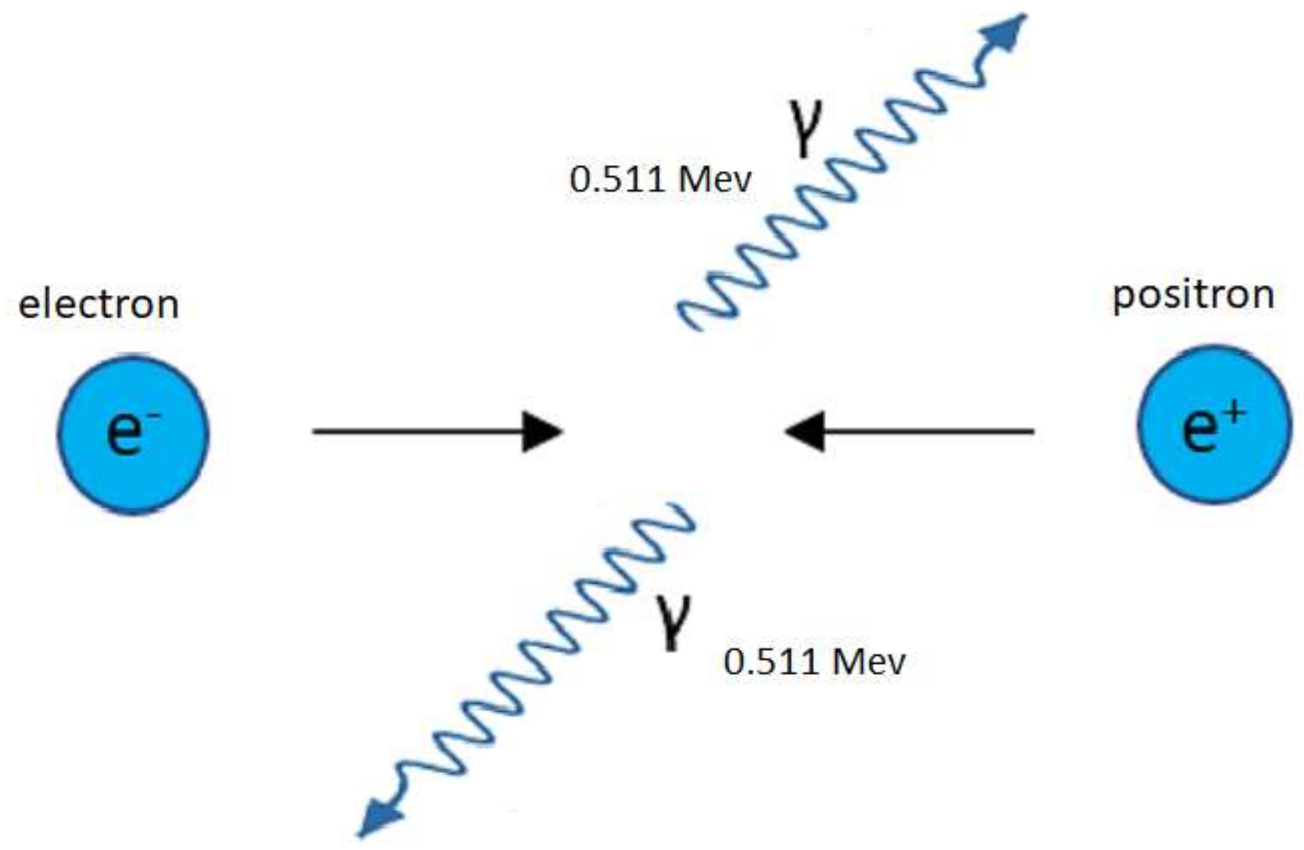
- When a photon having energy > 1.02 MeV, passes near the nucleus of an atom, will be subjected to strong nuclear field.
- The photon may suddenly disappear and become a positron and electron pair.
- For each particle 0.511 MeV energy is required and the excess energy > 1.02 MeV, would be shared between the positron and electron as kinetic energy.
- Actually, the interaction is between a photon and the nuclear field.
- This process is an example for the conversion of energy into mass as predicted by Einstein.





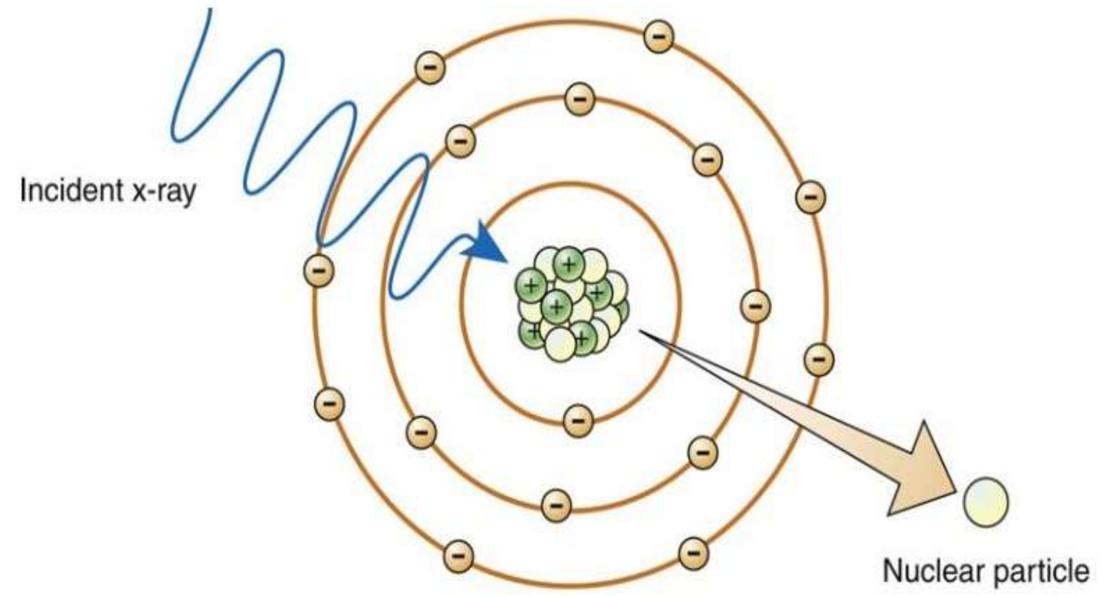
ANNIHILATION

- After the pair production process, the electron comes to rest, by joining with an atom.
- The positron comes to rest by combining with an electron and the two particles annihilates each other.
- The combined mass of the two particles is converted into energy in the form of two photons.
- The combined mass of two particles is 1.02 MeV and this energy is shared by the two photons. Hence, each photon will have energy of 0.511 MeV.
- The above process is called the positron annihilation.
- This is an example of conversion of mass into energy and forms the basis for positron emission tomography.



PHOTODISINTEGRATION

- Photodisintegration occurs when the extremely high energy (7-15 MeV) photon interacts directly with the nucleus of an atom.
- The photon energy directly absorbs that resulting in the ejection of a nucleon or other nuclear fragment.
- Photodisintegration does not occur with energies less than 7 MeV.



Photodisintegration

INTERROGATIONS

1. What is Compton effect ?
2. Define Pair production
3. What is Annihilation ?

REFERENCES

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3. Basic Medical Radiation physics – Stanton.
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THANK YOU