X-Rays Pre Lecture Investigation

ANSWER (1) Concept of photoelectric effect

Photoelectric effect, or **photoelectric absorption** (**PEA**) is a form of interaction of X-ray or gamma photon with the matter. A low energy photon interacts with the electron in the atom and removes it from its shell.

The probability of this effect is maximum when

- the energy of the incident photon is equal to or just greater than the binding energy of the electron in its shell ('absorption edge') and
- the electron is tightly bound (as in K shell)

The electron that is removed is then called a photoelectron. The incident photon is completely absorbed in the process. Hence it forms one of the reasons for attenuation of X-ray beam as it passes through the matter.

PRODUCTION OF X-RAYS:

The production of X rays involves the bombardment of a thick target with energetic electrons. The cathode is the negative terminal of an X-ray tube. It is a tungsten filament and when current flows through it, the filament is heated and emits its surface electrons by a process called thermionic emission, which is actually the principle behind the X rays.

ANSWER (2) Bremsstrahlung Principle .

Electrons undergo a complex sequence of collisions and scattering processes during the slowing down process, which results in the production of bremsstrahlung and characteristic radiation.

Energetic electrons are mostly slowed down in matter by collisions and excitation interactions. If an electron comes close to an atomic nucleus, the attractive Coulomb forces cause a change of the electron's trajectory. An accelerated electron, or an electron changing its direction, emits electromagnetic radiation, given the name **bremsstrahlung (braking radiation)**, and this energy of the emitted photon is subtracted from the kinetic energy of the electron. The energy of the bremsstrahlung photon depends on the attractive Coulomb forces and hence on the distance of the electron from the nucleus.

Whereas in proton bombardment there is a nuclear reaction in which a nucleus is bombarded or struck by another nucleus or nuclear particle. Here fission or fusion may occur. so, this the basic difference between bremsstrahlung radiation and proton bombardment.

ANSWER (3) *Difference between X-Rays and Gamma Rays.*

X RAYS	GAMMA RAYS
The wavelength of X-rays has a range from 0.01 nanometers to 10 nanometers. By applying the equation C = f λ, where C is the speed of light in a vacuum, f is the frequency of the electromagnetic wave, and λ is the wavelength of the electromagnetic wave, we get a frequency range for X-rays from 30 petahertz (3 x 10_{16} Hz) to 30 exahertz (3 x 10_{19} Hz).	The frequency of gamma rays is in the range of exahertz (1019 Hz) or above.
X-rays are produced by collision of a high-energy electron beam with a metal. The rapid deceleration of the electrons causes high-energy photons to be emitted. This is called the braking radiation.	Natural sources of gamma rays are sub atomic particle interaction and high-energy lightning strikes. Gamma rays are artificially produced by particle antiparticle annihilation, braking radiation and neutral p ion decay.
The high-energy electrons also knock out-bound electrons from inner energy levels. The electrons at outer energy levels transit to the lower level to stabilize the atom. This causes a characteristic emission with peaks at specific wavelengths.	Since gamma rays have very high energies, these are capable of breaking bonds of several molecules thus creating a biological hazard.
The frequency region of X-rays has an upper bound, as well as a lower bound	gamma rays frequency region only have a lower bound.

ANSWER (4)

Hard X-rays	Soft X-rays
i) Have short wavelength	i) Have longer wavelength
ii) Are less penetrating	ii) Are more penetrating
iii) Are produced by low voltage	iii) Are produced by high voltage
iv) Are produced by slow moving electrons	iv) Are produced by fast moving electrons

Hard X-Rays might be harmful for certain tissues of the human body and due to its radiation, it can mutate cells which causes ionisation. This often leads to cancer

REFERENCES:

[1] 'Photoelectric effect' by Dr Sachintha Hapugoda and Dr Ayush Goel .

[2] 'Diagnostic Radiology Physics' by D.R. Dance , S. Christofides , A.D.A. Maidment , I.D. McLean and K.H. Ng.