719.

<u>Problem 49.47 (RHK)</u>

X rays with a wavelength of 71.0 pm *eject photoelectrons from a gold foil, the electrons originating from deep within the gold atoms. The ejected electrons move in circular paths of radius r in a region of uniform magnetic field* $\vec{B}$. *Experiment shows that* $rB = 188\ \mu\text{T.m}$. *We have to find* (a) *the maximum kinetic energy of the photoelectrons and* (b) *the work done in removing the electrons from the gold atoms that make up the foil.*

<u>Solution:</u>

(a)

Energy ε of a photon in terms of its wavelength λ is given by the relation

$$\varepsilon = \frac{1240\ \text{eV. nm}}{\lambda}.$$

Therefore, the energy of a photon of wavelength 71.0 pm is

$$\varepsilon = \frac{1240}{71\times10^{-3}}\ \text{eV} = 17.46\times10^{3}\ \text{eV}$$

$$= 17.46\ \text{keV}.$$

Let the maximum speed of the photoelectrons ejected from the gold foil be v m s^{-1}. As these electrons move in the magnetic field B in circular orbits of radius r, we have the condition

$$\frac{mv^2}{r} = evB,$$

or

$$v = \frac{erB}{m}.$$

It is experimentally measured that $rB = 188\ \mu\text{T.m}$.

Therefore, the maximum speed of the photoelectrons is

$$v = \frac{1.6\times10^{-19}\times188\times10^{-6}}{9.11\times10^{-31}}\ \text{m s}^{-1}$$

$$= 33.0\times10^{6}\ \text{m s}^{-1}.$$

Therefore, the kinetic energy of electrons moving with speed of $33.0\times10^{6}\ \text{m s}^{-1}$ will be

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}\times9.11\times10^{-31}\times\left(33.0\times10^{6}\right)^2\ \text{J}$$

$$= 4960.4\times10^{-19}\ \text{J}$$

$$= \frac{4960.4\times10^{-19}}{1.6\times10^{-19}}\ \text{eV} = 3.1\ \text{keV}.$$

(b)

And, the work done in removing the electrons from the gold metal is $(17.5-3.1=14.4)$ keV.