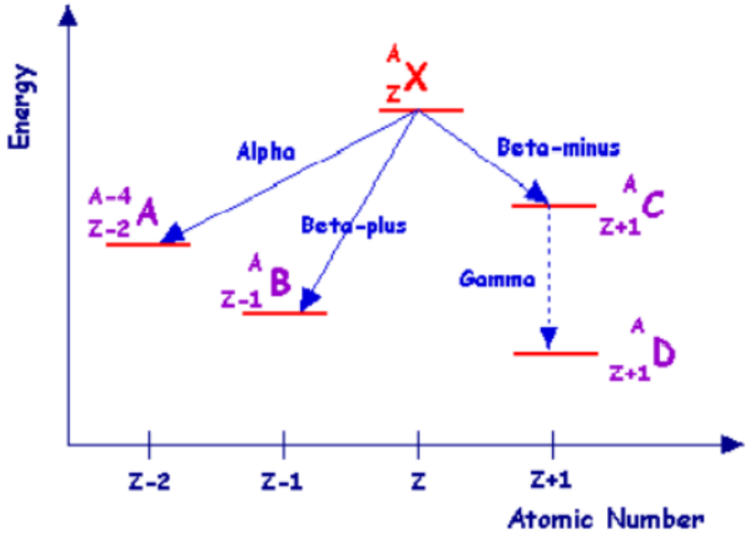
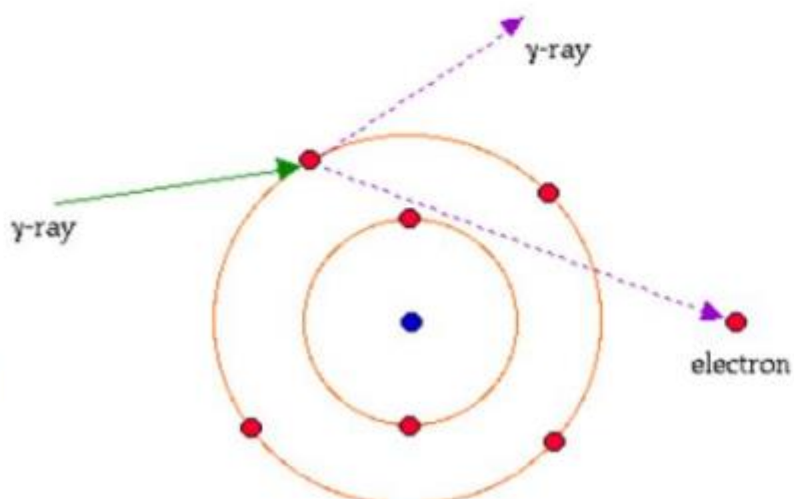
1- **Decay schemes**:



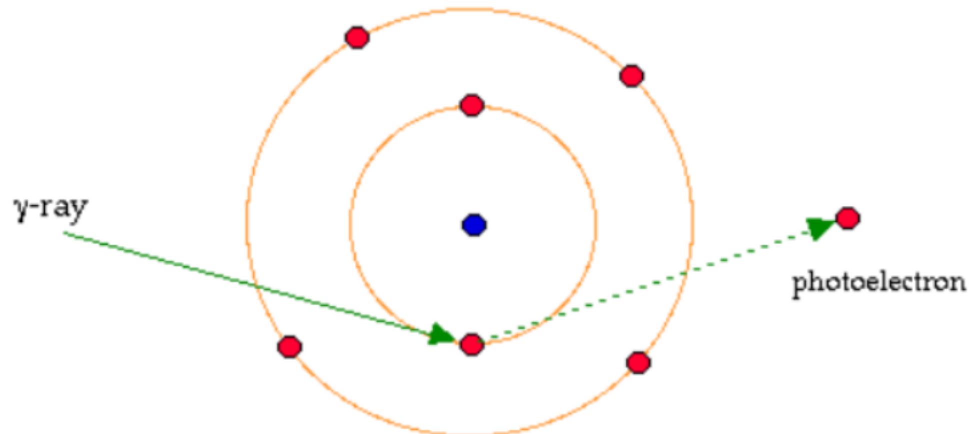
2- **Compton effect (especially photon absorption or not, learn its shape)**
Certainly! The Compton Effect is a phenomenon in which a gamma-ray transfers some of its energy to a free electron, causing the electron to leave the atom like a beta particle. The gamma ray then deflects in a different direction, leading to scattered radiation. This effect can occur multiple times within a material.



The Compton Effect involves partial absorption of a gamma ray by a valence electron, unlike the photoelectric effect.

3- **Photoelectric effect (especially learn whether photons are absorbed or not)**

Gamma-ray hits an atom, and transfers all energy to an orbital electron, creating a photoelectron. Photoelectron leaves the atom with kinetic energy equal to gamma-ray energy minus orbital binding energy.
When the photoelectron leaves, the atom becomes an ion. Gamma-ray energy is entirely absorbed. The photoelectron can cause ionizations, akin to a beta particle. X-ray emission may happen when an outer-shell electron fills the vacancy left by the photoelectron.



Yes, in the photoelectric effect, photons are absorbed. When a gamma-ray collides with an orbital electron, it transfers all its energy to the electron, leading to the ejection of the electron (photoelectron) and the ionization of the atom. the gamma-ray energy is entirely absorbed in the process.

4- What do attenuations depend on? What increases and what decreases?

Factor	Increase Attenuation	Decrease Attenuation
Atomic Number	Increase with higher atomic number	Decrease with lower atomic number
Density	Increase with higher density	Decrease with lower density
Thickness	Increase with greater thickness	Decrease with smaller thickness
Gamma-Ray Energy	Decrease with higher energy	Increase with lower energy

5- Spect components:

1- a rotating multi-headed Gamma Camera:
2- Patient Imaging Table
3- Radiotracer
4- Computer System
5- Collimator
6- Detectors

7- Data Acquisition System

6- what is the Order of passage of gamma rays in spect systems?

A radiopharmaceutical is injected into the patient's body, which travels into the bloodstream and concentrates in the Region of Interest (ROI). The radiopharmaceutical undergoes decay, emitting gamma rays, which are detected by the SPECT machine's gamma camera head. The gamma rays are collimated to improve image quality. The collimated gamma rays are then converted to visible light by a crystal detector, usually Sodium Iodide crystals doped with Thallium. The light then travels through Photo Multiplier Tubes (PMT) to absorb the light and emit electrons. The electrons are detected by a Positioning and Summing Circuit and a Pulse Height Analyzer. The information is passed to a digital computer, where algorithms reconstruct the image. The resultant image provides a physiological state of the organ, with hot spots indicating potential pathology like arthritis, infections, fractures, or tumors.

7- what are the Part's names and the tasks on gamma cameras?

The component of gamma camera are:

1- Collimator: effectively absorb gamma rays, reducing environmental interference.

2- Scintillation Crystal:
Catches the gamma photons.
Converts the high-energy photons into lower-energy ones.
It can be in many shapes and thicknesses depending on the task.

3- Photon Multiplier Tube (PMT):
The process converts photon energy into electrons, increasing their number as they travel through the tube. The electrons are collected in the anode and converted into an electric signal.

4- Pulse Height Analyzer (PHA): Analyzes pulses, • Filters them • Sends the pulses with desired energies to the recording unit

5- Image Recording Unit

8- Derivation of half-life formulas?

We can easily answer this question by using the definition of Half Life and applying it to the Radioactive Decay Law.

Once again the law tells us that at any time, t:

$$N_t = N_0 \exp\ (-\lambda t)$$

and the definition of Half Life tells us that:

$$N_t = \frac{N_0}{2}$$

when

$$t = t_{\frac{1}{2}}$$

We can therefore re-write the Radioactive Decay Law by substituting for N_t and t as follows:

Therefore

$$\frac{N_0}{2} = N_0 \exp\ (-\lambda t_{\frac{1}{2}})$$

$$\therefore 2^{-1} = \exp\ (-\lambda t_{\frac{1}{2}})$$

$$\therefore \ln\ 2^{-1} = -\lambda t_{\frac{1}{2}}$$

$$\therefore \ln\ 2 = \lambda t_{\frac{1}{2}}$$

$$\therefore 0.693 = \lambda t_{\frac{1}{2}}$$

$$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$$

the formula for the half-life ($t_{\frac{1}{2}}$) is: $t_{\frac{1}{2}} = \frac{\ln(2)}{\lambda}$

9- Derivation of formulas for half-value thicknesses?

$$I_x = \frac{I_0}{2}$$

when

$$x = x_{\frac{1}{2}}$$

and inserting it in the exponential attenuation equation, that is:

$$I_x = I_0\, exp\ (-\mu x)$$

to give

Therefore

$$\frac{1}{2} = exp\ (-\mu x_{\frac{1}{2}})$$

$$2^{-1} = exp\ (-\mu x_{\frac{1}{2}})$$

$$\therefore ln\ 2^{-1} = -\mu x_{\frac{1}{2}}$$

$$\therefore ln\ 2 = \mu x_{\frac{1}{2}}$$

$$\therefore 0.693 = \mu x_{\frac{1}{2}}$$

10- PET working principle

PET scans use a scanning device to detect photons emitted by a radionuclide in an organ or tissue being examined. Radionuclides are created by attaching a radioactive atom to chemical substances used naturally by the organism or tissue during its metabolic process. For example, in PET scans of the brain, a radioactive atom is applied to glucose to create fluorodeoxyglucose (FDG). Other substances may be used depending on the purpose of the scan, such as radioactive oxygen, carbon, nitrogen, or gallium.

The radionuclide is administered into a vein through an intravenous (IV) line, and the scanner moves over the part being examined. Positrons are emitted by the breakdown of the radionuclide, and gamma rays called annihilation photons are created when positrons collide with electrons near the decay event. The scanner detects these annihilation photons, which are then analyzed by a computer to create an image map of the organ or tissue being studied. The amount of radionuclide collected in the tissue affects the tissue's brightness and function level.

11- PET annihilation events

Annihilation Process: Positrons interact with electrons, leading to mutual annihilation.[PET annihilation events are the result of the interaction between emitted positrons and electrons in the body, leading to the production of gamma-ray photons that are detected and used to generate PET images.]

12- PET in physics

Positron Emission Tomography (PET) finds applications in physics across several domains:

1. **Nuclear Physics:**
   - Probing fundamental forces and weak interactions.
   - Studying nuclear structure using positron-emitting isotopes.
2. **Materials Science:**
   - Characterizing materials at the atomic scale.
   - Detecting defects and structural features using positron behavior.
3. **Particle Physics:**
   - Utilizing PET scanners for validation and calibration.
   - Contributing to detector development for particle physics experiments.
4. **Medical Physics:**
   - Applying PET technology for imaging and research in medical physics.
   - Optimizing imaging protocols and studying radiation dosimetry.

13- LOR in PET

3. **Line of Response (LOR):** The line connecting the two points where the gamma-ray photons were detected is the Line of Response. Each LOR corresponds to a specific location in the body where the annihilation event occurred.
4. **Image Reconstruction:** By collecting information from multiple LORs, the PET scanner can reconstruct a three-dimensional image of the distribution of the radiotracer in the body. The intensity of signals along different LORs contributes to the final image.

14- SPECT

SPECT stands for Single Photon Emission Computed Tomography. • It is a nuclear imaging technique that uses gamma-rays to produce three-dimensional images of organs by the distribution of radioactive substances in the body.

15- radiopharmaceutical

Radiopharmaceuticals are medications that include radioactive isotopes. They can be employed as both diagnostic and therapeutic agents. Diagnostic radiopharmaceuticals are used to image pathology in a specific area of the body. Therapeutic radiopharmaceuticals are used to treat disorders such as cancer.