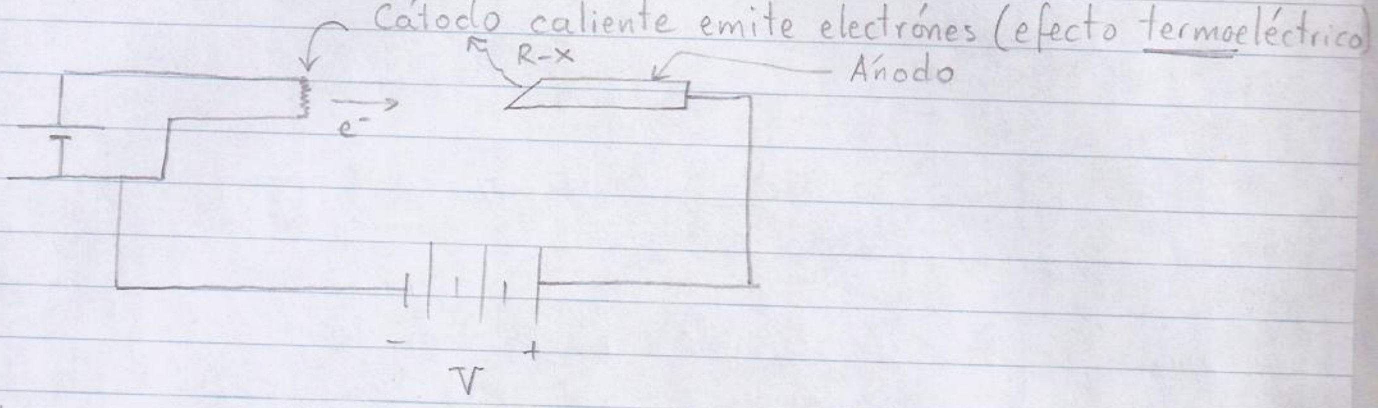
Producción de Rayos X



Los e^- que salen del cátodo son acelerados por una d.d.p hasta adquirir una $K = eV$. El e^- se desacelera cuando choca contra un núcleo pesado del ánodo y pierde energía en forma de radiación (fotones de rayos X)

$$K - K' = h\nu$$

El e^- transfiere momento lineal al núcleo pesado pero la masa de éste (del núcleo) es tan grande que su energía cinética es despreciable.

Cada e^- tiene muchas colisiones y en cada colisión puede perder una cantidad distinta de energía. Además hay muchos e^- interactuando de forma que el espectro de rayos-X es un continuo como se muestra en la siguiente figura para tungsteno.

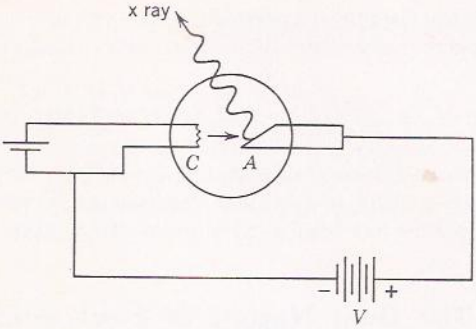


FIGURE 2-9

An x-ray tube. Electrons are emitted thermally from the heated cathode *C* and are accelerated toward the anode target *A* by the applied potential *V*. X rays are emitted from the target when electrons are stopped by striking it.

Figure 2-10 shows, for four different values of the incident electron energy, how the x rays emerging from a tungsten target are distributed in wavelength. (In addition to the continuous x-ray spectrum, x-ray lines characteristic of the target material are emitted. We shall discuss the lines in Chapter 9.) The most notable feature of these curves is that, for a given electron energy, there exists a well-defined minimum wavelength $\lambda_{\min}$; for 40-keV electrons, for instance, $\lambda_{\min}$ is 0.311 Å. Although the overall shape of the continuous x-ray distribution spectrum depends on the choice of target material as well as on the electron accelerating potential V, the value of $\lambda_{\min}$ depends only on V, being the same for all target materials. Classical electromagnetic theory cannot account for this fact, there being no reason why waves whose wavelength is less than a certain critical value should not emerge from the target.

A ready explanation appears, however, if we regard the x rays as photons. Figure 2-11 shows the elementary process that, on the photon view, is responsible for the continuous x-ray spectrum of Figure 2-10. An electron of initial kinetic energy K is decelerated during an encounter with a heavy target nucleus, the energy it loses appearing in the form of radiation as an x-ray photon. The electron interacts with the charged nucleus via the Coulomb field, transferring momentum to the nucleus. The accompanying deceleration of the electron leads to photon emission. The target nucleus is so massive that the energy it acquires during the collision can safely be neglected. If K' is the kinetic energy of the electron after the encounter, then the energy of the photon is

$$h\nu = K - K'$$

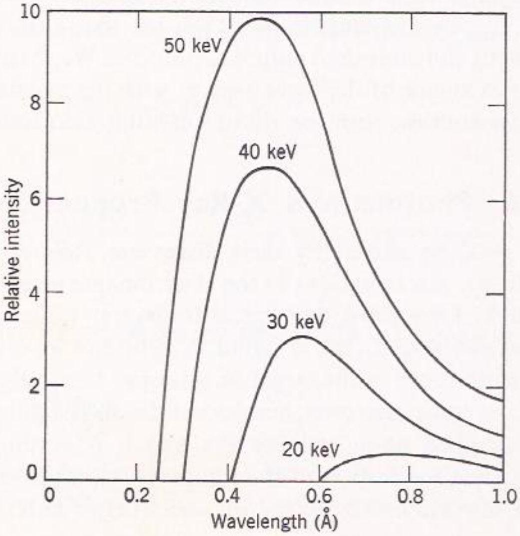


FIGURE 2-10

The continuous x-ray spectrum emitted from a tungsten target for four different values of *eV*, the incident electron energy.

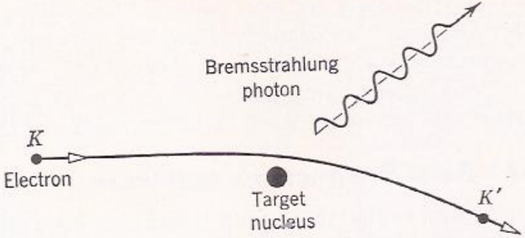
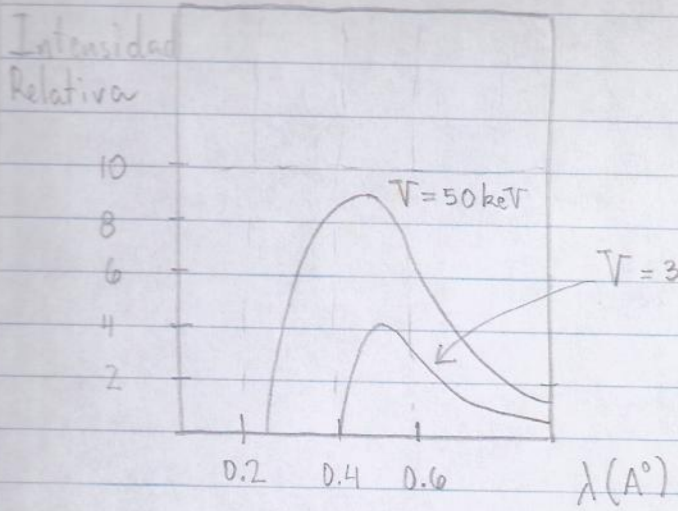


FIGURE 2-11

The bremsstrahlung process responsible for the production of x rays in the continuous spectrum.

and the photon wavelength follows from

$$hc/\lambda = K - K' \tag{2-13}$$



$\lambda_{min} \propto \frac{1}{V}$

$$h\nu = K - K' \Rightarrow \frac{hc}{\lambda} = K - K' \Rightarrow \lambda = \frac{hc}{K-K'}$$

λ_{min} se produce cuando $K'=0$, es decir el e^- pierde toda su energía en una colisión y emite un fotón por el proceso de bremsstrahlung (brems = desacelerando) + (strahlung = radiación)

Pero $K = qV \Rightarrow$

$$\lambda_{min} = \frac{hc}{eV} \qquad (50)$$

Mínima $\lambda \Rightarrow$ máxima ν debida a completa conversión de la energía cinética del e^- en radiación

Comentario: A)
Si $h \to 0$ $\lambda_{min} \to 0$ lo cual es la predicción clásica

Esto implica que la existencia de λ_{min} es un efecto cuántico.

B) El proceso de bremsstrahlung puede ser considerado como el inverso del efecto fotoeléctrico.