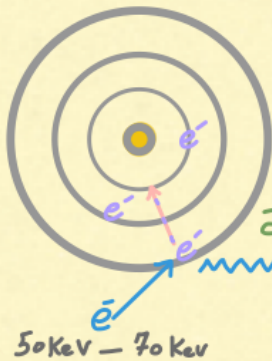
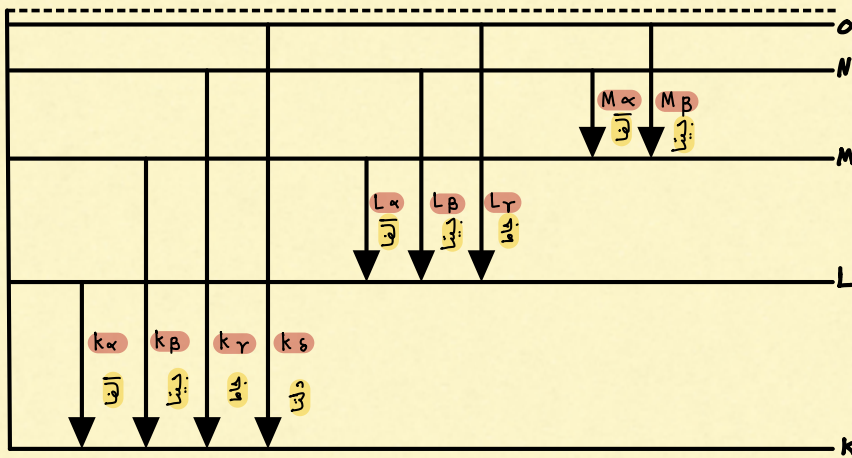


Chapter 24

- X-rays are high energy (ultraviolet) electromagnetic radiations (photons)
- X-rays has higher energy than light wave
- X-rays have high frequency and small wavelength
- Characteristic X-rays are produced when a fast moving electron removes an electron from the inner shell of an atom and an outer-shell electron fills the vacancy in the inner shell thus releasing X-rays in a pattern that is "characteristic" to each element.



• عندما أنتج اشعة سينية X-Ray ، احتاج إلى الكترون طاقته عالية بحيث لو انتقل إلى مدار أقل يبعث له فوتون طاقته = 50 - 70 .
 عندما كذا راح أجيب الكترون خارجي و انتحكم بطاقته حيث تكون عالية
 ثم انطلق يصحدم بالالكترونات التي توجد في المدار .



- $K\alpha$ الفا = الانتقال من L-shell إلى K-shell
- $K\beta$ بيتا = الانتقال من M-shell إلى K-shell
- $K\gamma$ جاما = الانتقال من N-shell إلى K-shell
- $K\delta$ دلتا = الانتقال من O-shell إلى K-shell

- $L\alpha$ الفا = الانتقال من M-shell إلى L-shell
- $L\beta$ بيتا = الانتقال من N-shell إلى L-shell
- $L\gamma$ جاما = الانتقال من O-shell إلى L-shell

Note :

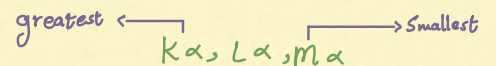
- The figure indicates that the energy difference between the orbitals decreases as the value of n increases
- To remove a valence electron from heavier atoms requires less energy
- Once an inner electron is removed electrons in higher orbitals fill the vacancy
- For the elements heavier than hydrogen the same transitions require more energy

- $M\alpha$ الفا = الانتقال من N-shell إلى M-shell
- $M\beta$ بيتا = الانتقال من O-shell إلى M-shell

- المقارنة من حيث الطاقة لو ثبت المستوى :



- المقارنة من حيث الطاقة لو اختلف المستوى :

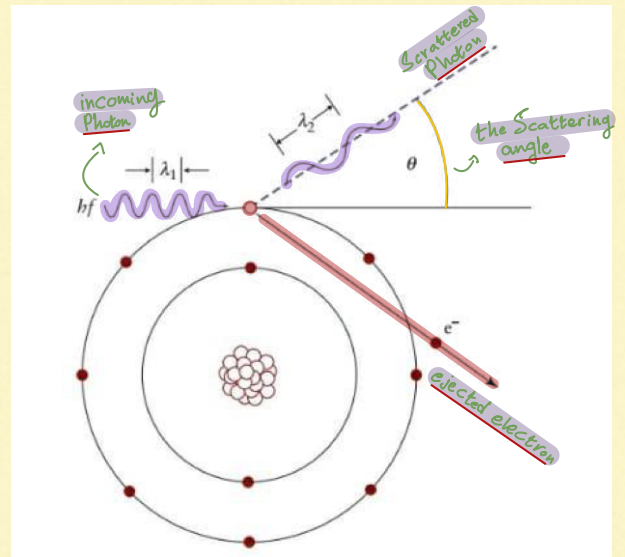


Compton

- **Compton Effect:** Compton scattering, is the scattering of a photon by a charged particle, usually an electron.
- It results in a decrease in energy (increase in wavelength) of the photon. Part of the energy of the photon is transferred to the recoiling electron.

إلكترون متحرك

- **Compton scattering:** is the main interaction of X- rays in the energy range from about 250 keV to 30 MeV *
- is a process that occurs when an X-ray photon interacts with a valence electron, the electron is ejected from the atom and the photon is scattered, with reduced energy.



$$E_{\text{photon},i} = E_{\text{photon},f} + E_{\text{electron}}$$

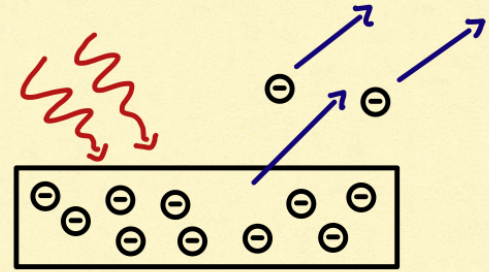
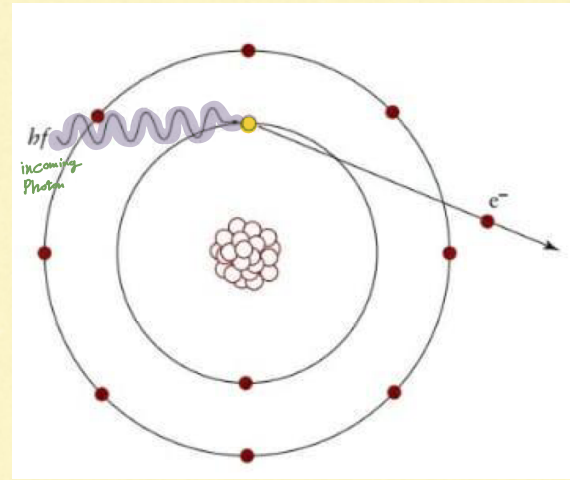
- In X-ray imaging the scattered photons are much more likely to be detected in the image, thus reducing the image contrast.
- In Compton scattering due to energy conservation the energy of the incident photon is equal to the sum of the energy of the scattered photon and the kinetic energy of the ejected electron
- In Compton scattering also subjected to the conservation of momentum
- In Compton scattering confirmed the applicability of the corpuscle model of the X-ray photon
- In Compton scattering the ejected electron from the atom losses its energy in surrounding material
- The probability of Compton increases as the incident photon energy increases up to energies of 50 keV
- The probability for Compton events then decreases for X-ray energies above 100keV.
- Hydrogenous material has a higher probability of Compton scattering than hydrogen-free material of equal mass.

الانقراض الكهروضوئي

Photoelectric Effect: When a photon hits an electron on a metal surface, the electron can be emitted.

The emitted electrons are called photoelectrons.

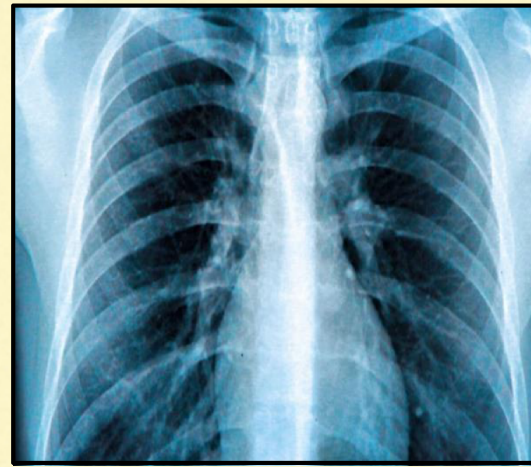
- In photoelectric effect the entire energy of the X-ray photon is transferred to the electron.
- The probability for photoelectric absorption in a sample of unit mass is proportional to Z^3/E^3
- Directly to atomic number And inversely to photon energy
- Photoelectric effect is exclusively an absorption process in which all the energy is absorbed by the ejected electron and it's binding energy
- In photoelectric effect the entire energy of the incident X-ray photon is transferred to an electron which in turn is ejected from the atom
- The kinetic energy of the ejected electron is equal to the incident photon energy minus the binding energy of the electron in its orbital.



$$E_{kin,electron} = E_{photon} - E_{binding}$$

Simple X-Ray images (Radiography)

When imaging with X-rays, an X-ray beam produced by a X-ray tube passes through the body. On it's way through the body, parts of the energy of the X-ray beam are absorbed. This process is described as attenuation of the X-ray beam. On the opposite side of the body, detectors or a film capture the attenuated X-rays, resulting in a clinical image. In conventional radiography, one 2D image is produced.



- In x-ray imaging the shadowing occurs mainly due to photoelectric effect

Contrast Angiography: Angiography is a medical X-ray imaging technique using liquid contrast agents (known as contrast media) injected into the bloodstream to visualize the lumen of blood vessels mainly focused on arteries and veins as well as the chambers of the heart. The images taken are called angiograms.

The contrast agent typically contains a heavy metal such as iodine, which due to its high atomic number ($Z = 53$) has high photoelectric absorption. Thus the iodine containing arteries appear clearly in X-ray image.

