Hello students, this module is for Bachelor of Science Physics students. Course code is P Y C 108. Course title: atomic and molecular physics. Unit name is X ray Spectra. We are going to learn in this module characteristic X ray spectrum and mosely's law.
At the end of the module, students will be able to describe characteristic X ray Spectra, state mosely's law and explain its consequences.
Characteristic Spectra X rays are electromagnetic radiations of very short wavelength.

Wavelength range is .01 Angstrom Unit,to 100 Angstrom unit. When X rays from an X ray tube are analyzed using a crystal spectrometer, it is observed that the X ray beam from a target consists of two distinct types of Spectra. 1A continuous spectrum number two a sharp line spectrum superimposed on the continuous spectrum. Now this figure shows a typical X ray spectrum.Here, the intensity of X rays is plotted against the wavelength. The curve for tungsten this curve for tungsten shows the continuous spectrum.The X ray tube is operated at 35K Volt with the tungsten is the target. The other curve is for molybdenum, this curve shows 2 sharp lines characteristic of element molybdenum. Which are superimposed on the continuous spectrum. These lines are known as K alpha and k bita lines of molybdenum.To get similar lines for tungsten,it is observed that the tube has to be operated at a very high voltage of about 70 kilovolt.
Characteristics of the spectrum.
In general, the spectrum is continuous.It has a minimum wavelength limit,Lambda minimum called Duane Hunt limit.This short wavelength limit is the characteristic of the operating voltage and is independent of the material of the target.Therefore, both tungsten and molybdenum have the same short wavelength limit. Keeping the target material same if the operating voltage is increased then it is observed that lambda minimum, that is the short wavelength limit decreases. It is found that Lambda minimum is inversely proportional to the applied voltage. As one can easily see from the graph. If the voltage at which the tube is operated is increased above a certain minimum voltage, called the critical voltage sharp peaks appear. Depending upon the nature of the target material.This peaks correspond to definite wavelengths which are characteristic of the material of the target and hence the corresponding lines are called the characteristic lines.
Origin of continuous spectrum. According to the to electromagnetic theory of light, when charged particles travel with accelerated or decelerated motion, they emit electromagnetic radiation of different frequencies. A part of their kinetic energy is transformed into the energy of emitted radiation.When the electrons accelerated within the X ray tube, hit the target, then motion becomes decelerated and their velocities decrease. As a result, they emit electromagnetic radiation with a continuous distribution of wavelengths starting from a minimum. This radiation is known as bremsstrahlung radiation.
The production of a continuous spectrum is a result of this radiation. According to quantum theory, X rays consist of photons.The energy of these photons is H new. Where new is the frequency of radiation. The kinetic energy of electrons accelerated from rest through a potential difference V is eV. Which is the energy with which they are incident on the target. Hence, in general, the energy of the photon that is H new must be less than the kinetic energy of the incident electron,
that is H new is less than eV.

The maximum energy of photon can have is given by H New Max is equal to a new eV.

H C by Lambda, minimum is equal to eV.Therefore, Lambda minimum is equal to HC by eV, which is duane hunt limit. **Mosley's law** when a systematic study of X ray radiation from various elements was made Moseley found that the wavelengths of the characteristic X ray lines change smoothly as one goes from element to element. The X ray spectrum consists of discrete lines superimposed on the continuous X ray spectrum. The wavelength of the X rays decreases as Z increases indicating that the frequency of the X rays increases with increase in Z. When the plot of square root of Nu K alpha radiation versus atomic number Z was made, it was expressed as Mosley Law as square root of nu kalfa proportional to Z. Where nu k alpha is the frequency of K alpha lines for the various elements.Nu kalfa is equal to three by 4C into R into Z -- 1 the square where the constant C&R is the speed of light in vacuum and Rydberg constant respectively. Mosley drew the following important conclusions from the study of X ray Spectra of different elements.

Elements in the periodic table should be arranged according to their increasing atomic number Z and not their atomic weight.The results show also showed how the elements with smaller atomic weight should be placed after the elements with greater atomic weights. If the elements with greater atomic weights have smaller Z. For example, cobalt with Z is equal to 27, which has atomic weight of 58.9, comes before nickel with Z is equal to 28, which has atomic weight of 58.7. Many elements which were missing in the periodic table could also be predicted. Thus Moseley predicted the occurrence of scandium with Z is equal to 21 and promethium With Z is equal to 61, which were discovered later With the discovery of high resolution spectrometers, the fine structure of K series lines, the doublets K alpha one K alpha 2 , K beta 1 K beta two, was discovered when square root of nu alpha was plotted versus Z.

So we can write $v = C_n\,(Z - S)^2$ where S is called the screening constant. Both the constants C_n and S are different for different series. For hydrogen like atoms, we have $v = c\,R\,Z_{eff}^2\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$

$$v = c\,R\,(Z\text{-}S)^2\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

where the effective nuclear charge has been replaced by (Z-S).

For the K series $n_i = 2$ and $n_f = 1$

Therefore $v_K = c\,R\,(Z\text{-}S)^2\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$

$$v_K = \frac{3}{4}\,c\,R\,(Z\text{-}S)^2$$

When an electron jumps from the L shell to the K shell, the effective charge seen by the electron is $+Z_e$ on the nucleus plus (-e) on the K electron. Hence $Z_{eff} = (Z - 1)$

Hence above equation becomes $v_K = \frac{3}{4} c R (Z-1)^2$ which is Mosley's law as stated earlier.

Here are some references.

Thank you.