X-RAY SPECTRA

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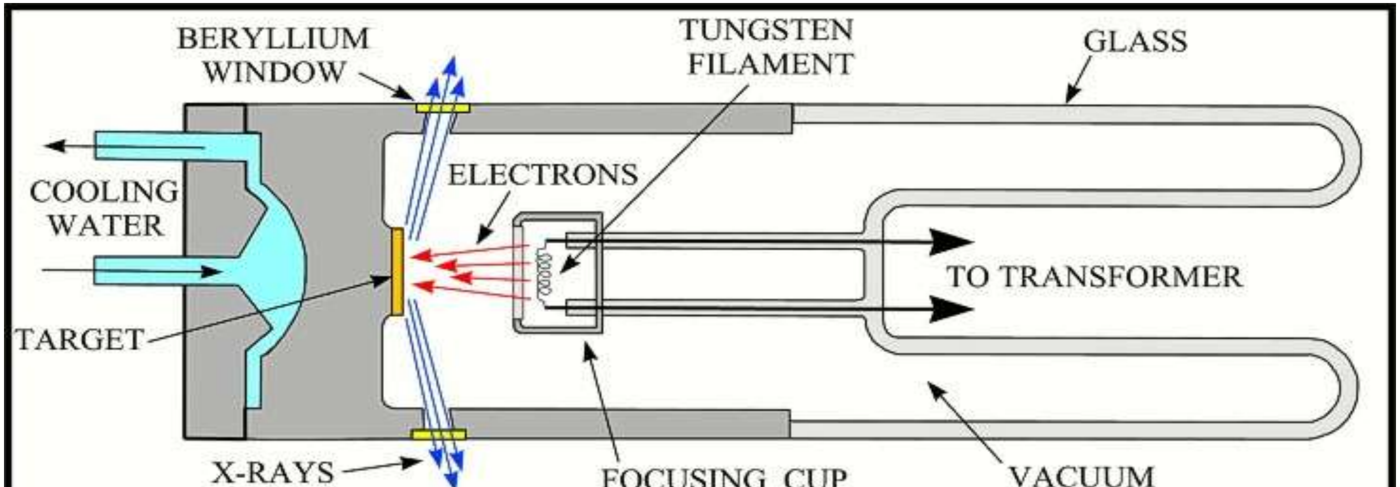
X-RAY TUBE CONSTRUCTION

It consists of an evacuated glass envelope which insulates the anode at one end from the cathode at the other. The cathode is a tungsten filament and the anode a water-cooled block of copper. High-voltage transformer is connected to the filament. The filament is heated by a filament current of about 3 amp and emits electrons which are rapidly drawn to the target by the high voltage across the tube. Surrounding the filament is a small metal cup maintained at the same high (negative) voltage as the filament: it therefore repels the electrons and tends to focus them into a narrow region of the target, called the focal spot. X-rays escape from the tube through two or more windows in the tube housing made of beryllium, since these windows must be vacuum tight and yet highly transparent to x-rays.



SCHEMATIC CROSS SECTION OF AN X-RAY TUBE

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Types of X-rays

When the target of an X-ray tube is struck by energetic electrons, two kinds of X-ray radiations are emitted by the target

1. Continuous Spectrum

2. Characteristic X-ray Spectra

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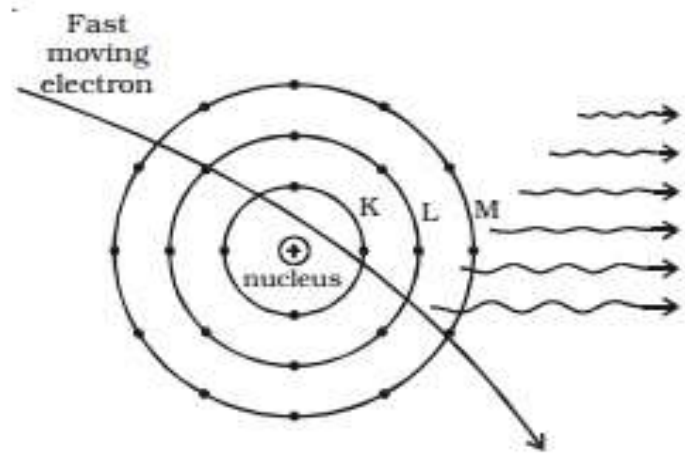
CONTINUOUS X-RAY SPECTRA

Continuous X-rays are produced when any electrically charged particle of sufficient kinetic energy rapidly decelerates. The continuous spectrum results from the rapid deceleration of the electrons hitting the target since any decelerated charge emits energy. Continuous radiation is also known as white radiation, as it is made up, of rays of many wavelengths , like white light. White radiation is also called Bremsstrahlung, (German for "braking radiation"), because it is caused by electron deceleration.



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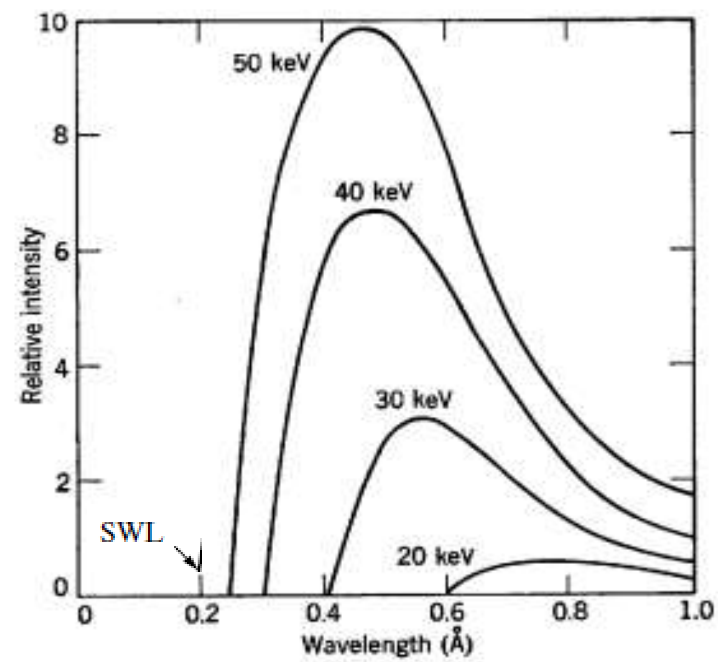
The variation of intensity of continuous X-rays is shown in the figure. The intensity is zero up to a certain wavelength, called the *short-wavelength limit* (SWL), increases rapidly to a maximum and then decreases, with no sharp limit on the long wavelength side. When the tube voltage is raised, the intensity of all wavelengths increases, and both the short-wavelength limit and the position of the maximum shift to shorter wavelengths. Not every electron decelerates in the same way, however; some stop in one impact and release all their energy at once, while others lose fractions of their total energy in successive deflections until all energy is spent. The electrons which are stopped in one impact produce photons of maximum energy, i.e., x-rays of minimum wavelength. Such electrons transfer all their energy *eV into photon energy so that*

$$eV = h\nu_{\max}$$

$$\lambda_{SWL} = \lambda_{\min} = \frac{c}{\nu_{\max}} = \frac{hc}{eV}$$

$$\lambda_{SWL} = \frac{(6.626\times10^{-34})(2.998\times10^{3})}{(1.602\times10^{-19})V} m$$

$$\lambda_{SWL} = \frac{12.40\times10^{3}}{V} \qquad \text{Å}$$



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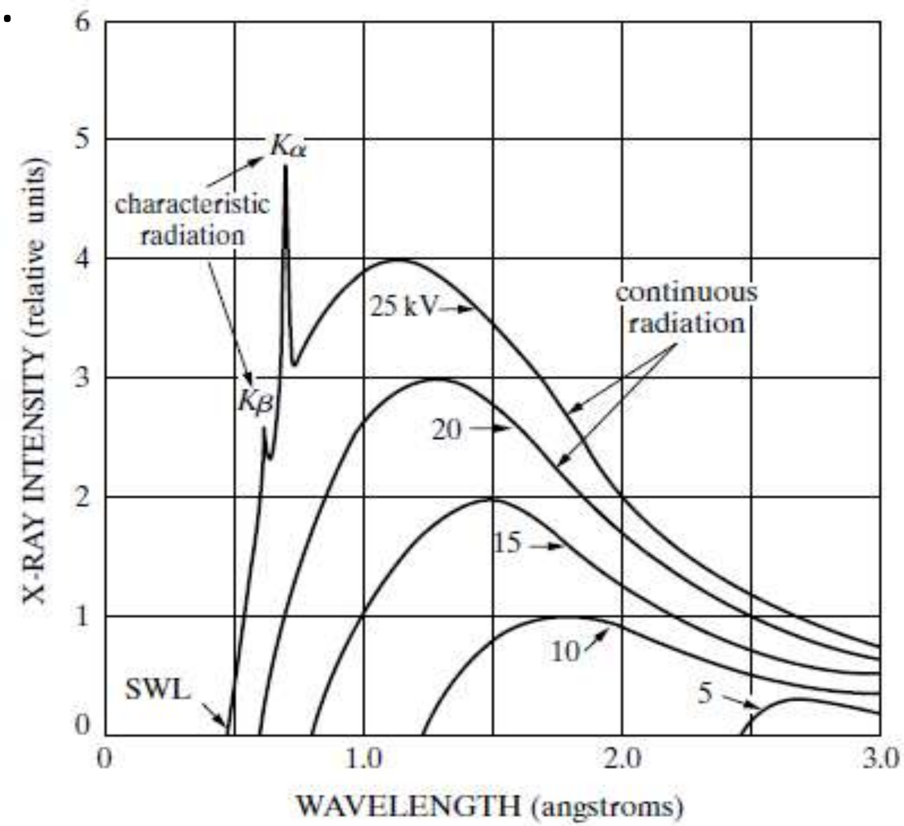
CHARACTERISTIC X-RAY SPECTRA

When the voltage on an x-ray tube is raised above a certain critical value, characteristic of the target metal, sharp intensity maxima appear at certain wavelengths, superimposed on the continuous spectrum. Since they are so narrow and since their wavelengths are characteristic of the target metal used, they are called characteristic lines.

These lines fall into several sets, referred to as K, L,M, etc., in the order of increasing wavelength, all the lines together forming the characteristic spectrum of the metal used as the target.



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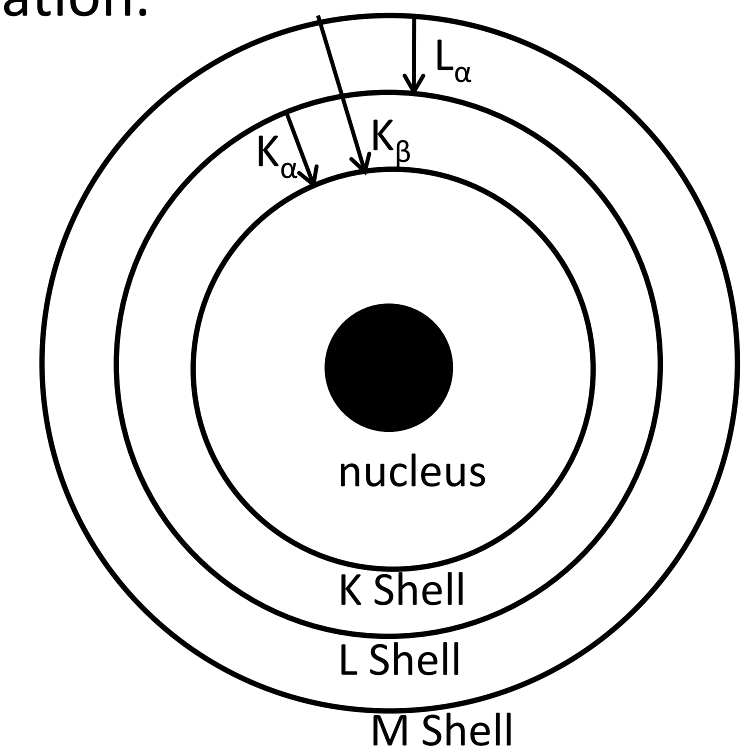
An atom as consisting of a central nucleus surrounded by electrons lying in various shells, *K, L, M, ... corresponding to the principal quantum* number *n = 1, 2, 3, ... An electron bombarding the target with sufficient* kinetic energy knocks an electron out of the *K shell, leaving the atom in an* excited, high-energy state. If the K shell is filled with an electron falling from L shell, the energy released is in the form of K_α radiation. While an electron falling from M shell gives rise to K_β radiation.

Vacancy of L shell filled by electrons from higher shells gives rise to L series of radiation. It follows that it is impossible to excite a K characteristic radiation without L, M, etc., radiation accompanying it.



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Thank You

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