PROBLEMS ON THE PHOTOELECTRIC EFFECT

Information:

$h = 6.63 \times 10^{-34}$ J.s	$1\ e = 1.6 \times 10^{-19}$ C
$= 4.14 \times 10^{-15}$ eV.s	$c = 3.0 \times 10^{8}$ m/s
$m_e = 9.1 \times 10^{-31}$ kg	$1\ Å = 10^{-10}$ m
$1\ eV = 1.6 \times 10^{-19}$ J	$1\ nm = 10^{-9}$ m

1. Violet light has a wavelength of about 4.4×10^{3} Å. Calculate the energy of one photon of violet light in joules and electron volts.

2. The binding energy of the photoelectrons of a surface is 1.8 eV. Blue light of wavelength 4.8×10^{-7}.m falls on the surface.
   Find (a) the kinetic energy of the ejected electrons in eV
   (b) the voltage required to stop the electrons from leaving the surface.

3. The average wavelength of a light source is about 5.5×10^{2} nm and energy is emitted at the rate of 7.2×10^{-12} joules per second.
   Find (a) the average energy of a photon in joules
   (b) the number of photons emitted in one second
   (c) the average distance between photons.

4. About one percent of the energy emitted by a 1.2×10^{2} W bulb is in the form of photons in the visible region of the spectrum having a wavelength of 5.0×10^{-7} m.
   Find (a) the number of these photons emitted per second
   (b) the momentum of one of these photons
   (c) the magnitude of the force due to these photons on a black surface having an area of 0.50 m^2 and 1.5 m away from the bulb. Assume that the photons are emitted equally in all directions and hit the surface normally.

5. When photons of wavelength 4.0×10^{-7} m strike a certain photoelectric surface, electrons are ejected. The maximum kinetic energy of an ejected electron is 4.0×10^{-19} J.
   Find (a) the energy of a photon in electron volts and in joules
   (b) the momentum of a photon
   (c) the binding energy of the photoelectric surface in joules
   (d) the minimum frequency that a photon must have in order to eject an electron from this surface
   (e) the momentum of an electron that is ejected with an energy of 4.0×10^{-19} J.

6. When photons from a monochromatic light source strike a photoelectric surface, electrons are ejected. The maximum kinetic energy of these photoelectrons is 3.0×10^{-19} J. The threshold frequency of the photoelectric material is 1.7×10^{14} Hz.

Find (a) the threshold (binding) energy of the photoelectric material in joules
(b) the energy of a photon in joules
(c) the wavelength of a photon
(d) the momentum of an ejected electron

7. A certain photoelectric surface ejects electrons when bombarded with photons of wavelength 5.0×10^{-7} m. The maximum kinetic energy of an ejected electron is 3.2×10^{-19} joules.

Find (a) the speed of the electron ejected with this maximum kinetic energy
(b) the momentum of this electron
(c) the energy of the photon in electron volts
(d) the ionization (threshold) energy of the photoelectric surface in electron volts.

8. A certain photoelectric surface has a work function of 2.0 eV. It is bombarded with photons each having 3.0 eV of energy.

Calculate (a) the threshold frequency of this photoelectric surface
(b) the momentum possessed by each photon
(c) the maximum kinetic energy (in joules) that an electron could receive
(d) the speed of an electron ejected with this maximum kinetic energy
(e) the momentum of this electron.

9. Photons with 3.1 eV of energy bombard a surface whose work function is 1.6 eV.

Calculate (a) the wavelength of the photons
(b) the momentum of each photon
(c) the maximum kinetic energy of each photoelectron in joules
(d) the momentum of a photoelectron which possesses the maximum amount of kinetic energy.

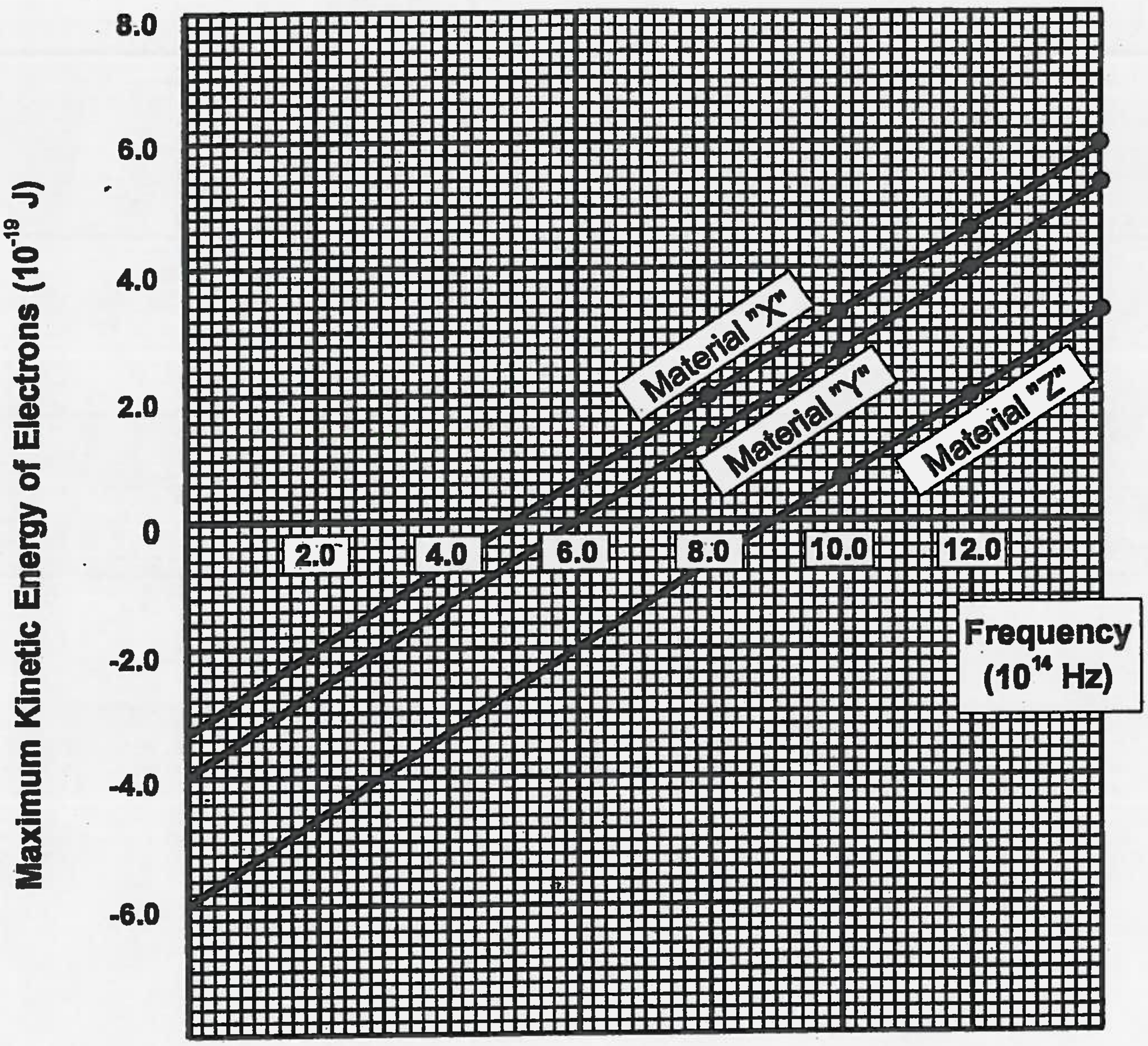
10. Light with a wavelength of 2.6×10^{-7} m falls on a tungsten photoelectrode which has a work function of 4.52 eV. The retarding potential is 0.15 V.

Find (a) the maximum kinetic energy (in joules) of an electron as it leaves the photoelectrode
(b) the maximum speed with which an electron reaches the collector plate.

11. Light of frequency 8.5×10^{14} Hz falls on a photoelectric surface. When the retarding potential is 0.75 V, the maximum speed with which an electron reaches the collector plate is 5.0×10^{5} m/s.

Find (a) the maximum kinetic energy (in joules) of an electron as it leaves the photoelectrode
(b) the work function (in eV) of the photoelectrode.

12. The graph below shows the relationship between the energy of ejected photoelectrons from various surfaces, and the frequency of light used.



(a) Which of the above three lines represents the material with the largest work function ? Explain your reasoning.

(b) What was the approximate energy of a photon of light which ejected an electron from material Y with a maximum kinetic energy of 4.0×10^{-19} J ?

(c) What is the minimum frequency that a photon must have in order to eject an electron from a metal whose binding energy is 1.5 electron volts ?

ANSWERS

1. 2.8 eV, 4.5×10^{-19} J

2. (a) 7.9×10^{-1} eV (b) -7.9×10^{-1} volt (retarding potential)

3. (a) 3.6×10^{-19} J (b) 2.0×10^{7} photons (c) 1.5×10^{1} m

4. (a) 3.0×10^{18} photons (b) 1.3×10^{-27} kg.m/s in the direction of the photon
   (c) 7.1×10^{-11} N

5. (a) 3.1 eV, 5.0×10^{-19} J (b) 1.7×10^{-27} kg.m/s in the direction of the photon
   (c) 9.7×10^{-20} J (d) 1.5×10^{14} Hz
   (e) 8.5×10^{-25} kg.m/s in the direction of the electron

6. (a) 1.1×10^{-19} J (b) 4.1×10^{-19} J
   (c) 4.8×10^{-7} m (d) 7.4×10^{-25} kg.m/s in the direction of the electron

7. (a) 8.4×10^{5} m/s (b) 7.6×10^{-25} kg.m/s in the direction of the electron
   (c) 2.5 eV (d) 4.9×10^{-1} eV

8. (a) 4.8×10^{14} Hz (b) 1.6×10^{-27} kg.m/s in the direction of the photon
   (c) 1.6×10^{-19} J (d) 5.9×10^{5} m/s
   (e) 5.4×10^{-25} kg.m/s in the direction of the electron

9. (a) 4.0×10^{-7} m (b) 1.7×10^{-27} kg.m/s in the direction of the photon
   (c) 2.4×10^{-19} J (d) 6.6×10^{-25} kg.m/s in the direction of the electron

10. (a) 4.2×10^{-20} J (b) 2.0×10^{5} m/s

11. (a) 2.3×10^{-19} J (b) 2.1 eV

12. (a) Material Z, the y-intercept is largest (in terms of absolute value) for this line
    (b) 8.0×10^{-19} J (c) 3.6×10^{14} Hz