Answer on Question 58597, Physics, Quantum Mechanics

Question:

If a work function for the metal is $1.85\ eV$. What would be stopping potential for light having wavelength $410\ nm$?

Solution:

Using the mathematical description of the photoelectric effect, we can write the maximum kinetic energy E_{Kmax} of an emitted electron as follows:

$$E_{Kmax} = hf - \varphi,$$

here, $h = 6.626 \cdot 10^{-34}\ J \cdot s$ is the Planck constant, f is the frequency of the incident photon, φ is the work function for the metal.

In practice, the maximum kinetic energy of the emitted electrons can be measured by making the metal plate or 'cathode' increasingly positive with respect to the metal anode used to collect the electrons. The electrons need to do extra work to move away from the cathode if it is positively charged. As a result, the maximum kinetic energy of the electrons is reduced by an amount equal to eV(here, V is the potential of the cathode relative to the metal anode, e is the charge of the electron). In other words, $E_{Kmax} = hf - \varphi - eV$ for a cathode at potential $+V$.

The number of electrons emitted per second decreases as the cathode potential is made increasingly positive. At a certain potential referred to as the stopping potential V_s, photoelectric emission is stopped because the maximum kinetic energy has been reduced to zero. As the work done by the electron in moving through a potential difference V_s is equal to eV_s, we get:

$$E_{Kmax} = hf - \varphi - eV_s = 0,$$

$$eV_s = hf - \varphi.$$

From this formula we can find the stopping potential for light having wavelength $410\ nm$:

$$V_s = \frac{hf - \varphi}{e}.$$

Let's first calculate the frequency of the incident light:

$$f = \frac{c}{\lambda} = \frac{3 \cdot 10^{8}\ \frac{m}{s}}{410 \cdot 10^{-9}\ m} = 7.32 \cdot 10^{14}\ Hz.$$

Let's substitute the numbers:

$$V_s = \frac{hf - \varphi}{e} = \frac{6.626 \cdot 10^{-34}\ J \cdot s \cdot 7.32 \cdot 10^{14}\ Hz - 1.85 \cdot 1.6 \cdot 10^{-19}\ J}{1.6 \cdot 10^{-19}\ C} = 1.18\ V.$$

Answer:

$V_s = 1.18\ V.$